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FOR MODEL RR

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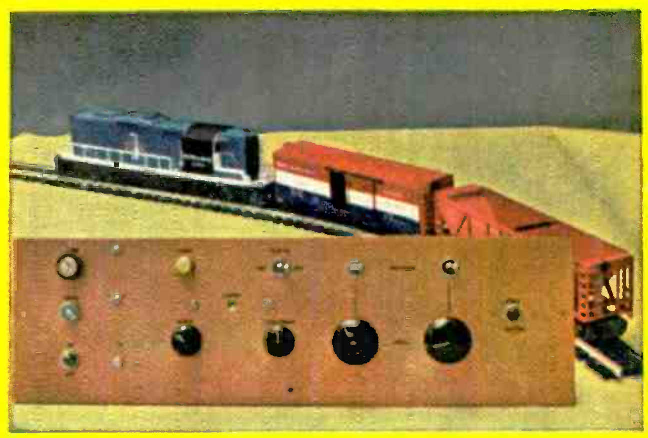
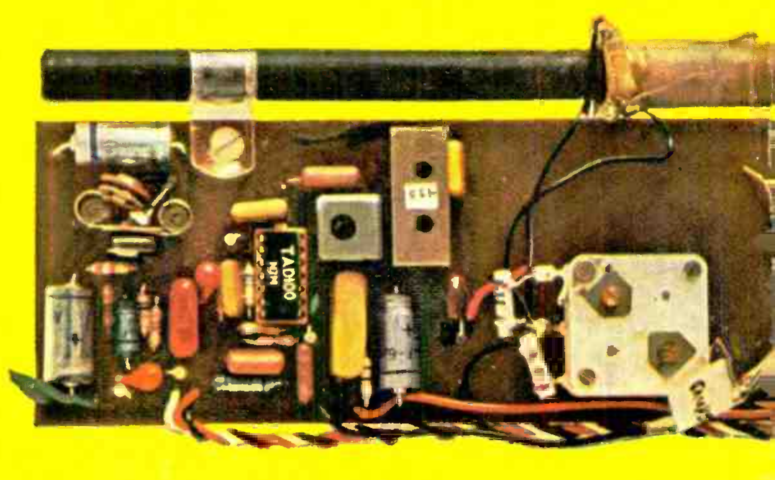


E[illegible]rimenters

N[illegible] Build R-E's

One-IC Radio



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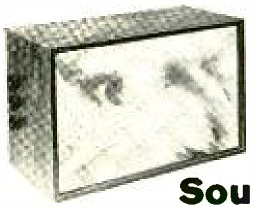

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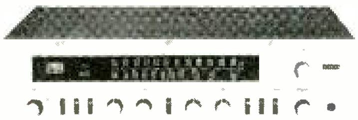

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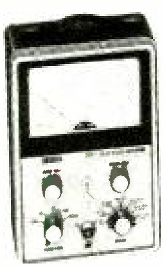

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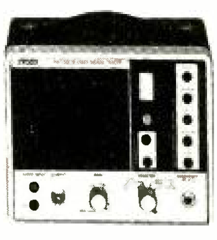

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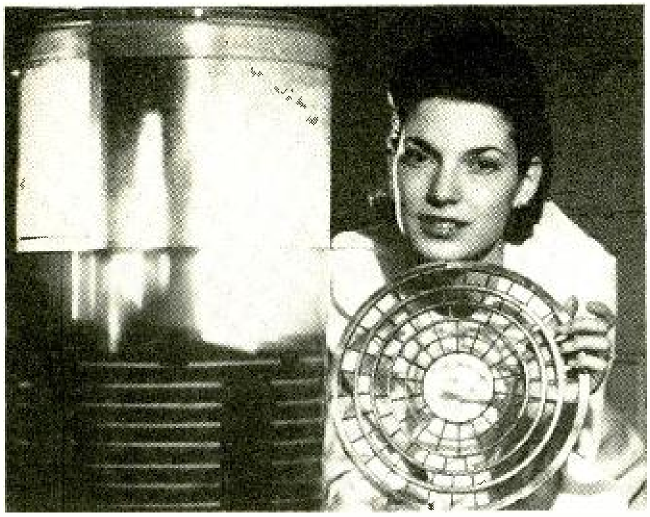

MURRAY HILL, N.J.—The conical grid held next to this new cylindrical lead-acid battery is a key element for doubling battery life to 30 years over the 15-year life of present batteries. The new Bell Labs design causes the battery to improve with age.

The circular grid is made with pure lead instead of commonly used lead alloys that corrode more rapidly. A special energy-producing paste with an interlocking crystal structure is also used. The cylindrical design causes the grid to expand evenly as the lead corrodes. This, unlike normal batteries, keeps the rings in contact with the paste constantly. Eventually, corrosion effectively increases the amount of paste, which improves the battery capability.

The Bell System uses about $15 million worth of batteries a year as an emergency power source. Although not designed for car batteries, the principle will probably be applied in the automobile market.

IN THIS ISSUE

Experimenters note: They've packed most of the elements for a radio on an IC chip. Learn how you can use it on page 49.

BRUSHLESS MOTOR

TOKYO—Use of the Hall effect for a brushless dc motor has been announced by Pioneer Electronic Corp. for portable and car tape recorders. The motors, which do not need commutators or brushes, reportedly provide noise free operation with very low rumble, wow and flutter.

With the Hall effect, a voltage is developed across a conductive material when it is placed in a vertical magnetic field. Pioneer uses IC's in conjunction with the Hall device to electronically operate the motor.

LOOKING AHEAD

by **DAVID LACHENBRUCH**
CONTRIBUTING EDITOR

Entertainment via EVR

The first group of entertainment programs for Electronic Video Recording (EVR) players has now been announced, perhaps foreshadowing a new type of "television" service to the home. EVR is the TV cartridge-film ystem developed by CBS Laboratories. Initial black-and-white EVR players will be made next year by Motorola for educational use, with home color players scheduled in 1971.

The EVR entertainment cartridges are part of a service being offered by Motorola initially to hospitals and nursing homes for playing through their TV distribution systems. They include films on professional football, great prizefights, Laurel & Hardy classics, children's cartoons. In offering these enterment cartridge to hospitals (in additon to health films, such as "How to Stop Smoking"), Motorola reasons that bedridden patients are entitled to daytime visual entertainment other than the normal telecast fare of soap operas.

Even more significant, however, is the entry of Motorola—currently the exclusive U.S. producer of EVR—into the EVR software field. It could be that this is a test to prepare for the eventuality of a huge home market for entertainment and educational video recordings.

Brighter & costlier

Those new super-bright color tubes announced by almost all television manufacturers are going to be reflected in the cost of the sets they go into. Initial indications are that most or all of the manufacturers will compensate for the increased cost by raising prices of sets with the new tubes about $20. Some, however, will avoid an outright increase by using the new tubes only in yet-to-be-introduced models, rather than phasing them into existing models. Either way, the tubes cost more, and the buyer will pay more. R-E

(continued on page 12)

ELECTRON BEAMS REDUCE IC SIZE

PITTSBURGH—A new technique that uses electron beams instead of light to make integrated circuits can make possible "the next generation of miniaturized electronic circuitry," according to Westinghouse.

With the technique, some 4 million three-element electronic devices can be squeezed onto a postage stamp size area. A Westinghouse scientist said circuit components 100 times smaller than those available for large-scale integration IC's today will be possible.

To make the masks used to fabricate the LSI wafers, the drawings are digitized and put on magnetic tape. A computer then uses the information to control a scanning electron microscope, which traces an exact-size mask pattern into a sensitized metal plate. The stencil-like, light-sensitive masks are then placed one after another at the cathode of an image tube. When light is shined on the masks they eject electrons toward the anode of the tube. A sensitized silicon wafer at the anode records the pattern of each mask.

The photo shows a TV display of one of the masks used to form the LSI circuit on the wafer being held.

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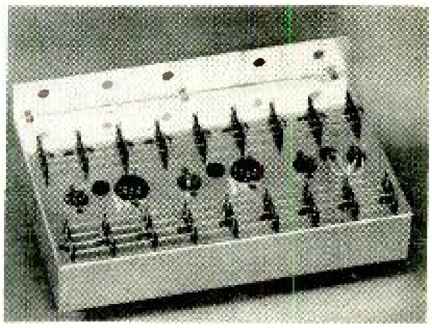
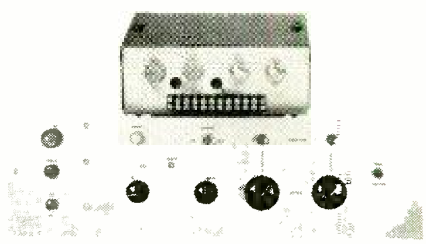
DEPARTMENTS

Got this on the screen? If the sync circuit uses a 6HS8, Kwik-Fix can be the solution. see page 52



Breadboards have changed. See how the new ones can help you set up trial circuits fast and easy. see page 62



Model Railroaders! Here's a throttle control that makes those model trains operate like the real ones. see page 42

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AUTOMATIC TINT CONTROL FOR COLOR TV

By ROBERT F. SCOTT

SENIOR TECHNICAL EDITOR

An innovation in some 1970 Magnavox color TV receivers is certain to make life simpler for the viewer and will, no doubt, accelerate the growth and popularity of color TV. This new development, called *automatic tint control* or *atc*, keeps flesh-tones relatively constant and eliminates the need to adjust the set's tint and color controls after program changes or when switching channels. It keeps flesh-tones just as you want them, even when the station switches cameras on live programs or switches to film or tape. For now, we'll take a look at the basic operation of automatic tint control operation and will leave a detailed circuit analysis for later.

Each color produced on a TV screen is the result of a definite phase difference between the 3.58-MHz burst and the 3.58-MHz sinewave chroma signal. The color wheel (below) shows that

when the burst is taken as a reference point, all colors lag the burst by varying degrees.

Fleshtones and all other impure colors are the mixture of the two pure colors (red-blue, blue-green or green-red) that lead and lag them in phase. Small phase errors occurring during the transmission of colors such as magenta and cyan are seldom detected or are not objectionable because these colors occupy relatively wide areas between red and blue and blue and green, respectively. Too, a viewer may not detect the error if the magenta coffee can he sees on the TV screen is a little too red or too blue.

On the other hand, the viewer likes fleshtones confined to a very narrow sector occupying a few degrees above and below 57 degrees. If the phase lag of the chroma signal is less than 57 degrees, the face takes on a greenish hue. A transmission error causing the 57-degree or "I" vector to shift toward 90 degrees produces red faces.

The Magnavox scheme, called *T*otal *A*utomatic *C*olor or TAC, is a combination of automatic fine tuning, automatic chroma control and automatic tint control. Aft and acc are needed for satisfactory operation of the atc circuit. A block diagram of the atc circuit is shown below. The chroma amplifier, red and yellow gates and the 3.58-MHz switch are transistors.

The output of the bandpass amplifier is tapped off the arm of the COLOR control and fed to the input of the chroma amplifier. It is also fed through a 3-position switch (FULL-PARTIAL-OFF) directly to the yellow gate and through a 90-degree phase-shift network to the red gate.

The red and yellow gates are set up somewhat like gated or keyed agc amplifiers with their emitters returned to ground through the collector-emitter circuit of the 3.58-MHz switch. The npn gates can conduct only when their bases are forward-biased by the positive portions of the chroma signal and only during the periods when the switch is closed (turned on) by the positive half-cycles of the 3.58-MHz reference signal from the color oscillator.

The reference signal has a phase of 90 degrees. The phase-shift network and PREFERENCE control can vary the phase of this reference signal fed to the 3.58-MHz switch. The normal phase for the sample or gating time is 13 degrees. The PREFERENCE control permits the gating time to be varied plus or minus 30 degrees. The precise setting of the control produces the desired fleshtones.

The "on" time of the gates is very short because the switch closes only on the positive peaks of the 3.58-MHz reference signal. Chroma signals between yellow and magenta are positive-going during the gating time and produce correction voltages at the gate outputs. Chroma signals such as blue, cyan and green are negative-going and cannot produce correction voltages.

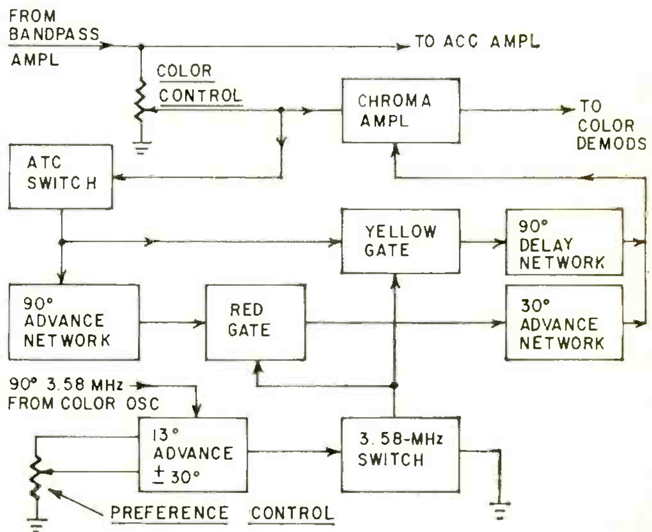
Maximum output is obtained from the yellow gate when a yellow chroma signal is fed to its input. The 13-degree yellow chroma signal is at its positive peak when the gate closes at 13 degrees. The yellow signal produces very little output from the red gate. When the red gate is keyed on at 13 degrees from the reference oscillator, the chroma signal—advanced 90 degrees to 283 degrees—is passing through zero and cannot forward-bias the keyer's base.

The red gate produces maximum output from a chroma signal of 103 degrees. This signal is advanced (moved back toward zero) 90 degrees to 13 degrees so it is at its peak when the gate is keyed on. The yellow gate produces little or no output at this time because it is passing through zero when the keying pulse hits its emitter.

The correction voltage from the yellow gate is delayed 90 degrees and the red-gate output is advanced 30 degrees before the two correction voltages are fed in parallel to the base of the chroma amplifier. Both signals are then inverted 180 degrees by the chroma amplifier.

The chroma signal from the color control is fed to the chroma amplifier emitter. The ultimate phase of the yellow correction voltage is 103 de-

(continued on page 41)



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PHONE LINES CARRY HIGH GRADE CCTV

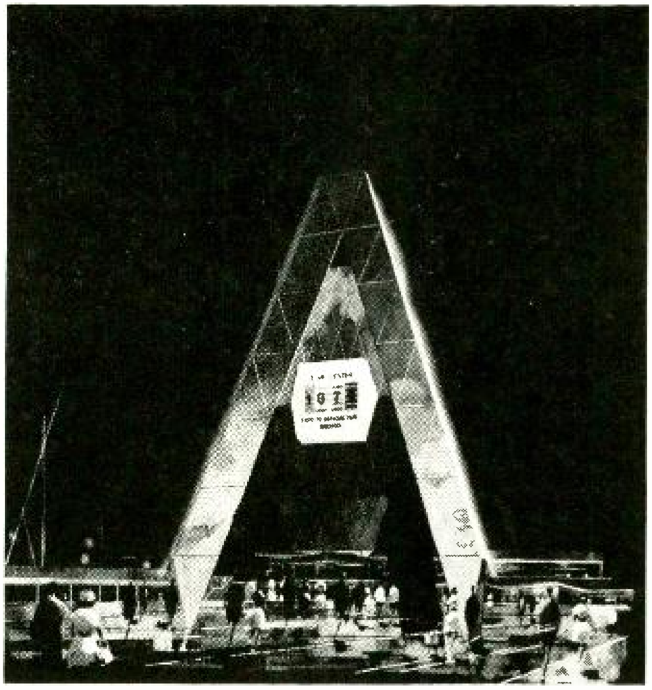
RIVER FOREST, ILL.—Closed circuit TV signals are being transmitted over a pair of 22-gage, voice-grade phones between a bank and police station in River Forest. Although the experimental security-monitor circuit is only 1000 feet long, according to a recent *Electronic News* report, tests by the Canadian Broadcasting Co. with similar equipment suggest quality (875-line) images can be sent 15,000 feet.

Costs with the CCTV system are only 5% of the customary coaxial cable system, according to Hiett Electronics, Inc., a US franchiser for West Germany's Grundig, who make the system.

A scramble/unscramble technique is used in which the camera signal is split and transmitted in two 180° out-of-phase halves. Grundig reportedly plans simultaneous voice transmission over a single pair and color TV capability over 22 wire pairs within a year.

Bell System's Picturephone service, now being put into operation, uses a 6-wire loop with amplifiers for two-way transmission.

ATOMIC CLOCK FOR EXPO '70



OSAKA, JAPAN—Visitors to Japan's world fair, Expo '70, will be sure of having the right time handy. Some 110 standard and digital clocks throughout the fairgrounds are being equipped with uhf receivers.

An atomic-regulated master clock installed in a time center (see drawing) will transmit super accurate time signals to the receivers operating with each clock.

The master clock uses a crystal oscillator system that is in turn regulated by an atomic frequency standard. The system is designed to vary in accuracy by only one or two seconds in several thousand years.

Seiko of Japan, a watch manufacturer and official time keeper for the world exposition, is preparing the system.

NEW X-RAY STANDARDS SET FOR COLOR TV

WASHINGTON—A gradual tightening of standards to cut X-ray emission from color TV was approved by a Department of Health, Education and Welfare technical committee in August.

According to the three-part proposal, by January 1970, sets must be built so that radiation does not exceed 0.5 milliroentgens per hour about 2 inches from any point when power supply voltages exceed normal levels. By June 1970, this 0.5 mR could not be exceeded even if viewers tried to readjust controls.

Finally, effective in 1971, the new rules call for limiting X-radiation to below the 0.5 mR level even if the set malfunctions.

SEMICONDUCTORS MAY BOOST REPAIR RATES

CHICAGO—The National Alliance of Television Electronics Service Assn. went on record against extended warranties again, and members were told solid-state components and warranties might require service rate increases to offset parts profits decline. **R-E**

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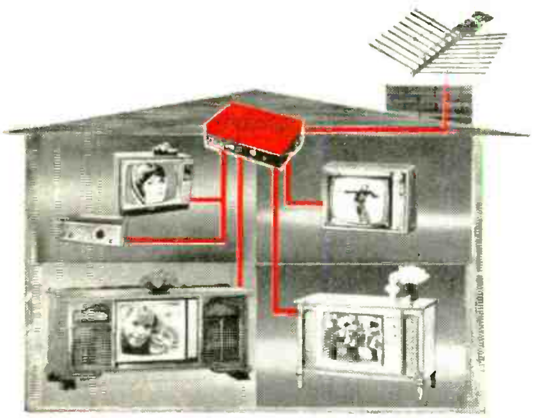

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LOOKING AHEAD

(continued from page 2)

Pictures from FM stations

The FCC has been asked to authorize tests of TV picture transmission from an FM station in a trial of a special educational service. The pictures would be sent by slow-scan techniques (no motion could be shown) on a 5-kHz subcarrier of a Flint, Mich., educational FM outlet. Other subcarriers of the same station would transmit audio educational material, while the main channel would carry the station's normal programming. Educasting Systems, Inc., which has requested the test, would supply specially modified television receivers for the TV-FM broadcasts. Pushbuttons on the receiver would permit students to answer questions asked by the instructor. The various subcarriers, selected by the pushbuttons, would tell students whether their replies were correct or incorrect, and why.

SCA receiver ban

The FCC, in a surprise action, has banned the sale of SCA (multiplex) receivers by a retail and mail-order chain to general consumers. Armed with a Justice Department opinion, the Commission obtained agreement by Lafayette Radio to stop selling radios designed to receive Subsidiary Communications background music subcarrier transmissions. The Justice Department said that unauthorized use of private transmissions was illegal when the listener derives a "gain" from it—the "gain" in this case presumably being enjoyment of music. Previous FCC advisory opinions had indicated that the Commission saw no law violation in consumer reception of SCA transmissions.

FM dominates radio

The dream that frequency modulation some day would be the dominant force in radio has finally been realized. For the first time in history, Americans are buying more FM-equipped than AM-only radios. In this year's second quarter, the crossover became apparent. Of 8.9 million table, clock and portable radios sold in the United States, 4.6 million (or 51.9%) had FM.

Thus the common garden variety home and portable radio has now joined the more sophisticated component tuner and the radio-phonograph or TV combination in converting to FM. The only radio field which is still a virtual AM monopoly is auto radio—but even this is gradually changing. In 1968, about 11% of car radios sold had FM. The share inched up to 13% in the first half of this year.

Government X-ray standards

Agreement has been reached between the government's Bureau of Radiological Health and a government-industry-public advisory committee on standards for radiation for color sets, involving a progressive tightening of permissible limits. As of next Jan. 1, no receiver may radiate more than 0.5 milliroentgens per hour (mR/hr.) as measured at 5 centimeters (about 2 inches) from any surface of the outside of the set with line voltage at130 and all user controls set for maximum radiation.

Beginning June 1, the same limits will apply, but with service controls set so as to produce maximum radiation. And, as of June 1, 1971, the 0.5-mR limit will be enforced with receivers doctored to simulate failure of components or circuits (shunt regulator, etc.) to increase radiation. Television set manufacturers, now concentrating on introducing such fail-safe components as solid-state high-voltage rectifiers, feel that they can meet this schedule.

The next X-ray standard to be propounded by the Bureau is expected to set limit on radiation of receivers during servicing, for the protection of technicians. **R-E**

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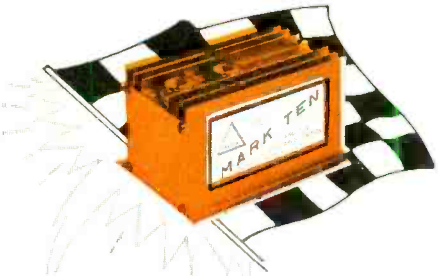

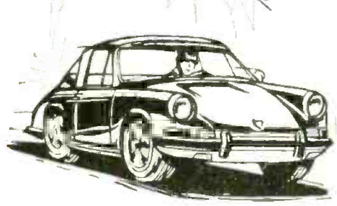

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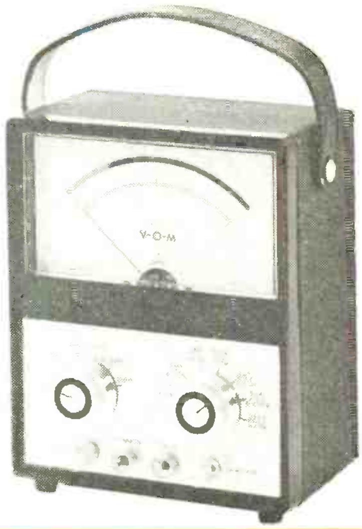

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Circle 14 on reader service card

In the Shop . . .With Jack

By JACK DARR
SERVICE EDITOR

TRANSISTOR TESTING: WHAT WITH?

ONE FELLOW SAYS "AN OHMMETER'S not worth a darn for transistor testing! I like a curve-tracer."

Another one says, "Nay, nay. In-circuit beta-tester is the only thing that'll give you good results!"

The truth of the matter is that almost *any kind* of test equipment will give you some results in transistor testing. It depends on how you use it and how you interpret the results. There's no such thing as a Universal Tester for solid-state stuff.

Plain old ohmmeter

The first and probably the most frequently used is the ohmmeter. You can get a lot of dope in a hurry with an ohmmeter. The No. 1 test is strictly a "bang-bang" check on any medium-resistance range. Take a reading from any element to any other; then reverse the prods. This reverses the polarity of the ohmmeter battery (Fig. 1). So you get a low resistance reading (forward-biased junction) one way, and a high-resistance reading (back-biased junction) the other.

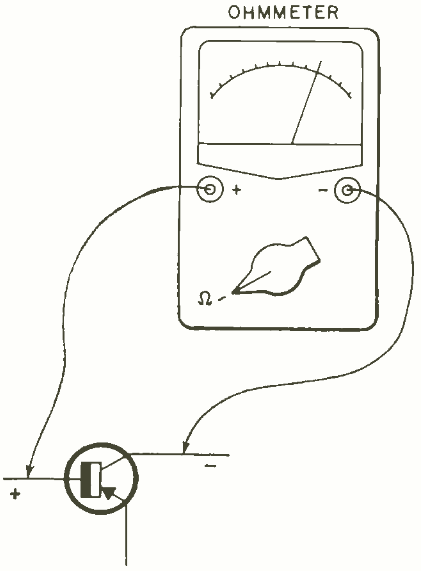
Due to the wide variation of transistor resistances, and the difference in ohmmeter battery voltages, there's no such thing as a standard resistance. So, all you need to look for is "High one way, Low the other." Very low or zero resistance both ways—it's shorted. OR! There is something shunted across it, in the circuitry under test.

Check the schematic, if available. If not, yank the transistor out and recheck. If you get this kind of reading out-of-circuit, *it IS shorted.*

Don't set the ohmmeter on too high a range. The X100 scale is a good compromise setting. On a batch of typical transistors, I got low readings from 1,000 ohms to 5,000 ohms, and 15,000 ohms up to 50-60,000 ohms on high. You hear repeated warnings about using an ohmmeter on transistors, for fear of blowing the transistor with the ohmmeter battery voltage. I won't say it can't happen, but it has never happened to me. Possibly the series resistance inside the ohmmeter limits the current to a very low value. It's *current* which blows transistors.

One thing you do need to know is the polarity of your ohmmeter battery. In many older vom's and some vtvm's, the red lead was always negative. Most late models have the red lead positive. If you know which is which, you can find out the sex of any transistor with a simple test.

Put the ohmmeter negative lead on the base. If this is a pnp device, you'll read a low resistance to both collector and emitter. Reversing the prods: high resistance to both. If it's an npn, putting the positive lead to the base will give you low resistance to collector and emitter. Reverse the prods; both high. You automatically check for internal shorts at the same time, of course.



Measuring leakage

Now comes the real bugaboo—leaky transistors. In germanium transistors, a small amount of leakage is OK. With silicons, so popular now in rf, i.f. and even af stages—none. Zero!

Leakage must be read with the transistor out-of-circuit and on an accurate leakage-tester. Any of the better modern in-circuit out-of-circuit transistor testers will read it.

Leakage problems show up in TV agc; agc-controlled i.f.'s; direct-

(continued on page 16)

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Circle 16 on reader service card

IN THE SHOP
(continued from page 14)

coupled audio amplifiers; rf amplifiers, and so on. Transistor bias is always critical, but there seem to be quite a few stages where it's super-critical. And if you think 10-mA leakage isn't a heck of a lot, put one with this much leakage into an agc stage and watch the fur fly!

Back to the good old days

You should never grab a transistor tester, ohmmeter or anything like that and jump in checking transistors at random. This is a waste of time. As far as I can see from quite a bit of bench-testing of test-methods, we're probably going to have to go back to signal tracing!

This started in the late 1930's. There were quite a few specialized test instruments built for just this purpose. In fact, if you happen to have an old Hickok Trace-Ometer or Meissner Analyst under your bench, blow the dust off it.

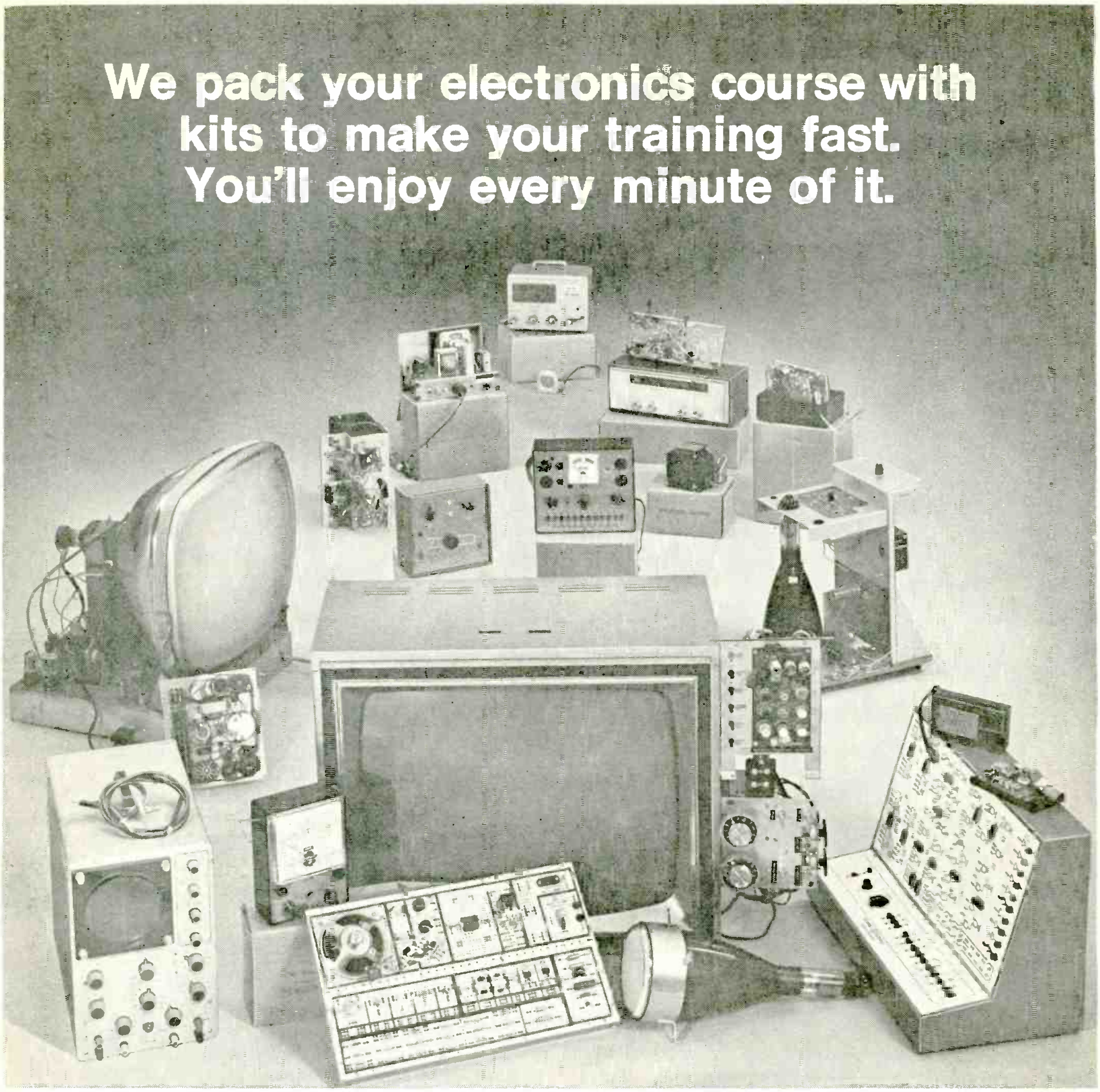
The idea of this is very simple. We need to know *where the signal stops*. That's where we start our testing. The part causing trouble is either in this stage or one of the stages which control it.

This brings up another highly useful instrument—the oscilloscope. Using it, and any kind of signal source—even a broadcast signal—you can get into the area of the trouble in far less time than with any other test instrument. You can feed any kind of identifiable signal into the input of the device and literally go "bang-bang-bang" through the circuit until you find the point where the signal stops.

Any kind of signal is useful. You can check out a video amplifier stage with a record player and an audio test-record if you want to.

One good quick-check for normal operation, very useful in places like transistor i.f. stages, and any stage using the popular common-emitter circuit, is the emitter *voltage*. There will almost always be an emitter resistor, and the voltage drop across this is a good clue.

If the emitter voltage is normal, the transistor is conducting normally. Zero emitter voltage means the transistor is either cut off or completely open. Abnormally high emitter voltage means the transistor is either conducting very heavily, or is shorted. Either one means trouble. *CAUTION: In stages where the bias varies quite a bit with an input signal, be sure to check the schematic to see exactly how this voltage is measured—with signal or no-signal. This can make a great difference in agc, i.f., sync or even audio stages.* **R-E**



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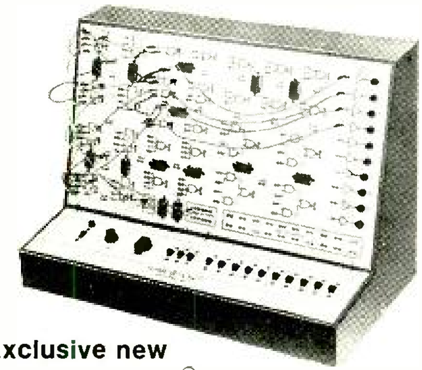

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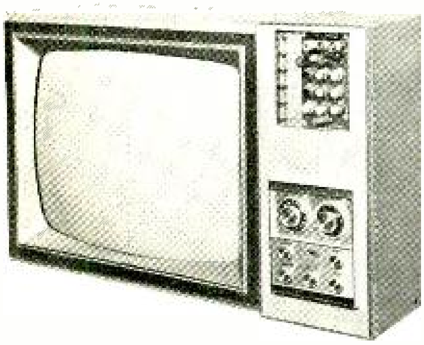

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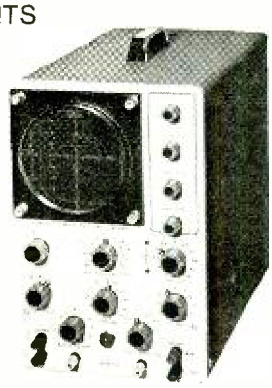

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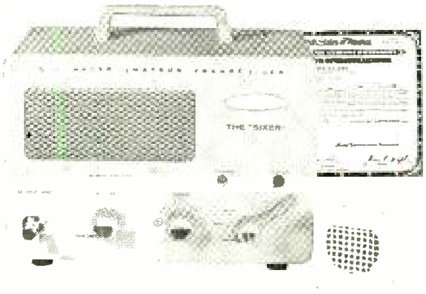

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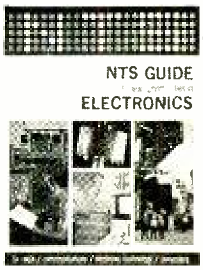

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Correspondence

REPAIR VS. DESIGN

In your August issue Jack Darr, in his "In The Shop . . . With Jack" article, indicates that technicians should be called "service engineers" because "they do engineering work." He goes on to describe the work of a TV repairman.

The author makes a big mistake in comparing the two professions. Nowhere in his article does he indicate that the repairman does any engineering work. Instead, he is busy comparing what he finds (trouble) with the indications he should find, and isolates the problem. This is not engineering.

The work of an engineer is to do the original circuit design. It is the engineer who tells the technician what the circuit should do in the first place.

If the technician feels that he has enough knowledge to design a TV set, let him do it and be titled "engineer." There is enough need in industry today for engineers that any qualified applicant will be accepted. But let those who repair and fix be called by the time-honored title, "technician." In this time when the title "engineer" is being abused by so many people, let those who should know better refrain from this practice.

JOHN PRITCHETT,
Electronic engineer,
Altec Lansing

WANTS MORE DARR

I've been reading Jack Darr's "In The Shop . . . With Jack" for several years, and think he does an excellent job of making difficult servicing problems easy to understand for beginners like myself. Does he have any books published, and could you give me all the titles?

N. VELEZ-CASANOVA
Mayaguez, P.R.

Mr. Darr begins his 10th year with us in January simplifying tough problems on a regular basis. Listing all his books, though, might take more room than we have here. Instead, for a starter, write: Howard W. Sams & Co., Inc., 4300 W. 62 St., Indianapolis, Ind. 46206; or, TAB Books, Blue Ridge Summit, Pa. 17214.

(continued on page 24)

smooth

RCA WP-700A, 702A, 703A and 704A constant voltage dc power supplies are all solid-state. A negative feedback circuit maintains constant output voltage with low ripple—regardless of varying line. In fact, at rated load, these supplies are so smooth that "they hardly cause a ripple."

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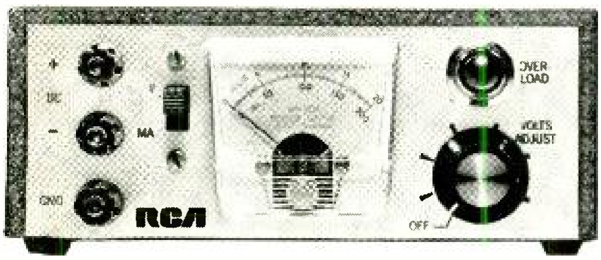
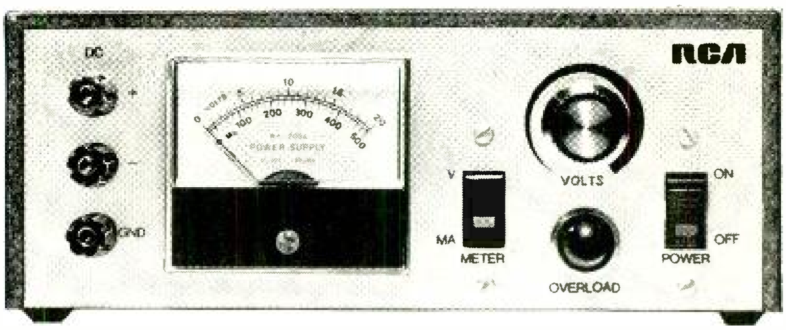
All four power supplies have built-in electronic short-circuit protection—and a front panel overload-indicator that signals approach to maximum rated current level.



WP-700A: $40.00* (five or more) $48.00* (less than five)



WP-703A: $49.00* (five or more) $58.00* (less than five)
WP-704A: $49.00* (five or more) $58.00* (less than five)

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RCA

Circle 22 on reader service card

CORRESPONDENCE
(continued from page 22)

DOUBTFUL DIGITS

Somehow I doubt if many of your readers will rush to construct that $250 IC digital clock described in your September issue. I would say that article is the zenith (or perhaps nadir) of expensive absurdity in construction articles. I just can't see the advantage of such a clock in view of the mechanical numeral clocks on the market that do the same thing for one-tenth the cost.

Surely a simpler and less expensive clock with numeral readout tubes could be constructed using inexpensive clock and timing motors driving low-friction rotary switches to activate the tube circuits.

KEN GREENBURG
Chicago, Ill.

We felt many of our readers would like to tackle such a project, Ken, so we asked for comments in an April 1969 article (page 23). Based on the hundreds of enthusiastic requests, we decided to run it. We'd still like to have other opinions.

There's no doubt about your second point, but we preferred an electronic to an electromechanical version—they're considerably more reliable.

TV CAMERA ERRORS

I discovered the following mistakes while going over the TV camera article in your July issue:

Resistor R52 is 222K in the parts list and 220K on the schematic. Isn't 220K the correct value?

The parts list indicates C39 as a 0.1 μF, 400V. It's marked 1000 μF on the schematic, which I believe circuit specifications call for. Right?

You have two C45's listed: one in the horizontal scan and one in the video amplifier. I discovered the horizontal scan C45 is in reality C43.

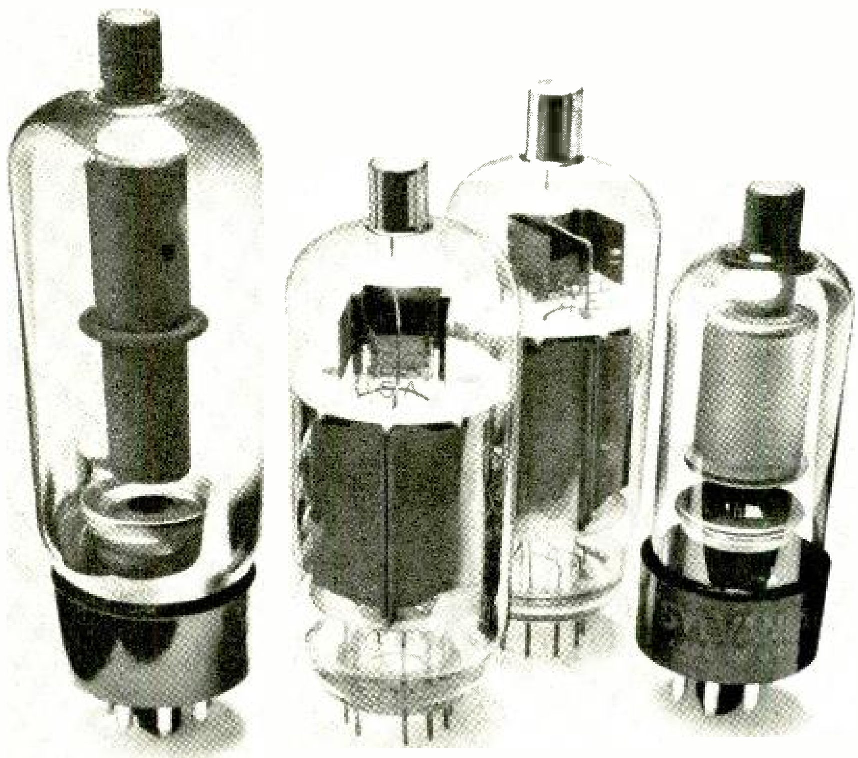
Incidently, I've found an old Army ammo can is perfect for the chassis. I was all set to suggest such a project, and I thank you for the opportunity to build such a camera.

FRANCIS E. FULLER
Fort Monmouth, N.J.

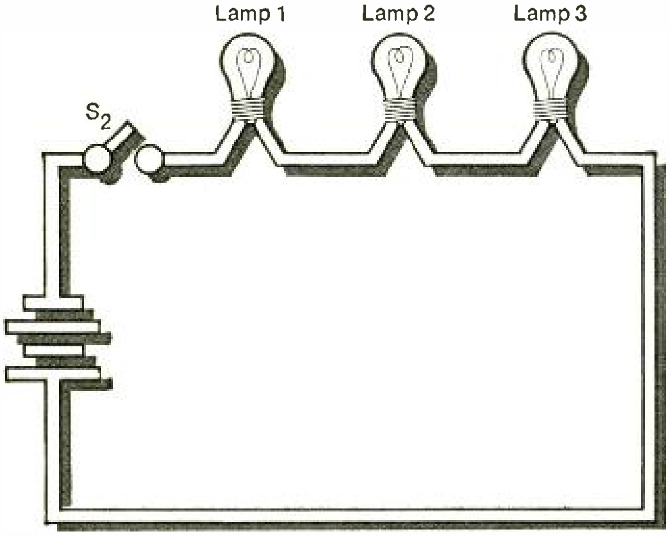
You're right on all counts, Francis. Also, there should be a dot indicating a connection between C30, C31, C29 and Q16's collector. **R-E**

NEXT MONTH

The new solid-state antenna rotators are described in November by R-E's technical editor. Find out how they work to help pull in better signals for TV.



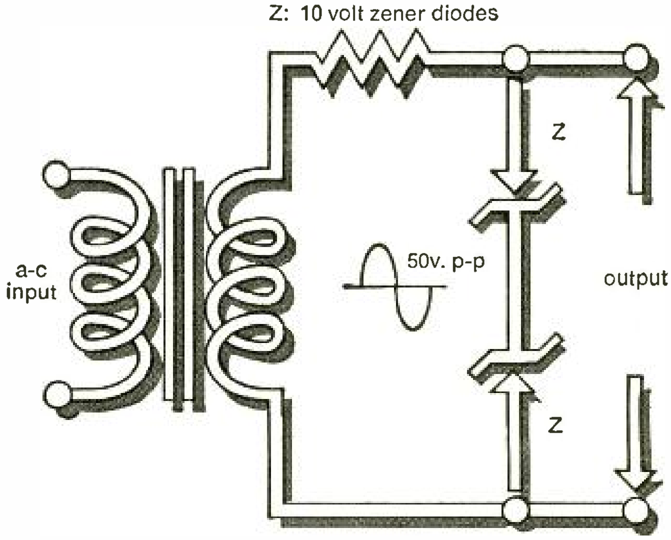
Can you solve these two basic problems in electronics?



This one is relatively simple:

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

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



This one's a little more difficult:

What is the output voltage (p–p)?

Note: If you had completed the first lesson in the new courses in Solid State Electronics, you could have easily solved this problem.

These new courses include the latest findings and techniques in this field. *Information you must have if you are to service today's expanding multitude of solid state instruments and devices used in Television, Digital, and Communications Equipment.*

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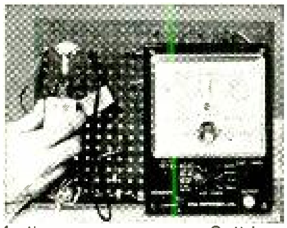

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MOSFET's

Part 1—What they are. How they work

By THOMAS R. HASKETT

IN A PREVIOUS ARTICLE ("THE JFET Story," RADIO-ELECTRONICS, May 1969) you learned how the junction field-effect transistor (JFET) works, and how to use it in circuits. Now you're going to find out about the other type of field-effect transistor—the MOSFET. (Its name will be explained later.)

As you know, the JFET has an input impedance much like that of a vacuum tube, and higher than that of an ordinary transistor. The MOSFET has an even higher impedance (10^9 ohms for the JFET, 10^{14} ohms for the MOSFET). Because it has such a very high impedance, the MOSFET also has very low input leakage. And it has a higher gain–bandwidth product than the JFET.

Of course, both MOSFET's and JFET's share certain advantages over other amplifying devices. As a dc amplifier, a FET has a zero temperature coefficient; it doesn't drift. As a general-purpose amplifier, it has the high power gain of a vacuum tube and less noise than either tube or transistor. As a vhf mixer, the FET has less noise and cross-modulation than either a tube or an ordinary transistor.

Other FET features: higher frequency response than most ordinary transistors; nearly constant current-output characteristic (flat drain-current/drain-voltage curve); almost completely unilateral gain function excellent input-output isolation.

Chief disadvantage of the MOSFET is that it's noisy at low frequencies. Thus it's poorly suited for a dc or audio preamp. Of course, like the JFET, the MOSFET cannot produce much power output.

Though expensive a few years ago, the MOSFET is now priced comparably to conventional transistors and vacuum tubes.

Depending on physical construction, an FET can operate in one of three ways—with reverse bias (or in the *depletion mode*, called *type A*), with zero bias (in the *depletion-enhancement mode*, called *type B*) and with forward bias (in the *enhancement mode*, called *type C*).

To refresh your memory, Fig. 1 shows an n-channel JFET, a type-A device. (Type-A devices are usually JFET's, although a few type-A MOSFET's have been made.) Two p-type junctions are diffused into the sides of a bar of n-type material. These junctions are connected internally to form the *gate*, while the ends of the bar form the *drain* and *source*. If a battery is connected to the JFET (positive terminal to the drain, negative terminal to the source) much current flows from source to drain (Fig. 1-a). Another battery connected with its negative terminal to the gate and its positive terminal to the source reverse-biases the gate. This bias voltage establishes electric fields or *depletion regions* around the gate junctions. The more negative the gate, the wider the depletion regions, and the less source-to-drain current flow (Fig. 1-b). When gate bias is great enough, drain current is almost completely pinched off or cut off. This value of gate bias is known as *pinch-off voltage*. It's obvious that gate bias controls drain current (Fig. 1-c). This is how an n-channel JFET operates. (A p-channel JFET is made of a bar of p-type material, with n gate junctions.

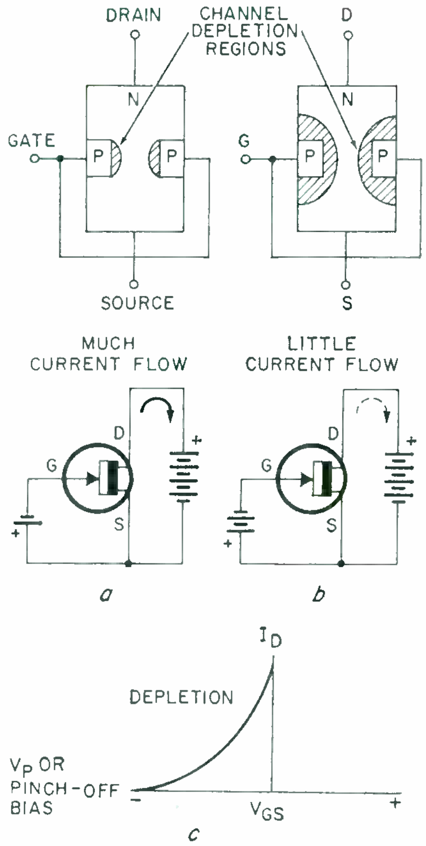
Now look at Fig. 2, which shows the operation of a type-B device. (Type-B devices are usually MOSFET's, since JFET's don't operate too well in this mode.) Two junctions of n-type semiconductor material are diffused into and near the ends of a bar of p-type material, forming drain and source terminals. (The p-type material is called the *substrate*, *body*, *bulk* or *base*, depending on manufacturer. It's merely used as a base for the other terminals. The substrate is usually connected to the source, either internally or externally.) Between the drain and source terminals is diffused a channel of n-type material. Above the channel is placed a layer of oxide insulating material, and atop this layer is deposited a thin strip of metal, forming the gate terminal.

From this construction comes the device name: *m*etal (gate electrode) *o*xide (insulator) *s*emiconductor (the bar of p-type material with n-type junctions) *f*ield-*e*ffect *t*ransistor, or MOSFET. Since the gate is insulated from the semiconductor (instead of being a junction, as in the JFET) the device is also called an *i*nsulated-*g*ate *f*ield-*e*ffect *t*ransistor, or IGFET. The oxide insulator is very thin and the gate and substrate act as the plates of a capacitor.

If the drain is made positive with respect to the source, current flows through the channel (Fig. 2-a). If the gate is biased negative with respect to the source, the channel is *depleted* by a field (Fig. 2-b) just as in the JFET.

Keep in mind that as long as the JFET gate junction is reverse-biased, its impedance is high—because it draws no current from the channel. Should the JFET gate become forward-biased (positive with respect to the source in an n-channel type), the gate junction draws current and its impedance goes down drastically.

Fig. 2-c shows what happens when the gate of a type-B MOSFET is forward-biased; the existing channel is *enhanced* by the gate field, and *more* current flows from source to drain. As Fig. 2-d shows, the type-B MOSFET can operate with both negative and positive gate bias without



Figs. 1-a, b—Increased bias in type-A JFET. c—Depletion region JFET operation.

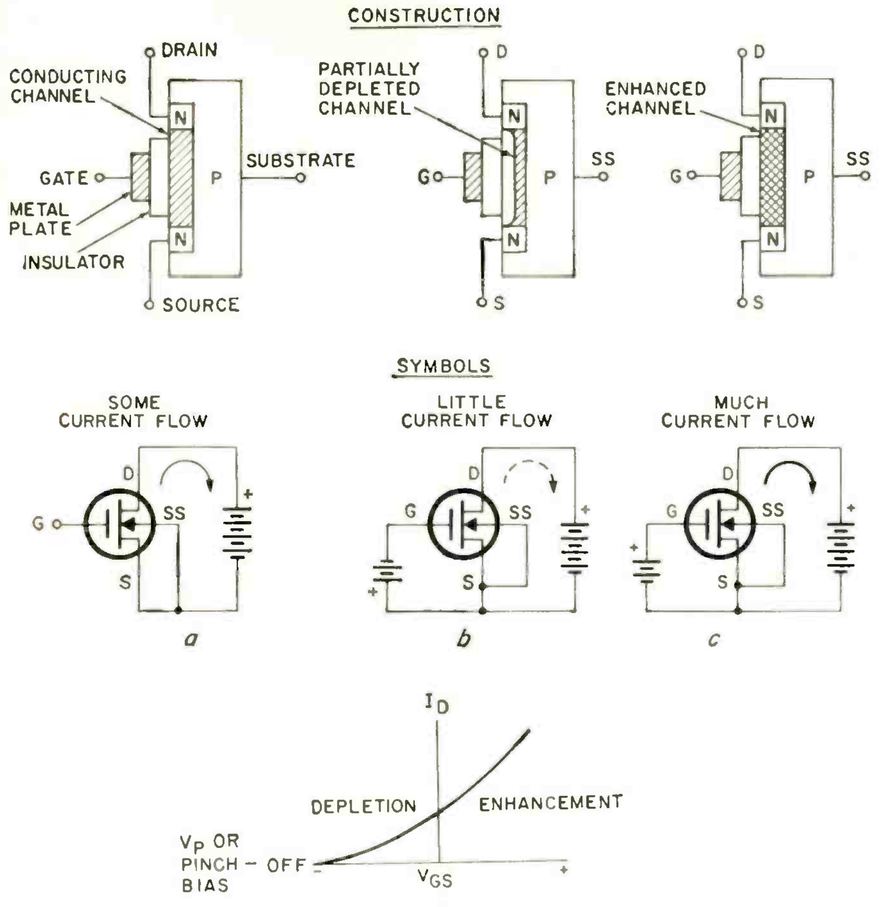
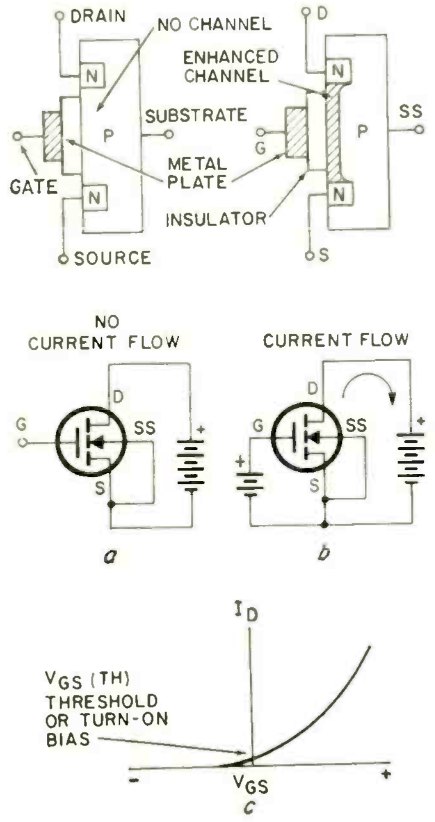


Fig. 2-a–d shows increasing gate bias in type-B MOSFET and its operating curve.

Fig. 3-a–d—Applying bias to type-C MOSFET and the enhancement mode curve.



drawing gate current. The device operates in both depletion and enhancement modes.

The type-B MOSFET, then, is a normally *on* device. It can be turned *off* by reverse gate bias, or channel depletion. It can also be turned *more on* by forward gate bias, or channel enhancement. A hybrid, the type-B MOSFET, acts like both a vacuum tube and a conventional transistor.

Fig. 2 shows the operation of an n-channel type-B MOSFET. Its substrate is p-type material and the channel, drain, and source terminals are n-type material. Type-B MOSFET's are also made in p-channel versions: all materials and supply voltages are of opposite polarities.

Type-C FET

In Fig. 3 you see the operation of a type-C device. (All type-C devices are MOSFET's.) Normally there is no channel between the drain and source terminals; make the drain positive with respect to the source (in the n-channel version shown) and no current flows (Fig. 3-a). Only when the gate is forward-biased (made positive with respect to the source, in this case) does current flow. A channel has been *enhanced*, or formed, by the action of the voltage field placed by the gate between drain and source. See Fig. 3-b.

As Fig. 3-c shows, the type-C MOSFET operates only when the gate is forward-biased; it's an enhancement-mode-only device. The type-C device, then, is normally *off* and must be turned on by forward bias or channel enhancement. In this respect, the type-C FET operates like a bipolar transistor.

Fig. 3 illustrates operation of an n-channel type-C FET. P-channel devices are also made, in which semiconductor materials and supply voltages are of opposite polarities.

Some MOSFET's are made with symmetrical geometry, as are most JFET's. Thus it makes no difference which end of the bar (or channel) you call the drain or source. Current flows in either direction. Fig. 4-a shows an alternate symbol for the symmetrical type-B MOSFET.

Many MOSFET's, however, are nonsymmetrical. In Figs. 4-b, c, and d you see alternate symbols for type-B nonsymmetrical MOSFET's. Note that in the symbol of Fig. 4-d the substrate is tied internally to the source. An alternate symbol for a nonsymmetrical type-C MOSFET is shown in Fig. 4-e.

All symbols in Fig. 4 represent n-channel devices. Since the symbols for FET's haven't yet been standardized, a few manufacturers show the arrowhead pointing the other way.

Bipolar and unipolar devices

Once again, to refresh your memory: Conventional transistors are now called *bipolars*, to distinguish them from FET's. A bipolar transistor uses both majority and minority carriers. In an npn version, for instance, electrons flow from emitter to collector and are the majority carriers. Holes flow the other way and are the minority carriers. In a pnp version, the opposite is true. Bipolars are also called *injection* transistors, because of electron-hole injection into the base.

The FET, on the other hand, is a *unipolar* device. It uses only majority carriers—electrons in the n-channel version, holes in the p-channel version. And because the gate of a MOSFET is insulated from the channel, neither holes nor electrons are injected into the channel.

Operating characteristics

In most respects, the MOSFET operates like the JFET. To illustrate, Fig. 5-a shows transfer characteristic curves (drain voltage vs drain current for various gate bias values) for a type-A MOSFET. As drain-to-source voltage is increased from zero, current flows through the channel. Channel current is approximately proportional to drain-source voltage—up to a point. This portion of the curve is known as the *ohmic region* because the channel resistance is varied linearly by the current flowing through it. It's also called the *triode region* because the curve looks like that of a triode tube. (Near the bottom of the ohmic region of the curve, channel resistance is several megohms in a typical MOSFET.)

At the knee of the curve the current has become so great that it sets up a reverse bias along the channel which acts the same as external gate bias—it depletes the channel. The curve flattens out because additional increase in drain-source voltage has little effect on drain current. (The channel resistance has decreased to about 1000 ohms.) Since this action resembles pinch-off voltage at the gate, this portion of the curve is known as the *pinch-off region*. The channel is saturated with current flow, so this part of the curve is also known as the *saturation region*. And since the curve is flat, like that of a pentode vacuum tube, this area is also called the *pentode region*.

By operating the MOSFET in the pinch-off region, with drain-source voltage between about 6 and 18 (referring to Fig. 5-a), small changes in gate voltage produce large changes in drain current. Thus the MOSFET is useful as an amplifier.

Beyond the pinch-off region is the *avalanche* or *breakdown region*. It's similar to the breakdown region in a bipolar transistor, and if total device power dissipation is not limited to a safe value, the MOSFET will be permanently damaged.

A simple amplifier stage is shown in Fig. 5-b to illustrate MOSFET operation. The device is an n-channel type A operating in the depletion mode as a common-source amplifier. Input signal is fed through coupling capacitor C_{c1} to the insulated gate, which is returned to ground through resistor R_G. This resistor is typically several megohms, depending on the desired input impedance. Drain-source current flowing through resistor R_S produces a voltage drop which provides sufficient negative bias at the gate to operate the MOSFET in the middle of the pinch-off region of its transfer curve. Bypass capacitor C_S allows R_S to act as a voltage dropper for dc but not for ac.

The substrate is connected to the source. It may also be grounded. (In some devices, it is internally connected to the source.) Drain–source current through load resistor R_D produces a voltage drop which is taken off through coupling capacitor C_{c2} and fed to the next stage.

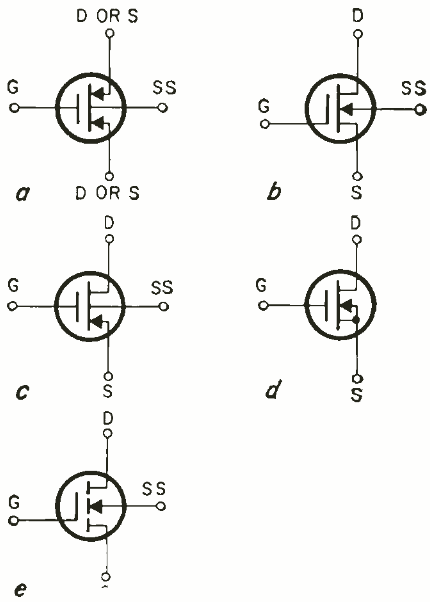
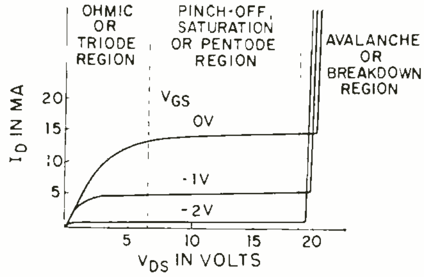
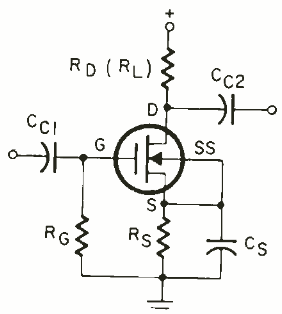


Fig. 4—Symbols used for MOSFET's. All devices shown are the n-channel type.



a

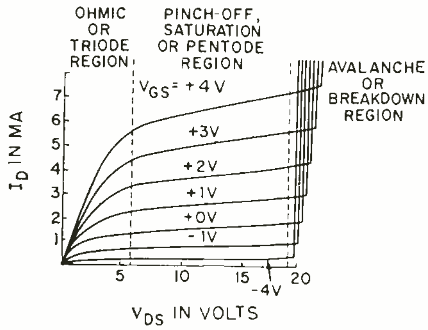


b

Fig. 5-a—Type-A MOSFET transfer curves. b—Typical common-source amplifier.

The MOSFET in Fig. 5-b is operating in the common-source (gate-drive) mode. This is similar to the bipolar common-emitter (base-drive) mode and the vacuum-tube common-cathode (grid-drive) modes. The MOSFET can also be operated in the common-gate (source-drive) mode, or the common-drain (source-follower) mode. And, of course, if the device were a p-channel type, supply-voltage polarity would be reversed.

The type-B MOSFET, you'll recall, operates in both depletion and enhancement modes. Fig. 6-a shows drain-current/drain-voltage curves for an n-channel version of this device. They are similar to the curves of Fig. 5-a, but notice that the gate varies



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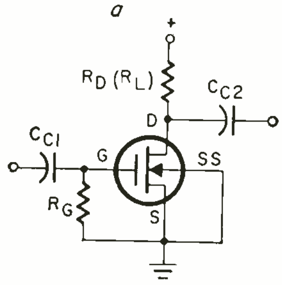

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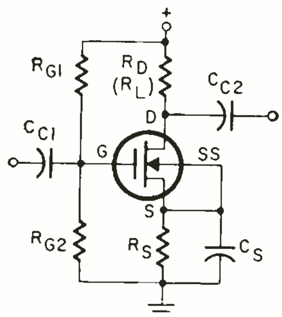
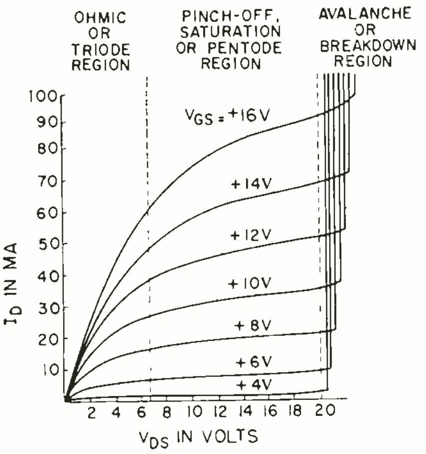


Fig. 6-a—Type-B MOSFET transfer curves. b, c—Zero bias and reverse-bias.



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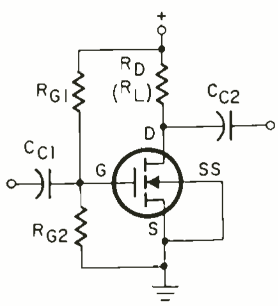


b

Fig. 7-a—Type-C MOSFET transfer curves. b—Common-source amplifier.

from negative to positive with respect to the source.

The circuits of two typical n-channel type-B MOSFET stages are shown in Figs. 6-b and c. At Fig. 6-b, the stage is operated with zero bias, so the source is grounded. Sometimes a very high value of R_G is used (22 megohms, for instance) and a certain amount of gate bias is developed therefrom.

Not all type-B MOSFET's operate well at zero bias, however. Many work best when reverse-biased, even though the input (ac) signal drives the gate positive on alternate half-cycles. Thus the circuit of Fig. 6-c shows several methods of such reverse bias. One system is self-bias furnished by source reistor R_S and bypass C_S, as in the type-A stage. Another system omits source components, using gate resistors R_{G1} and R_{G2} as a voltage divider across the supply. This is known as constant-current biasing, and useful because it allows the gate to go both positive and negative.

Even if zero bias is desired, the MOSFET gate must not be allowed to float—it *must* have a dc return to ground. Otherwise, the gate may build up a high potential from stray coupling. Such a high potential can puncture the insulator between gate and channel, destroying the device.

A p-channel stage, of course, would be the same except for supply-polarity reversal.

Curves for an n-channel type-C (enhancement-only) MOSFET are shown in Fig. 7-a; they look more like those of a bipolar transistor than of a vacuum tube. This is not surprising, as the enhancement-type MOSFET is normally *off* and must be turned *on*, just like a bipolar.

Typical biasing of a type-C MOSFET is shown in Fig. 7-b. Since only forward biasing is used, the source-resistor scheme cannot be used, and bias is usually obtained from a divider across the supply. Sometimes only a single resistor—R_{G1}—is used. A p-channel version would, of course, operate the same, but with reversed supply polarity.

In the previous article, differences between n- and p-channel JFET's were mentioned. These differences also apply to MOSFET's. The mobility of electrons, you will recall, is greater than that of holes. Since electrons are the majority carriers (which are all FET's use) in n-channel devices, they are better than their p-channel counterparts in several respects. N's have more gain (for a given input capacitance) than p's: they also have lower *on* resistance and lower noise figures.

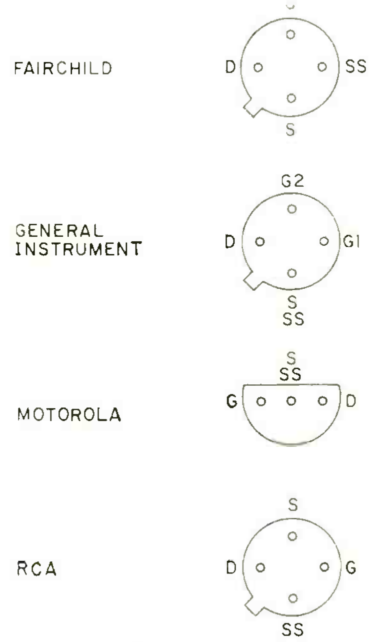


Fig. 8—Base terminals above for MOSFET's are the configurations used by some manufacturers.

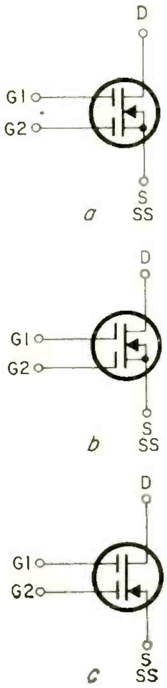


Fig. 9—Dual-gate or tetrode MOSFET symbols are illustrated on the left. All are type-B.

Dual-gate MOSFET's

You learned about dual-gate or tetrode JFET's in the previous article. MOSFET's are also available with two gates, and they are also useful as mixers, converters and in agc applications. Some are also used as stereo FM and color TV demodulators—and they would probably work well as product detectors in SSB receivers. Three symbols for dual-gate MOSFET's are shown in Fig. 9. All are nonsymmetrical type-B devices, and in each the substrate is connected internally to the source.

Handling precautions

Because the MOSFET gate has such high impedance, it's extremely sensitive to static voltages that may be discharged through it during handling and installation. The oxide insulator between gate and channel may easily be punctured by such a static voltage. It's common for the human body to build up a static charge of thousands of volts by walking across a rug, for instance. Though only a small current may flow when this charge is discharged to ground, the MOSFET's high impedance makes it so sensitive that the oxide insulator may be punctured. This causes permanent damage to the device.

To avoid damage to a MOSFET, you should observe three precautions while handling them.

1. Retain the shorting ring or wire around the MOSFET leads which is supplied with the device. If no shorting ring is supplied, the manufacturer usually tapes the leads together. Don't remove or unshort the leads until the device has been soldered or otherwise installed in a circuit. (I'll explain an exception to this rule later.)

2. Be sure the power is *off* before installing or replacing a MOSFET.

3. Ground yourself and the tip of the soldering iron or gun while soldering a MOSFET in a circuit. One way is to place the circuit on a grounded metal plate, and rest your elbows on that sheet during installation. Use a clip lead from the soldering tip to the sheet.

In an attempt to protect the gate from accidental static-voltage damage, some manufacturers fabricate MOSFET's with integral gate-protection networks. That covers the theory portion of this series. Next month we'll present some practical construction projects using low-cost MOSFET's, and show where the various types are best used.

(TO BE CONTINUED)

"I'm no engineer, but I think our physics department just lost a patent."

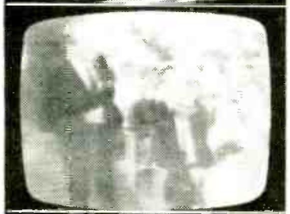
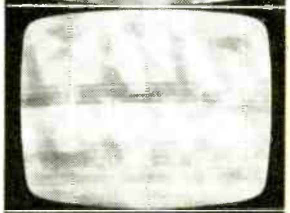
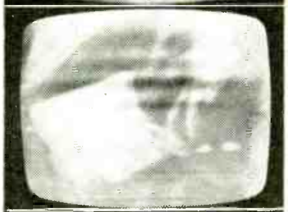
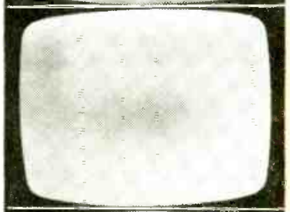
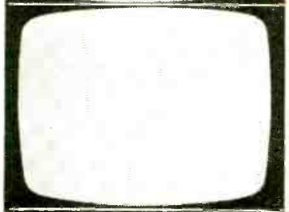
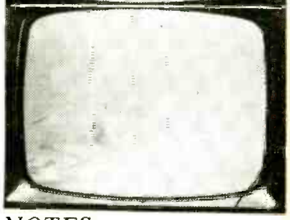
6HS8 noise-canceling sync/agc stage

agc section

NEW R-E EXCLUSIVE

Kwik-Fix™ picture and waveform charts

by Forest H. Belt & Associates*

SCREEN SYMPTOMS AS GUIDES		WHERE TO CHECK FIRST		
SYMPTOM PIC	DESCRIPTION	VOLTAGE	WAVEFORM	PART
	Agc overload, no sync, sound buzz	cathode-pin-1 screen-pin-2	WF1 WF2	R8 C5
	Weak picture, sync okay	G1-pin-7	WF2	R6 R7
	Weak picture, sync poor	G1-pin-7 plate-pin-3	WF1	C2
	Weak picture, bending and flagwaving	G3-pin-6	not much help	R1 R2
	Whiteout, sound remains	G1-pin-7	WF2	R7
	Whiteout, no sound	not much help	WF1 WF3	R4 and most others
	Agc overload, sync fairly normal, sound buzz	screen-pin-2 G3-pin-6	WF1	R2 R9 R10

NOTES:

Use this guide to help you find which key voltage or waveform to check first.

Study the screen and the action of the Agc and Noise Gate controls.

Most helpful clues to the fault are found at the key test points indicated.

Make voltage or waveform checks as indicated for screen symptoms.

Use the VOLTAGE GUIDE and WAVEFORM GUIDE to analyze results.

For a quick check, test or substitute the parts listed as the most likely cause of the symptoms.

THE CIRCUITS

THIS KEYED AGC STAGE IS POPULAR, ESPECIALLY IN color sets. Tube has special twin-pentode construction, with some elements common to both sides—cancels noise for both sync separation and automatic gain control action. This issue of *Kwick-Fix*™, number 6, covers keyed agc; next issue, number 7, covers other half of tube—sync separator.

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

SIGNAL BEHAVIOR

Video-and-sync signal from video amplifier is applied through compensating network R1-C1-R4 to agc grid (pin 6). Sync pulses in WF1, which are positive-going, exercise strong control over conduction in this section of tube, *when* tube can conduct. Thus, amplitude of WF1 sync pulses determines amount of conduction.

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

Meanwhile, high-amplitude keying pulse from flyback is applied to plate-pin-3 of tube through C3. Pulse is positive-going, acts as short-duration plate voltage for tube. Is large enough in value to make tube conduct, provided that, at same time, positive sync pulse in WF1 is present on grid-pin-6 *and* no noise in WF2 is cutting off tube at grid-pin-7. Amount of plate current is determined mainly by strength of positive-going sync pulse on grid-pin-6.

Noise or any other signal disturbance between sync pulses can't affect agc voltage developed, because keying assures no plate voltage except during retrace (and horizontal sync pulse) time.

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

DC DISTRIBUTION

Plate voltage for agc section of 6HS8 is pulse from flyback transformer (from horizontal output plate in some receivers). Exists only during sweep retrace in yoke. Result: tube acts as grid-controlled rectifier of keying pulse. Steady negative dc voltage develops on plate-pin-3, value controlled by amplitude of sync pulses in video-and-sync signal on grid-pin-6. Output decoupling network (not shown) distributes agc voltage to rf and i.f. stages, after filtering it. There, it controls gain, compensating for variations in signal strength.

Bias between cathode and grid 1 of tube is set by controls R7 and R8. Noise gate sets level of operation for G1. Control is set for dc voltage level just below tips of incoming sync pulses, so pulses won't quite overcome dc voltage. Agc control R8 adjusts cathode voltage—thus sets grid-cathode bias. Determines conduction for any particular amplitude of signal applied to grid 3 (pin 6). That, in turn, determines level of agc voltage.

Resistor R9 from cathode-pin-1 to plate-pin-3 applies slight positive bucking voltage to delay agc, and is input load for keying pulse. Constant screen voltage is applied from 250-volt line by R10.

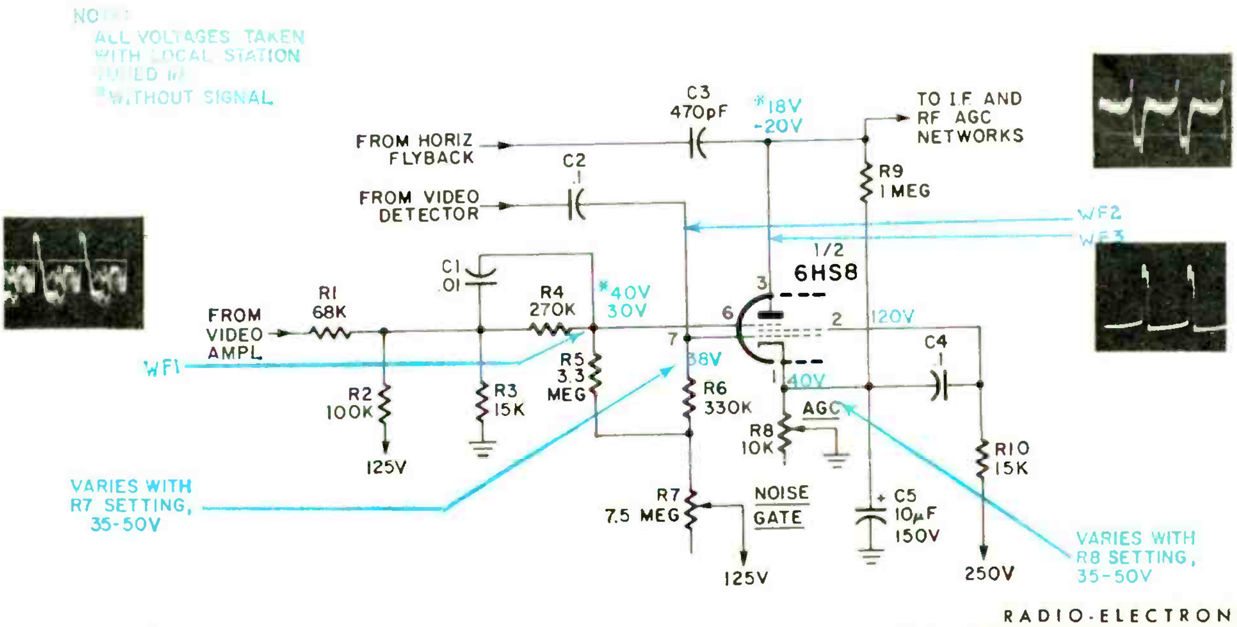
QUICK TROUBLESHOOTING

Overloading in i.f. and rf stages of receiver, caused by too much or too little agc voltage, can confuse troubleshooting attempts. Leaves no proper video to operate agc stage. First step, always, is to clamp agc at whatever value lets video through the screen.

Don't apply too much clamp voltage. Just clip variable dc bias supply to i.f. agc line and turn up voltage until picture is visible. May be out of sync, but that's okay. Leave agc and noise gate set at center of rotation.

Then, *with video on screen*, go ahead with waveform and dc voltage checks. Use scope first. Plenty of faults cause very little dc change, yet warp waveforms noticeably. Check output of video amplifier before analyzing WF1; it is source for that waveform. Likewise, check video detector output before condemning WF2. NOTE: If waveform display is shaky or jittery on scope, adjust receiver hold controls for as steady a TV picture as you can get.

Also, see next *Kwik-Fix*™, number 7, which is companion to this one—shows sync-separator side of stage. *(WAVEFORM CHARTS ON NEXT THREE PAGES)* **R-E**

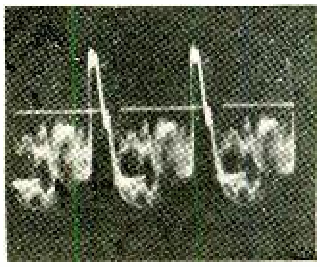


DC VOLTAGES AS GUIDES

Voltage change	to zero	very low	low	slightly low	slightly high	high
cathode-pin-1 Normal 40 V **Varies from 35 to 50 volts with setting of R8. Develops as result of average plate conduction in tube.**	R10 open C5 short	R7 open	R10 high C2 leaky C5 leaky		C2 open C4 leaky	R8 open R10 low C2 open
screen-pin-2 Normal 120 V **Is applied through R10 from 250-volt line.**	R10 open C4 shorted	C4 shorted C5 shorted	R10 high C4 leaky C5 leaky	C4 leaky	R6 open C2 open	R5 low R7 open R8 open R10 low C2 leaky
plate-pin-3 Normal −15 V to −30 V **Depends on how much video/sync reaches grid-pin-6. I-f agc line should be clamped for testing.**	R2 open R3 low R8 open [1] R9 low [1] R10 open R10 low [1] C3 open [1] C4 leaky	R1 open R2 open R3 low	R1 high	R7 open C2 open	R5 low R6 open	R2 low R3 open, high R10 high C2 leaky C5 leaky C5 shorted
G3-pin-6 Normal 30 V **Varies with amplitude of input video signal. Developed by grid-leak action across R5.**			R1 open R2 open R3 low R10 high C2 leaky C5 leaky	R6 open R7 open	R8 open C2 open	R2 low R3 open
G1-pin-7 Normal 38 V **Varies from 35 to 50 volts with setting of R7. Comes through R7 from 125-volt line.** [1] Voltage goes positive	R6 open R7 open R10 open	R6 high	R5 shorted R10 high C2 leaky C5 leaky	C2 open	C4 leaky	R8 open R10 open

NOTES:
Use this guide to help you pinpoint the faulty part.
BE VERY SURE to clamp i-f agc line as described in text; indications in this chart are valid only under those conditions.
Measure each of the five key voltages with a vtvm.
For each, move across to the column that describes the change you find.
Finally, notice which parts are repeated in the combination of changes you find.
Test those parts individually for the fault described.

WAVEFORMS AS GUIDES



WF1 Normal 15 V p-p

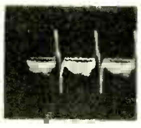
Taken at G3-pin-6, this is high-amplitude signal containing video and positive-going sync pulses. Has been amplified and inverted by video amplifier before being applied to input network R1-C1-R4. Effect of compensating network is to sharpen leading edges of video signal—result of frequency peaking. Amplitude of sync pulses is what determines how much dc agc voltage is developed at plate-pin-3 and fed to i.f. and rf stages of receiver.

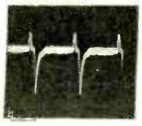
WAVEFORMS AS GUIDES

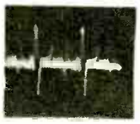
V p-p low	V p-p high	V p-p zero
R3 low C5 leaky	R1 open R1 high	R2 v. low C2 leaky

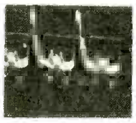

10 V p-p
R1 low

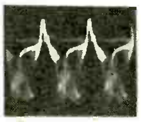

3 V p-p
R1 open

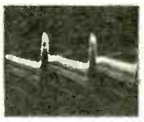

6 V p-p
R2 low

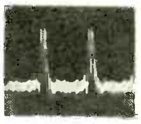

10 V p-p
R3 high

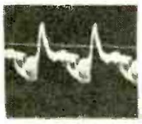

10 V p-p
R5 low

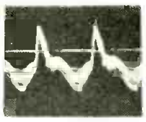

3.5 V p-p
R7 open

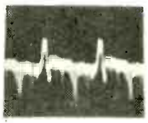

10 V p-p
R8 open


7 V p-p
C1 open

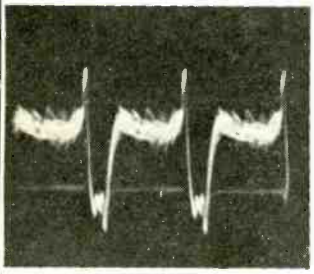

2 V p-p
C2 leaky


12 V p-p
C3 open


12 V p-p
C5 open


2 V p-p
C5 leaky

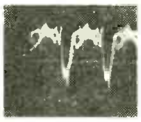

15 V p-p
C7 open

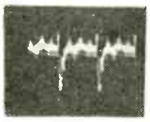


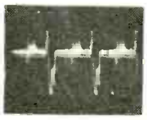
WF2 Normal 0.6 V p-p

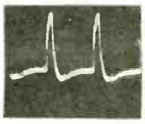
Taken at G1-pin-7, noise-canceling grid, this is video-and-sync signal directly from video detector. Sync pulses normally point negative. No compensating network at input, just dc-blocking capacitor C1. Note trailing edge is sharp, rather than leading edge as in WF1. This signal doesn't affect operation of tube much unless there is noise accompanying signal. In that case, noise pulse blocks conduction momentarily to keep noise from appearing in agc output (which is dc at plate-pin-3).

V p-p low	V p-p high	V p-p zero
R1 low R2 low C2 open	R8 open R9 low C4 leaky C5 open	C2 open


2 V p-p
R1 open

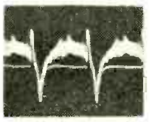

0.4 V p-p
R2 low


0.5 V p-p
R3 high

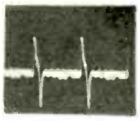

2.5 V p-p
R5 low

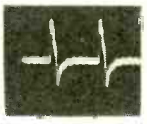

2 V p-p
R7 open


3 V p-p
R8 open


4 V p-p
R9 low


0.4 V p-p
R10 open


0.4 V p-p
C2 open


2 V p-p
C2 leaky


0.3 V p-p
C3 open

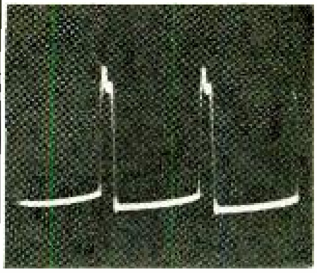

2 V p-p
C5 open


0.6 V p-p
C7 open


2 V p-p
C7 shorted

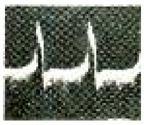
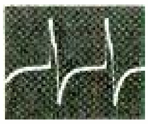

0.6 V p-p
C5 leaky

WAVEFORMS AS GUIDES



WF3 Normal 200 V p-p

Taken at plate-pin-3. Don't misconstrue this as output pulse, however. This waveform is high-amplitude, short-duration, positive plate voltage for tube. When this voltage is applied to plate at time that coincides with positive sync pulse at G3-pin-6, tube can conduct. If WF3 is missing or inverted, check wiring from C3 all way back to flyback transformer, or to whatever source supplies keying pulse.

V p-p low	V p-p high	V p-p zero		
C3 open		C3 open C9 short	 0.4 V p-p C3 open	 2 V p-p R9 low

NOTES:
Use this guide and the Voltages Guide *to help you pin down fault possibilities.*
ALWAYS clamp the i-f agc line at whatever voltage lets video reach the TV screen, even if sync remains poor. All waveform symptoms shown in this chart are taken under those conditions (see text).

With the direct *probe of the scope, check the three key waveforms. The scope should be set at H or about 5 kHz, to show three cycles of waveform.*
Note amplitude. If it's low or high, check parts under those descriptions.
Note waveshape. If there's a change from normal, check the parts indicated.

AUTOMATIC TINT CONTROL FOR COLOR TV

(continued from page 4)

grees at the chroma amplifier. The phase of the red correction voltage at this point is 343 degrees—leading the burst by 17 degrees.

When fleshtones shift from 57 degrees toward yellow, the correction signal produced at 103 degrees combines vectorially with the original chroma signal to produce a 57-degree resultant. (This assumes that the ATC switch is at FULL and the chroma error doesn't exceed 30 degrees.) When the fleshtone shifts toward red, the 343-degree correction signal adds to the chroma signal to produce a 57-degree resultant signal.

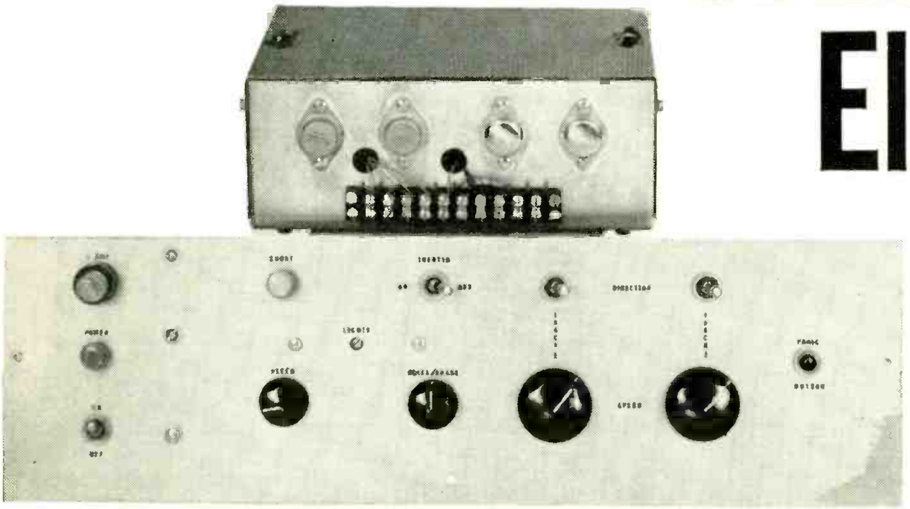
When the ATC switch is set at FULL, all colors between a yellowish-orange and a bright red are combined to produce a 57-degree orange in the fleshtone orange. Thus, a vectorscope pattern of a modulated color bar will show variations in the area between zero and 90 degrees, depending on the position of the ATC switch. When it is OFF, pulses representing ten color bars will appear 30 degrees apart; starting from the burst at zero degrees.

The first petal or pulse represents the yellowish-orange bar at 30 degrees; the second represents the orange bar at 60 degrees and the third is a bright red bar at 90 degrees. When the switch is in the PARTIAL position, the 90-degree pulse moves counterclockwise to around 78 degrees and the 30-degree pulse moves clockwise to about 45 degrees. Throwing the switch to FULL, causes the first three petals to overlap at 57 degrees and the fourth petal moves around to about 87 degrees. Thus, with full atc correction, all colors transmitted with phase angles between 30 and 90 degrees will reproduce as 57 degree fleshtones. Naturally, this correction causes shifts in some background colors between yellowish-orange and red but, generally, this is not as easy to detect nor as annoying to the viewer as an equal phase error in fleshtones without atc correction.

(A few weeks with the Magnavox T940 chassis with atc proved that automatic tint control does have disadvantages under some conditions. One evening my wife called to me, "Come and see the invisible singer on TV." All I could see was an almost solid orange screen with a pair of eyes, lips, the faint outline of a nose, gloved hands and shoes. My heart kicked up as it occurred to me that the picture tube had failed. When I regained my composure, I flipped the atc switch from FULL to OFF. Now, we could see a beautiful honey blonde in a light orange dress against an orange-red background. The atc circuit had converted nearly all colors in the scene to fleshtone-orange so the gal was nearly invisible.) **R-E**

OH-OH

FOR MODEL RR Electronic Throttle



Solid-state features include dual variable-speed and inertia controls, automatic-latching tripout and panic button

by HENRY J. MIERLAK

MODEL RAILROADING RECEIVED A mild "shot in the arm" with the introduction of N gauge. About half the size of the popular HO gauge, complex N-gauge layouts occupy much less space than any other gauge model railroad. But complex layouts (anything greater than a single-track circuit) fall flat in performance and enjoyment unless versatile control of train traffic can be achieved.

The dual throttle unit described here will give the hobbyist stability and versatility for a two-circuit layout with these features:

- Two 0–14-volt variable-speed outputs regulated up to 1 amp each.
- Ac accessory output (20 volts).
- Variable dc output for lighting.
- Variable inertia control. Trains accelerate and brake at a selectable rate.
- Automatic-latching tripout with indicator to remove all track circuit power when an overload occurs.
- Panic button to stop all track action in case of a collision course requiring quick action.

If some of the features are not desirable, a simpler and more economical throttle can be built. Simplifying the throttle unit will be described later and is accomplished by deleting sections of the unit. Before we start drilling and soldering, let's look at the circuit of the electronic throttle by sections (see Fig. 1).

Power-supply section

Transformer T1 supplies two rectifier systems: one full-wave for the track circuits and one half-wave for the lighting circuit. The full-wave dc line has a 750-μF filter (C1 and C2) as the minimum value for good speed regulation and stable operation of the tripout circuit. The lighting circuit receives unfiltered half-wave dc since regulation is not required here. The pilot light and ac accessory outputs are tapped from a 20-volt side of the transformer secondary.

The filtered dc line is fed to two series-control transistors (Q5 and Q8) through the tripout relay contacts, and to the reference-voltage source (D4 and Q2). Darlington amplifiers permit use of low values of control current from the control section.

Control section

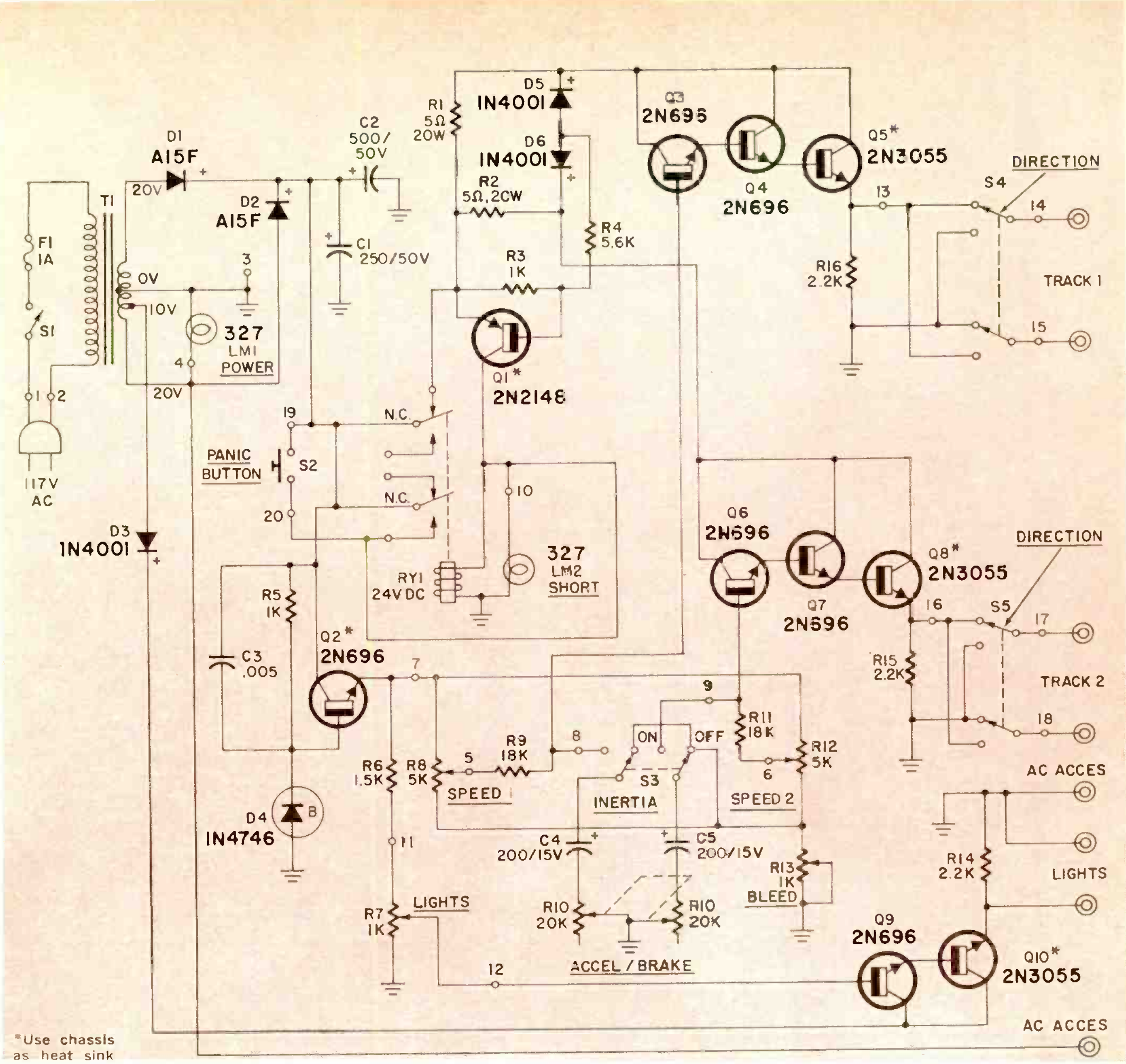
Zener diode D4 and R5 hold Q2's emitter at 17 volts, and Q2 offers isolation and current gain between this Zener and the control transistors. Capacitor C3 is used for RFI (rf interference) suppression. Transistors Q9 and Q10 are controlled directly from the wiper of R7. The lighting output voltage is about 1½ volts less than the wiper arm value of R7 due to base–emitter voltage drops. Up to ten 6-volt miniature lamps can be used to light up your model railroad layout.

Track circuits 1 and 2 are identical, so only the description of track 1's circuit is necessary. When S3 is in its shown position (INERTIA OFF), Q3's base is tied to the reference voltage source through R9. The track voltage is determined by the settings of R8 and R13, and it follows the speed control position as in any conventional throttle unit. When S3 is in the INERTIA ON position, R8, R9, R10 and C4 set up an RC delay for any change in R8's wiper position, thus the inertia or delayed-action effect. Pot R10 has a delay range of about 7 to 30 seconds for completion of the train's gradual response to the resetting of R8.

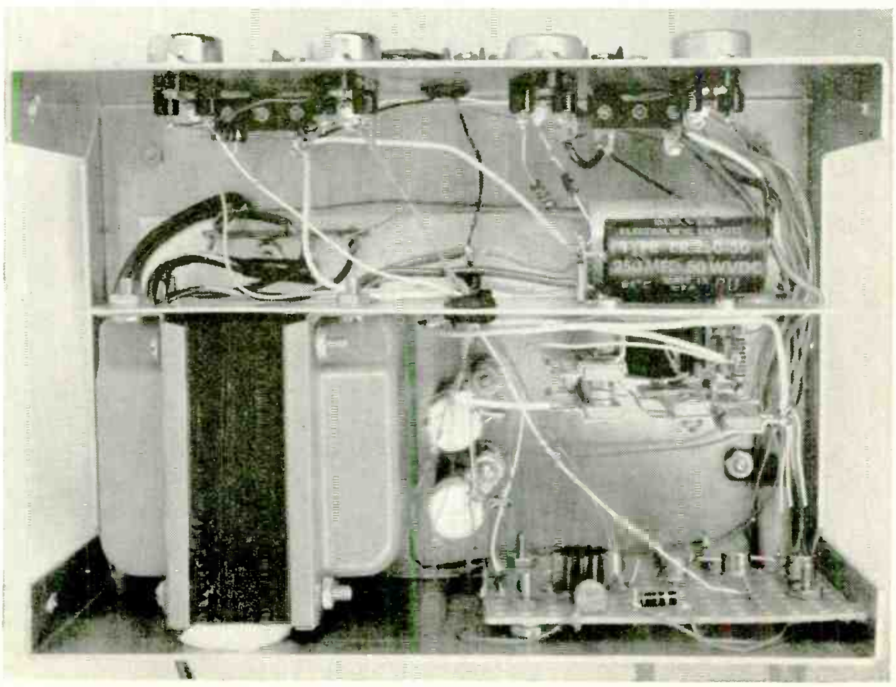
Bleed pot R13 maintains a dc potential on the tracks, and is set to the point where the engine(s) is just about to move. This gives the speed pots control over the full range of rotation, and train movement therefore begins during the first few degrees of rotation of the speed pots.

Tripout section

This section offers protection for the unit and warns of trouble on the tracks. When either track circuit draws more than 1 amp for any reason, the relay (RY1) activates and removes all dc from the two series pass transistors (Q5 and Q8). Relay RY1 is latched through its contacts;



Use Fig. 1 above to wire an electronic throttle like the author's or any of the variations described in the text. Numbered circles above are connections to a control panel. Photo shows U-chassis and L subchassis used in this version.



PARTS LIST

Capacitors
C1—250-μF, 50V, electrolytic
C2—500-μF, 50V, electrolytic
C3—0.005-μF, 100V ceramic or mylar
C4, C5—200-μF, 15V, electrolytic

All resistors 10% or better
R1, R2—5-ohm, 20-watt wirewound
R3, R5—1000-ohm, ½W
R4—5600-ohm, ½W
R6—1500-ohm, ½W
R7, R13—1000-ohm, 2 or 4-watt, linear wire-wound potentiometer
R8, R12—5000-ohm, 2 or 4-watt, linear wire-wound potentiometer
R9, R11—18,000-ohm, ½W
R10—20,000-ohm, dual linear poteniometer
R14, R15, R16—2200-ohm, ½W

Semiconductors
D1, D2—50 PIV, 3A, silicon diode (G.E. A15F or equal)
D3, D5, D6—50 PIV, 1A, silicon diode (1N-4001 or equal)
D4—18-volt, 1-watt, 10% Zener diode (1N4746 or equal)
Q1—2N2148 transistor
Q2, Q3, Q4, Q6, Q7, Q9—2N696 transistor
Q5, Q8, Q10—2N3055 transistor

Other parts
T1—40-volt center tapped with 10-volt tap power transformer (Triad types F-92A or R-204A)
RY1—24-volt, dpdt-contact relay (P&B type KA11DY or equal)
S1—spst toggle switch
S2—momentary-contact pushbutton switch
S3, S4, S5—dpdt toggle switch
MISC—prepunched board, terminal strip, T05 clip-on heat sink, knobs, cable, chassis

the ac power switch must be switched off and back on to unlatch it. When pressed, PANIC BUTTON S2 simply activates RY1. Transistor Q1 is normally off and R3 and R4 are selected to turn Q1 and RY1 on when either R1 or R2 drops 5 volts or more due to currents of 1 amp or greater. Lamp LM2 visually indicates the overload or short condition of the tracks.

Construction tips

Use whatever component layout your railroad calls for. I housed the controls and switches on a panel and the remaining components in a deep U chassis. A 20-conductor cable was used between the panel and chassis. Numbered circles on the conductors in Fig. 1 show where I used a cable between the two subassemblies. All small components (except C3 and C4) were mounted in the chassis. Parts T1, RY1, D1 and D2 are mounted on an L subchassis. A screw-type barrier strip was used for the output terminals. Transistors Q1, Q5, Q8 and Q10 are TO3-style devices, and since their maximum dissipation ratings far exceed circuit dissipations, the chassis was used as a suitable heat sink. Use silicone compound and a chassis 1/16 inch or thicker. Dry transfer letters were used for labeling the functions and a brush coating of clear nailpolish protects the labels.

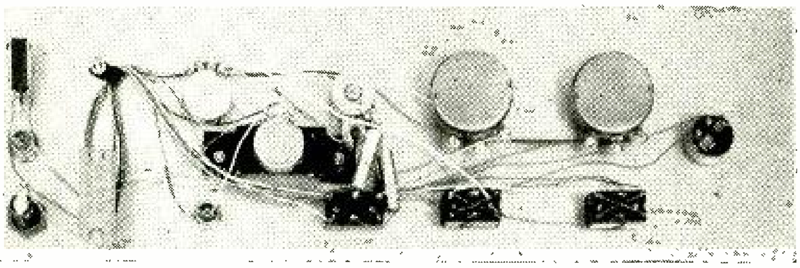
Design considerations

Wirewound controls should be used for R7, R8, R12 and R13, and 2N3055's should be used for Q5, Q8 and Q10. The rest of the components are not critical and appropriate substitutions can be made. Component layout is not critical, and the aluminum-plate heat sink for the four power transistors should be at least 8x4x1/16 inches. A chassis side may be used for heat sinking. A push-on heat radiator for Q2 is required.

If regulation of the lighting output is desired, add a 500-μF, 25-V electrolytic capacitor between Q10's collector and ground. If an adjustable tripout is desired, add a 5000-ohm pot between R3 and R4 and connect the wiper to Q1's base. Also change R4 to a 1000-ohm resistor. You can then set the tripout point to your needs. Delay time of the inertia feature can be increased or decreased by changing the values of C4 and C5.

By deleting portions of the unit, a simpler and cheaper throttle unit can be built. If the panic button and tripout feature are not desired, RY1, LM2, S2, Q1, R1, R2, R3, R4, D5 and D6 can be deleted. Just return the collectors of Q2, Q5 and Q8 to the positive ends of C1 and C2. To eliminate the inertia features, omit R9, R10, R11, C4, C5 and S3. Connect R8's wiper directly to Q3's base, and R12's wiper to Q6's base. To omit the lighting circuit, remove D3, R6, R7, R14, Q9 and Q10. A tapped transformer would not be a requirement for the unit now. **R-E**

Behind author's control panel. A 20-conductor cable ties controls to the chassis.



TOOLS FOR ELECTRONICS

by TOM HASKETT

Hand tools are vital to working in electronics. In the past two months we have presented a complete picture of how and when to use what kind of pliers. This month we continue our series with a complete rundown on screwdrivers. In the months to come many other kinds of tools, including wrenches, screwdrivers, alignment tool, power tools, etc. Each section will become a handy, practical addition to your R-E Reference Manual.

For those of you who have vainly tried to assemble the first two installments of this series, we offer our apologies. Our printer, in both issues, carefully turned the backup pages upside down, making this an impossible task. As soon as we have ironed out a method for providing you with corrected pages we'll let you know.

MAKE AN R-E REFERENCE MANUAL

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

SCREWDRIVERS

IF YOU WORK OR PLAY IN ELECTRONICS, YOU PROBABLY HAVE TO turn screws many times each day. The screwdrivers you use are designed to handle only a few sizes of screws, and therefore you can't get by with merely a couple of drivers; you have to have an assortment on hand. As with other tools, specialized drivers permit precise, safe and more efficient work. This article will describe the many kinds of screwdrivers available today, and how they can make your job easier and speed up your work.

The basic screwdriver

Probably no tool is more used and misused than the common screwdriver. As shown in Fig. 1, it's a simple tool, consisting of three parts—the **tip** (also known as the **bit** or **point**), the **blade** (also called **shank** or **shaft**) and the **handle.** A screwdriver is used to apply torque to a relatively small area—the head of a screw.

The common screwdriver has a thin steel blade anchored in a larger handle. The blade is forged from tool steel or other tough, resilient metal, which is then tempered. The tip is flat, hot-forged to size and heat-treated. The handle is made of wood or plastic, often fluted or ridged for a good grip. The blade is anchored in the handle by two or more tongs or wings on the end of the blade, which prevent the blade from turning in the handle.

Driver tips and screwheads

There are at least seven different kinds of screwheads and driver tips. Each of these screws and drivers comes in several sizes. To drive a screw properly, you must match the driver tip to the screwhead.

The most common type of screw has a **slotted head,** and two types

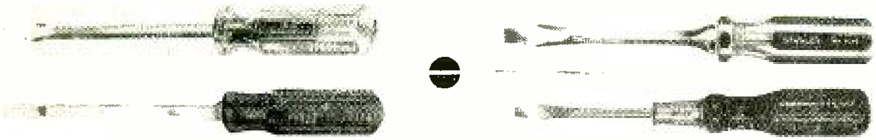


Fig. 1—Four standard slotted-head type screwdrivers. Top left, is Upson GC. Top right is Stanley 1006, bottom left Xcelite R5166. Bottom right, Crescent 94.

of driver tips are made to turn it. The **keystone** bit shown in Fig. 1 is most common and simple to make, but has the disadvantage that you

electronics, and requires its own driver, shown in Fig. 5. The recess in the screw head looks somewhat like a figure "8." The driver, known as a **Type G clutch head,** is made in six tip sizes: 3/32 inch, 1/8 inch, 5/32 inch, 3/16 inch, 1/4 inch, and 5/16 inch.

Developed in Canada, **Scrulox** (or **Robertson)** screws are making

Fig. 5—G-type clutch-head is still another tip style. This time only two such screwdrivers are shown. Left; Xcelite 3164; right, Owatonna CH 6.

their way into the US, and require a square-tipped driver (Fig. 6). Drivers are available with five tip sizes, from No. 00 to No. 3.

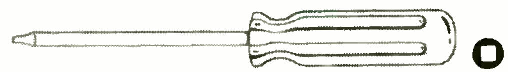


Fig. 6—Square-tipped screwdriver comes in five tip sizes. Unit shown here is Vaco driver model R10.

Two kinds of hexagonal recessed screwheads are in common use in electronics—often as control-knob setscrews. The **Allen head** is a

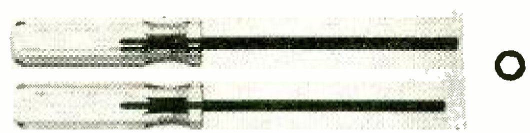


Fig. 7—Hexagon recessed screwheads require still another type driver. Here are two sizes, both by Proto. Model 6589 (top) and 6588 (bottom).

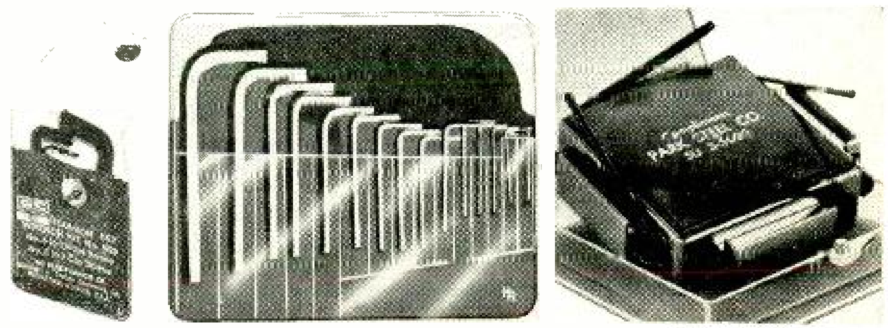


Fig. 8—Allen-head wrenches take all shapes and sizes. Three different sets are illustrated. Left, G-C 5029; center, Peer 41-565; right, Shelton 8-way.

can't work it into a recessed hole. The **cabinet** tip (Fig. 2) is straight-sided and far more useful, since no part of the blade is wider than the

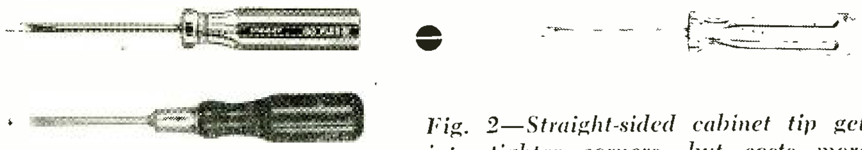


Fig. 2—Straight-sided cabinet tip gets into tighter corners, but costs more. Top left, Stanley 1016; top right, Vaco A316-6; bottom left; Crescent 9.

tip, permitting you to work recessed screws. A keystone-tip driver is often called a **mechanic's** screwdriver; the type with a cabinet tip is often called an **electrician's** screwdriver.

Two kinds of cross-slot screw heads are in general use. More common is the **Phillips** (Fig. 3), which is sometimes called a **U slot.** Phillips

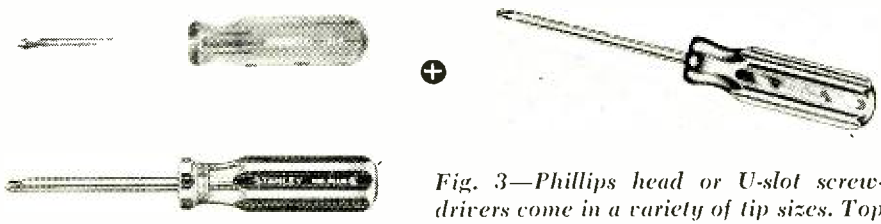


Fig. 3—Phillips head or U-slot screwdrivers come in a variety of tip sizes. Top left; Channellock 102-P; Top right, Xcelite RP 102; bottom left, Stanley 2912.

screwdrivers are made in five tip sizes, from No. 0 to No. 4, to fit the various sizes of screws.

The other type of cross-slot screw is called **Reed & Prince** or **Frearson,** and has a head with a **V slot,** different from the Phillips U slot (see Fig. 4) R&P drivers are made with tip sizes from No. 1 through No. 4. You cannot use a Phillips driver on an R&P screw, or vice versa.

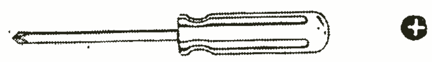


Fig. 4—Clutch-head or V-slot looks like a Phillips but isn't. Tool at the left is the Vaco model F-710 screwdriver.

The **clutch head** (or **butterfly**) screw is becoming more common in

hexagonal flat-sided recessed type, which can be turned with **Allen drivers** (Fig. 7) or **L-angle Allen wrenches** (Fig. 8). A unique variation is Hunter's **T-handle Allen driver** (Fig. 9), which is available in several sizes. Most Allen drivers and wrenches are available in kits which cover the most common screw sizes.

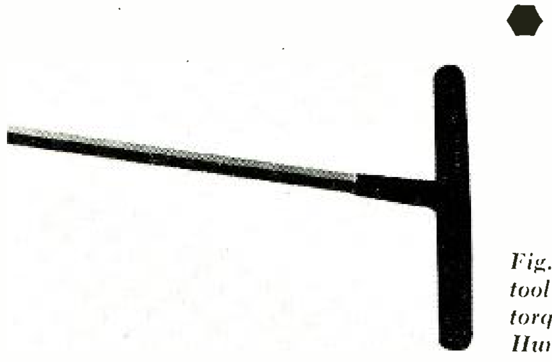


Fig. 9—T-handle Allen driver is a tool that provides high starting torque when required. It's made by Hunter as their model 3TH6.

The other kind of hexagonal recessed screwhead is called **Bristo spline.** You can turn it with **Bristo drivers** (Fig. 10) or **L-angle wrenches** (Fig. 11). Both are available in kits.

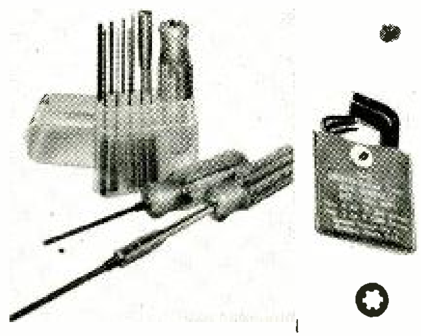


Fig 10—Bristo-spline heads can be turned with drivers too. Set on the left is Xcelite model 99PS-60.

Fig. 11—Another way to handle the Bristo-spline head is with L-angle wrenches. The set on the right is the General-Cement model 5070.

Blade types

To perform specific jobs, screwdriver blades are made in various lengths and widths. The length of a blade tells you the size of a screwdriver; that is, a 4-inch screwdriver has a 4-inch blade.

The most common type of driver has the **round blade** shown previously. (A cabinet-tip driver always has a round blade.) Also, drivers with Phillips, Reed & Prince, clutch and Scrulox tips usually have round blades.

Square blades (Fig. 12) are found only on longer keystone-tip drivers for slotted-head screws. There is more steel in a square cross-

Fig. 12—A square cross section, such as on the Xcelite S148 (left) and Armstrong 3062 (right), provides more steel in these square blades and delivers more torque. Design lets you lock on a wrench or pliers for more leverage.

section than in a round, so a square-bladed driver delivers more torque to a screwhead. Also, you can slip a right-angle wrench around the square blade to provide more leverage on hard-to-work screws.

The size of the screw to be turned determines the tip size, which in turn determines the length and thickness of the blade and the size of the handle. In general, the larger the screw, the larger and longer the screwdriver blade and handle. This is necessary to permit comfortable grasping, so that the proper amount of torque may be applied easily. If the handle is too small, you can't apply enough torque to turn the screw. If the handle is too large, you may be able to apply too much torque, stripping the screw threads or damaging the screwhead and/or the driver tip.

As you can see, there's a common-sense relationship between tip width and blade length, determined by the need for just so much torque and no more. For example, a rough kind of size progression might go like this (tip width vs blade length, both in inches): 3/32 × 3, 1/8 × 4, 5/32 × 5, 3/16 × 6, 1/4 × 8, 5/16 × 10, 3/8 × 12. This is no hard-and-fast rule, though. It is more applicable to keystone-tip drivers, in which the blade gets longer as the tip gets wider. You can buy cabinet-tip drivers in 3/16-inch or 1/8-inch widths with blade lengths from 2 inches to 12 inches.

For a given tip width, you can buy long- and short-bladed drivers, which are useful in certain situations. You should be aware of the general rule that the wider the tip, the longer the blade, and remember the need for only so much torque.

Probably the two most useful sizes of screwdrivers for slotted-

from the cabinet front. Of course, such drivers are also useful in other hard-to-reach locations. You have to be careful, though, not to use too much torque or you'll strip threads or damage heads.

The **right-angle** or **offset** screwdriver lets you work a screw in tight quarters, where the long blade of a conventional driver wouldn't fit. The double-tipped type (Fig. 15) has two bits—often one is slotted and one Phillips. Another type (Fig. 16) has four bits and is often called a **four-way** offset driver. Both kinds are about 4 or 5 inches long.

Fig. 16—Right-angle or offset arrangement lets you operate in cramped places. This General 808 offset has four bits for added versatility.

Some screwdrivers are made with insulation over the blade (Fig. 17). Only the tip is exposed metal, and thus the driver can be used on a

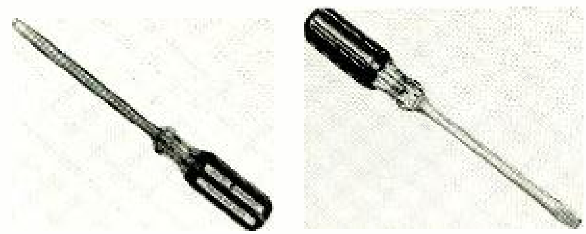


Fig. 17—Insulated-blade drivers, like the Crescent 2401-4 (left) or Klein 620 (right), have only the tip exposed, which simplifies working around dangerous voltages.

live circuit. You might find this one useful in some alignment and setup procedures.

Occasionally you may have to work a screw around a corner, which is impossible with most drivers. Several flexible-shaft screwdrivers which use a spring-steel wire blade permit work around corners and in nearly inaccessible places.

Another flexible screwdriver approach is the Allen driver (Fig. 18). As you can see, the tip is a hex ball which fits into Allen screws from several angles.

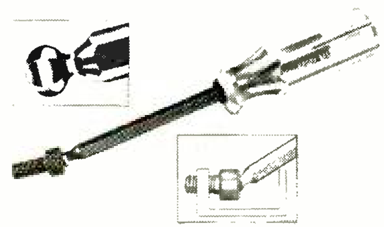


Fig. 18—Tightening or loosening a screw around a corner is made easier with the approach used by Upson: their ball-end, hex-allen driver has a hex ball for adjusting Allen screws easily.

head screws and bolts commonly used in electronics are these:

A 6-7-inch driver with a 1/4-inch tip (for 6-32 screws).

A 4-5-inch driver with a 1/8-inch tip (for 4-40 screws and setscrews).

A **stubby** screwdriver generally has a blade about 1 1/2 inches long, and a short, thick handle (Fig. 13). This tool is useful when you have

Fig. 13—Stubby screwdrivers are great in tight corners. Here are three of them. Left, Utica 90062; middle, Proto model 9651; right, Upson Stubby.

to work in tight quarters where a longer driver won't fit. The blade is often square; you can therefore use a right-angle wrench to obtain more torque. You can get stubby drivers with slot, Phillips, Reed & Prince, clutch and Scrulox tips.

Very useful in TV service is the long, slim-blade screwdriver shown in Fig. 14. This type has a 10-inch or 12-inch blade and a 1/8-inch or

Fig. 14—Long slim blades are extra handy in TV repair. The unit shown here is ideal for this application. It's an Xcelite R-810.

3/16-inch tip. Most have slot tips, but some have Phillips. There are very-long-blade Phillips drivers which are useful for working through the back of a TV cabinet to screws mounted on the inside front panel. Vaco's PP202 and Xcelite's X-2020 each have a 20-inch blade. A long, slim, slot-tip driver is useful for loosening frozen tuner oscillator slugs

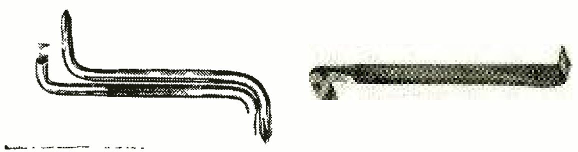


Fig. 15—Offset screwdrivers are also handy. They come as Phillips or slotted. Left, Omega offset; right, Utica U-90185.

Handle types

Carpenters' screwdrivers are usually made with wooden handles, but plastic handles are more useful in electronics, as plastic is a better insulator than wood. Some drivers are available with **rubber-** or **vinyl-plastic grips** over the handles (Fig. 19). Rubber is more comfortable and makes the driver easier to use, reducing fatigue and increasing your job efficiency.

Fig. 19—Plastic grips can make a screwdriver a lot more comfortable to use. Here's what they look like on a Klein 620. Worth looking for.

A **midget** screwdriver often has a **clip** attached so you can carry it in your pocket (Fig. 20). This is useful if you often adjust setscrews or

Fig. 20—Miniature units with a clip are handy for carrying in your pocket. Many types are available. At the left is Upson AU2; right, Xcelite R-181.

meter-zero screws around a broadcast station or industrial plant.

The size of a screwdriver handle, as pointed out before, is proportional to tip width and blade length, for proper torque. In medium and large tip sizes, however, drivers are available with somewhat larger than usual handles (Fig. 21). The usual driver with a blade 1/4 × 6 inches has a handle about 1 × 3 3/4 inches. The larger handle measures about 1 1/8 × 4 inches.

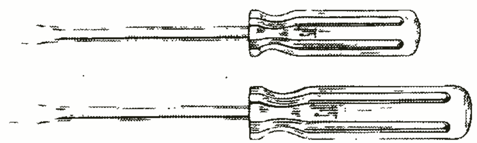


Fig. 21—Oversize handles improve torque ratio, makes it easier to handle tight screws. Both tools shown here are from Vaco. Top is standard model; bottom has oversized handle.

(to be continued)

Experiment With—

ONE-IC RADIO

New radio on a chip provides an unusual approach to portable AM receiver design

By LUCIJAN AUER & HARRY THANOS*

THE TAD100 IS A MONOLITHIC INTEGRATED circuit that incorporates all the active stages for a portable AM broadcast receiver.

It is designed for use with either a 6 or 9-volt supply, and features 4-μV sensitivity and a signal-to-noise ratio of 23 dB. The agc range is 10 dB maximum for a 60 dB rf change, and the output power of 50 mW is sufficient to drive an Amperex complementary transistor pair to an output of 1.5 watts.

Circuit operation

The rf signal is picked up by the ferrite antenna and applied via the secondary winding between the base of Q1 and the oscillator feedback winding. Optimum antenna source impedance presented to the mixer is 2500 ohms in the 535-1620-kHz frequency range.

Transistors Q1 and Q2 constitute a long-tail pair mixer. Oscillator injection is through dc coupling between Q2's base and the emitter of local oscillator Q3. Because of slightly increased V_{BE} on Q2 due to oscillator injection, some oscillator voltage, in addition to its regular dc bias, is supplied to Q1 through C1 so that the current in Q1 and Q2 are equal.

This connection also provides a low-impedance return to ground for the "cold" end of the antenna secondary. Another benefit of this connection is the in-phase feedback for variation in the dc operating points of the two transistors due to variation in oscillator injection voltage. Any change in oscillator injection on Q2's base is accompanied by a corresponding change in Q1, thus tending to maintain the currents of Q1 and Q2 eqeal.

Mixing occurs in the long-tail pair, and the i.f. signal is taken from the collector of Q2. This prevents "bottoming" oscillation in the mixer when the antenna is tuned to frequencies near the integral harmonics of the i.f.—for example, 910 or 1365 kHz. The emitter network which connects to pin 3 is designed to bias the mixer to provide 30 dB conversion gain and a uniform gain slope over a wide range of frequencies.

Oscillator, i.f. ampl, detector

A conventional grounded-base oscillator is used, but with several added features to improve circuit performance. The oscillator base bias is supplied from a dc-stabilized line in the i.f.-detector section. This insures negligible variation of oscillator amplitude with battery voltage. Additional oscillator amplitude stabilization is obtained from

*Amperex Electronic Corporation

paralleled-back-to-back diodes, which are across the feedback winding. (currently available TAD100's do not include the diodes. You must add R17 across the oscillator transformer primary or install ordinary silicon diodes between IC terminals 2 and 12.)

With the use of these two techniques, the oscillator activity, as well as the injection voltage, are maintained over optimum conversion gain for the mixer over a wide range of frequencies, supply voltage and temperature variations. Ideally, the oscillator injection voltage at pin 13 should be about 100 mV rms.

Several departures from conventional circuit techniques are used with the TAD-100. For example, all the i.f. selectivity is in "front" of the i.f. amplifier. This prevents oscillator feedthrough to the detector causing spurious beats, and permits use of a prealigned selective unit having any

EDITOR'S NOTE:

THE OSCILLATOR TRANSFORMER (T2) is shown with three windings, a 100-turn tuned primary, a 2-turn feedback winding in the collector circuit and a 10-turn winding to couple energy into the emitter circuit. You can use the more conventional transistor oscillator transformer with a tap on the tuned winding for the emitter circcit.

The tuning capacitor in this set has a maximum capacitance of 280 pF per section. A fixed padder (C18) is used to limit the maximum capacitance of the oscillator section. Most subminiature oscillator transformers are designed for a maximum oscillator tuning capacitance of 78–110 pF. This makes it necessary to change the value of padder C18 or replace it with an adjustable type with a maximum value of around 400 pF.

As an alternate, you might try a matched set including the antenna and oscillator transformers and tuning capacitor. One such set is the J. W. Miller 2108 capacitor, 2069 oscillator transformer and 2009 antenna transformer. With matched sets, padder C18 may have to be eliminated. See the maker's specifications and instruction sheet.

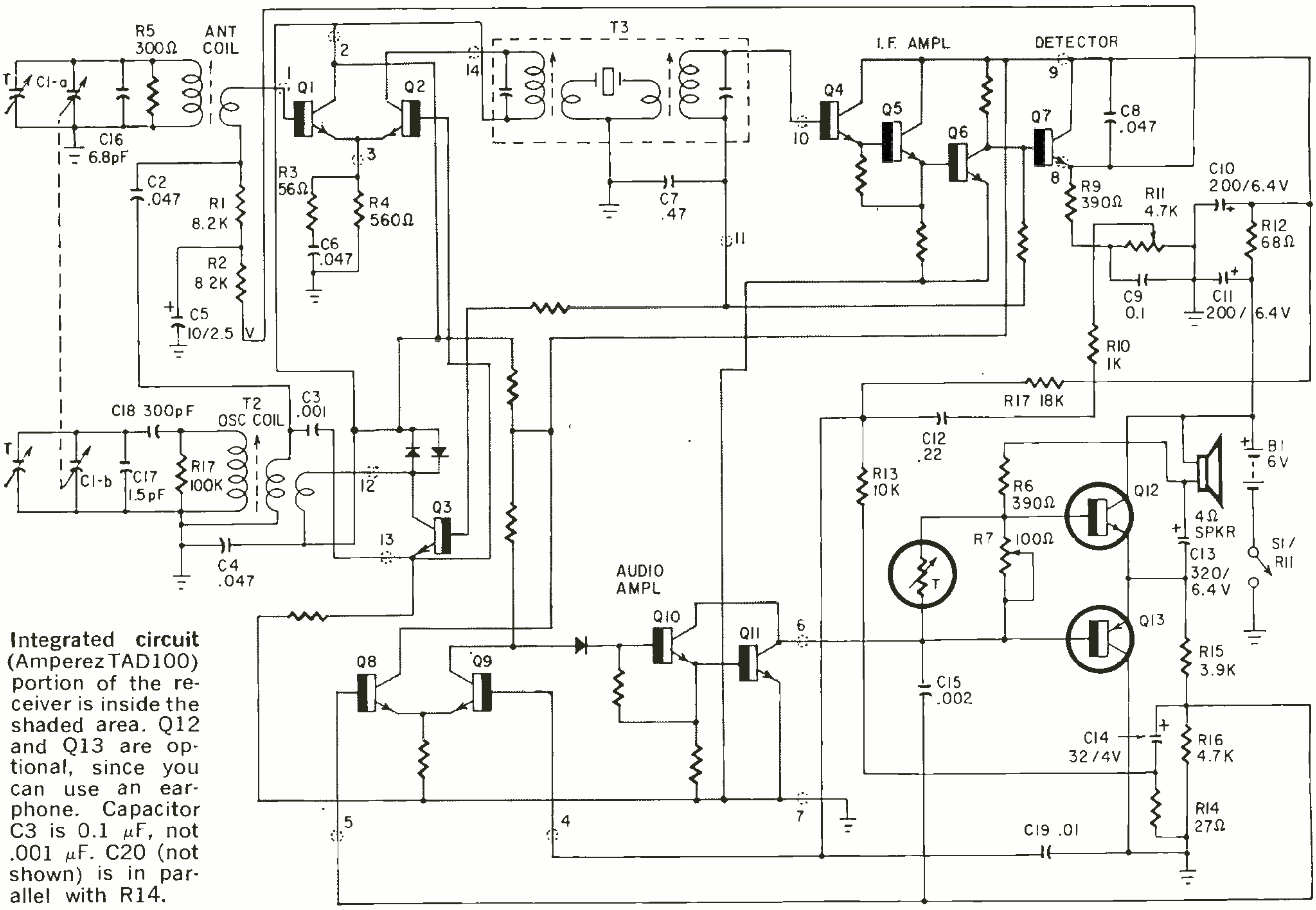
Ideally, the oscillator injection voltage fed to the mixer should be 100 mV rms. If it is too high, the oscillator voltage may get into the audio circuit and cause distortion and other troubles. If it is too low, it will adversely affect mixer operation.

Once you get your TAD100 receiver operating, we would like to hear from you. Performance might be improved with an added rf stage, and we'd like to learn about any modifications that make your receiver smaller and more sensitive.

PARTS LIST

Capacitors
C1—2-section, 280-pF—section, variable
C2, C4, C6—.047 mica
C3, 09—0.1-μF mica
C5—10-μF, 2.5V electroytic
C7—0.47 μF mica
C8—.047 ceramic
C10, C11—200 μF, 6.4V electrolytic
C12—.002 μF ceramic
C13—320 μF, 6.4V electrolytic
C14—32 μF, 4V electrolytic
C15, C20—.002 μF, ceramic disc
C16—6.8 pF tubular or disc ceramic NPO750
C17—1.5-pF tubular or disc ceramic NPO750
C18—300-pF mica (see text)
C19—.01 μF mica

Note: Electrolytic voltage and capacitance ratings are European standards. Use next higher available voltage and capacitance ratings.
R1, R2—8200 ohms
R3—56 ohms
R4—560 ohms
R5—330,000 ohms
R6—390 ohms
R17—100-ohm, subminiature (PC) linear trimmer potentiometer
R8—50-ohm NTC thermistor (Amperex No. 2322 610 11509)*
R9—390 ohms
R10—1000 ohms
R11—4700-ohm log. potentiometer and spst switch combination
R12—68 ohms
R13—10,000 ohms
R14—27 ohms
R15—3900 ohms
R16—4700 ohms
R17—100,000 ohms
All resistors ¼W. 5%
Q12, Q13—2N4105, 2N4106 transistors
IC—TAD100 (Amperex)
T1, T2—(see text)
T3—ceramic i.f. filter (Amperex No. 822 410 42010)
MISC—6-volt battery, 4-ohm speaker, 14-pin IC socket
An etched, drilled epoxy PC board is available for $1.75 ppd. (Part No. E-119) from Blakesley Electronics, Box 686, Syracuse, Indiana 46567.



Integrated circuit (Amperez TAD100) portion of the receiver is inside the shaded area. Q12 and Q13 are optional, since you can use an earphone. Capacitor C3 is 0.1 μF, not .001 μF. C20 (not shown) is in parallel with R14.

desired bandpass characteristic. A third advantage is that the i.f. amplifiers can be a series of dc-coupled transistors with the proper gain and phase characteristics for excellent stability.

The i.f. amplifier consists of Q4, Q5 and Q6 arranged in a dc feedback circuit (pins 10 and 11 connected), which maintains a constant collector voltage on Q6. Bias is also provided to the base of local oscillator Q3 from pin 11 as a stabilized voltage reference source.

The input impedance of the amplifier is very high (greater than 500K) due to the two emitter followers, Q4 and Q5. This arrangement eliminates the need for a tap and is highly stable. The power gain is approximately 70 dB.

The output of the last i.f. transistor, Q6, is dc coupled to Q7, which function as the detector. The volume control and bypass capacitor are connected to pin 8 and the demodulated audio appears across them. An additional RC filter is included to reduce further any residual 455 kHz signal that might appear across the volume control.

The capacitor on pin 8 must be connected back to the positive line and not to ground since Q7 is being driven between base and collector.

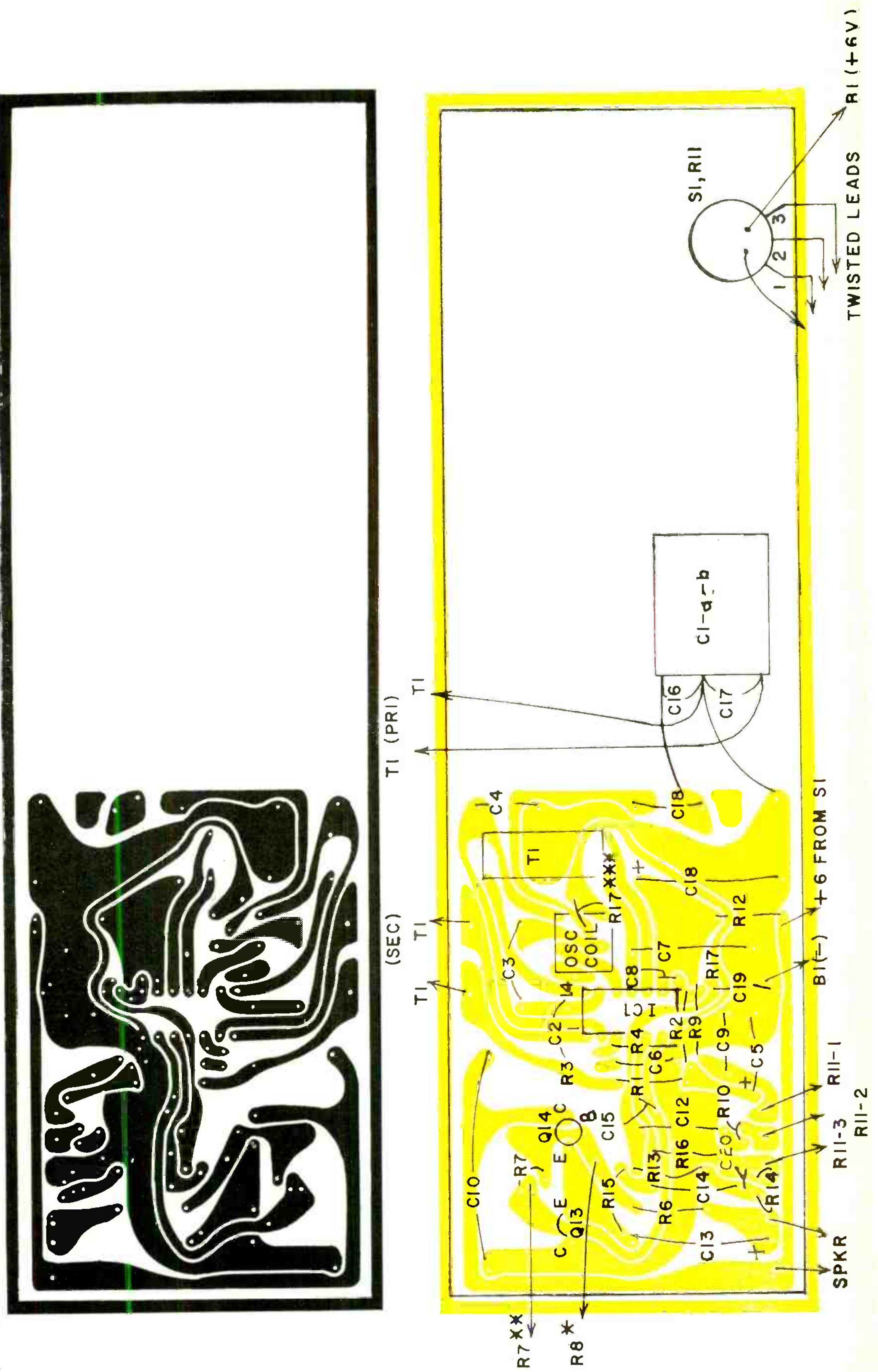
Audio amplifier stages

The basic IC audio amplifier consists of predrivers Q8 and Q9 and drivers Q10 and Q11. Transistors Q8 and Q9 form a long-tailed pair, and drive is taken from Q9's collector through D3 to Darlington pair Q10-Q11 which drives the output stage.

Choice of audio output circuitry depends upon the particular application. A battery-operated portable could use a complementary symmetry pair such as the 2N4107 yielding 1.5 watts with about 10% distortion with a 9-volt supply.

An ac only line-operated radio could use an "off-the-line" single-ended audio output operated Class A and delivering 1-watt with about 10% distortion.

In the battery-operated version, dc feedback is taken from the emitters of the output pair (the midpoint) to pin 5 by the voltage divider R12-R13. **R-E**



Actual-size PC pattern for the TAD100 receiver is shown with a component-side diagram next to it. The odd "notch" in the ground foil pattern is to prevent spurious signals from entering the i.f. stage of the sensitive TAD100.

*R8 MOUNTED ON Q12-Q13 COMMON HEAT SINK
**LEAD ATTACHED TO Q12-Q13 HEAT SINK
***ON COPPER SIDE OF BOARD

HOW TO FIX COLOR

Valuable tips for tracking down oddball color TV troubles

by MATTHEW MANDL

WEAK COLOR OR TOTAL ABSENCE OF color usually calls for a routine check of the fine-tuning setting, correct antenna orientation and the color controls. When the tint and chroma controls fail to help, we look for weak tubes or defective transistors in the killer and chroma circuitry. If these check all right, we may look for poor gain between the antenna terminals and the pix tube.

Often, however, weak color reception may be caused by troubles somewhat off the beaten path and hence overlooked. When circuits *appear* to be normal but poor color reception persists, it can be a frustrating experience.

We think of the horizontal oscillator as a generator of the sweep signals and locked in sync with incoming pulses. In black-and-white sets our primary goal is good synchronization and linearity. In color, however, more precise lock-in is essential because changes in *phase* between sync and oscillator signals can upset color reception. The horizontal oscillator frequency controls the timing of the pulse signals obtained from the horizontal output transformer for the burst amplifier, bandpass amplifier, color killer and blanker. Hence, even though the picture is locked in and doesn't tear, the oscillator frequency may be off fractionally and cause weak color or loss of color.

Adjust the horizontal hold control through its lock-in range and note if colors intensify at any point. If this is a critical setting, it may be necessary to make other adjustments, replace the tube, or test for defective components.

In order to insure good horizontal stability, the phase-detector system has been widely adopted. A typical circuit is shown in Fig. 1. Here, dual diodes are used for the phase detector and a 6FQ7 for the oscillator control section and the sweep generator. The phase detector compares the signals obtained from the sync separator with one obtained from the horizontal output section. The *difference* voltage which results when the sync and horizontal output signals are out of phase is used to lock in the horizontal oscillator.

To increase oscillator stability, a resonant circuit is included in the cathode (pin 8 in Fig. 1). An adjustable slug provides for stabilizing the frequency and permitting the setting of the hold control range. Thus, if the hold control must be turned to either extreme for sync stability, adjust the stabilizing coil to bring the hold control range around the center of its extreme settings.

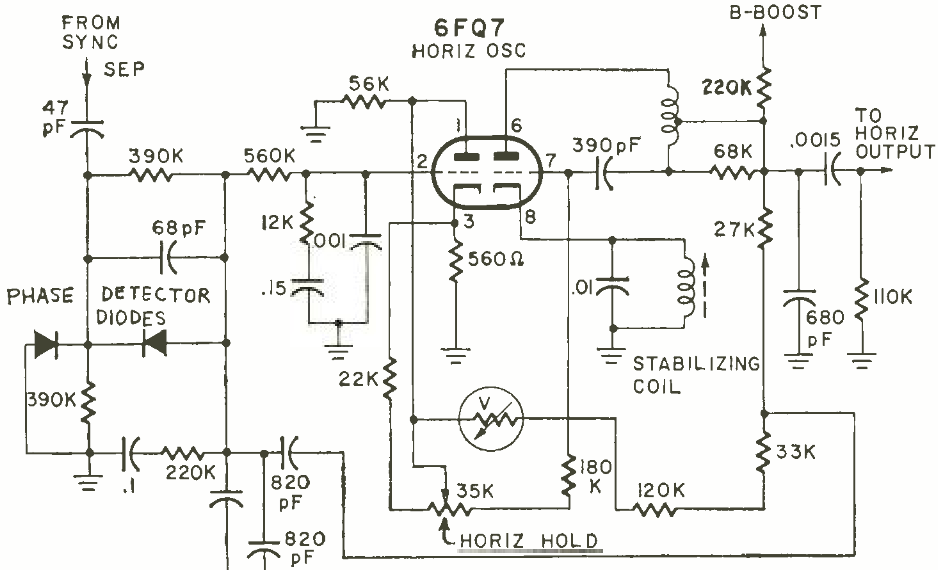


Fig. 1—Phase-detector circuit used in horizontal system for stability. When sync and horizontal output signals are out of phase, a difference voltage develops between the detector diodes, locking the horizontal oscillator into the correct frequency.

If the hold control setting is still critical for color after a new tube has been tried, check the diodes in the phase detector section. These should be matched pairs with forward resistance almost the same in each. If these check out, it will be necessary to test for off-value resistors or capacitors. Also check the varistor connected to pin 1 of the 6FQ7 for defective operation .

Some receivers use a dual-diode tube instead of the solid-state phase detector. A typical example is shown in Fig. 2 and has been used extensively in the GE receivers (chassis H-1, H-2, 2H5, 3H5, M2H5, etc.). A 6LT8 tube is used, with the pentode section in the oscillator circuit. (In some sets the 11LT8 is used instead of the 6LT8.).

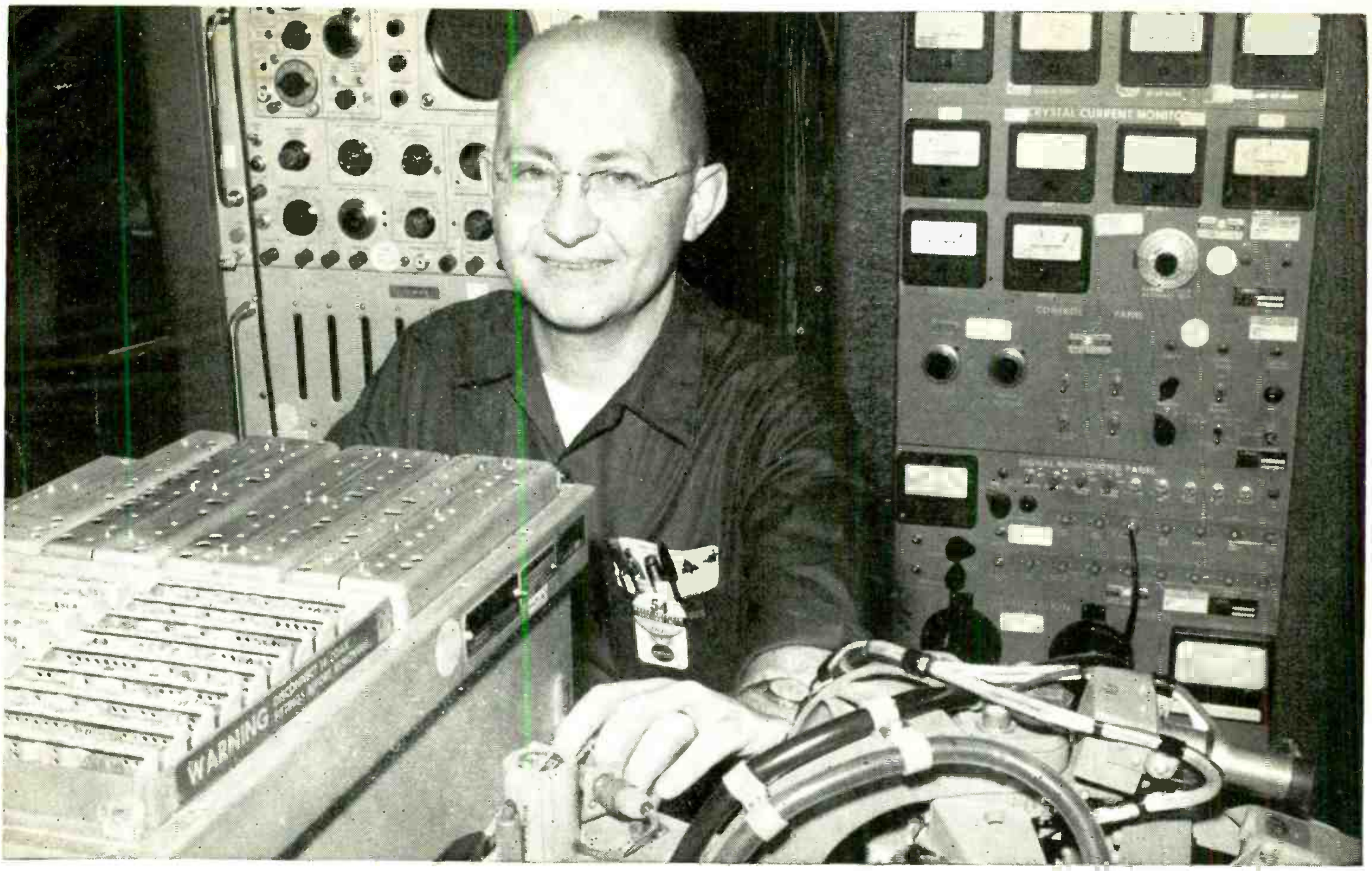
Here the slug-tuned inductance is the hold control and hence is the only manual adjustment possible. A tube change will, however, also replace the phase detector diodes and hence serves to check both circuits for low emission.

For the circuit in Fig. 2 the output from the anode of the oscillator tube is sampled and coupled back to the phase-detector network. A scope is useful for testing circuit operation because the sawtooth signal can be observed directly. For the lower diode (pin 6) the pattern should be as shown in Fig. 3, and should measure approximately 45v peak-to-peak. For the upper diode (pin 9) the waveshape is similar, though only a 3-volt P–P signal is obtained.

High-voltage factors

In b-w sets we assume the high voltage circuitry is functioning properly if we get a bright raster and no blooming. In color sets, however, more is involved. If the voltage is too high the regulator tube will have no latitude in correction of voltages to conform to changes of color intensity. For any highly saturated color scene, loading on the horizontal output system increases considerably and high-voltage values change.

With poor high-voltage regulation, vividly colored scenes may blur and picture size shrink. Even with



replacing components. You need to really know the fundamentals.

Without such knowledge, you're limited to "thinking with your hands" ...learning by taking things apart and putting them back together. You can never hope to be anything more than a serviceman. And in this kind of work, your pay will stay low because you're competing with every home handyman and part-time basement tinkerer.

But for men with training in the fundamentals of electronics, there are no such limitations. They think with their heads, not their hands. They're qualified for assignments that are far beyond the capacity of the "screwdriver and pliers" repairman.

The future for trained technicians is bright indeed. Thousands of men are desperately needed in virtually every field of electronics, from 2-way mobile radio to computer testing and troubleshooting. And with demands like this, salaries have skyrocketed. Many technicians earn $8,000, $10,000, $12,000 or more a year.

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Circle 30 on reader service card

proper high voltage the brilliancy control may have to be backed down slightly and the chroma control regulated so the regulator tube can function properly. With proper adjustments, pastel scenes to highly vivid ones should cause no blooming, shrinkage or blurs.

The high voltage can be measured at the cap of the shunt regulator tube or at the high-voltage clip where it enters the receptable on the picture-tube side. High-voltage tests points are usually provided in sets with the pulse-feedback type of regulation. If the high-voltage varies several thousand volts with color-contrast changes, try a new regulator tube. Don't set the high voltage above that specified in the service notes, and make sure your high-voltage probe is calibrated properly.

High-voltage probes use a special high-megohm resistor in series with the probe lead as shown in Fig. 4. These can be replaced, when defective, by unscrewing the double section making up the body of the assembly.

Since such probe resistors may have a value of 1090 megohms for some vtvm units, or 480 megohms for 20,000-ohms-per volt meters, they are too high in value to be made up by stringing together common resistors. Most meter manufacturers, however, furnish the proper resistor for their particular model. If you are in doubt regarding the resistance value necessary, the following will be of help.

If, for instance, you have a 20,000 ohms-per-volt meter the current through the meter at full-scale deflection is 50 μA. For a 30-kV reading on the 6000-volt scale we need to read an additional 24,000 volts: (30,000 − 6000 = 24,000).

Since we require an additional 24,000 volts at 20,000 ohms per volt, the resistance required is 24K × 20K = 480 megohms.

In one instance only a 1090-megohm resistor was available (formerly used on a vtvm on the 300-volt scale. This was used with a 20,000 ohms-per-volt meter to increase the scale to approximately 60,000 volts. For a 60-kV scale, we require an additional 54-kV range on the existing 6000-volt meter scale.

Thus, 20K x 54K = 1080 megohm which is sufficiently close to the 1090 megohm to give fairly accurate results.

When the shunt regulator fails to keep the high voltage within bounds or the voltage can't be adjusted properly with the control, circuit components must be tested. Most of the modern regulating systems have simplified circuitry, as shown in Fig. 5 for the Magnavox T932 receiver. After the receiver has been shut off, discharge the h-v charge and test the resistor values.

The H-V ADJUST should have a smooth change in resistance as the control is adjusted. Also make sure the series 1-megohm resistor has not changed value. Be sure the proper low voltage is applied to the cathode circuit. For the receiver mentioned, test points on the rear control board (printed circuit) can be reached without having to remove the chassis.

Make sure there are no h-v arcs from leads to chassis. Observe the chassis in a darkened room while the set is in operation. Clean off dust and dress high-voltage leads away from metal parts. Anti-corona spray is available for critical areas or sets operated in high-humidity locations.

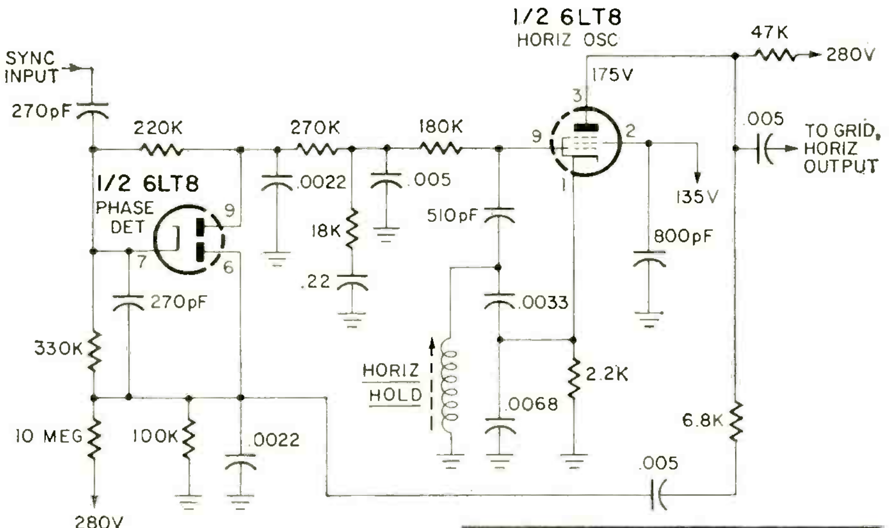


Fig. 2—Another phase detector arrangement, using the diode section of a 6LT8 instead of matched solid-state diodes.
ment, using the diode section of a 6LT8

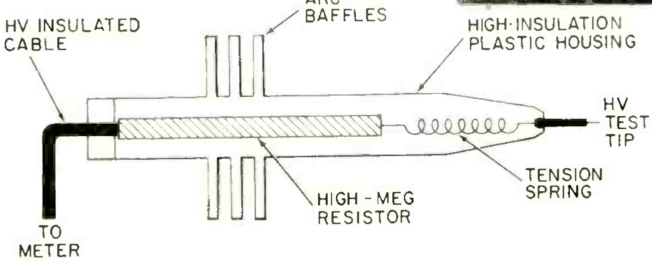


Fig. 4—High-voltage probe with built-in high-meg resistor. Units can often be separated to replace defective resistors.

Antenna system impedances

In areas where stations are not all from the same direction, an antenna rotator is a virtual necessity, even in strong signal areas. Pinpointing the antenna orientation does much for good color reception. Sometimes, however, even the best motorized antenna system can give some trouble because of lead-in length.

In theory, a 300-ohm antenna is to be attached to a 300-ohm lead-in, and this to a 300-ohm input tuner. If these three match in impedances, no trouble occurs. Input impedances of the tuner, however, may not be constant when changing stations (and also because of slight variations from 300 ohms in a given line or antenna). A mismatch at the tuner can cause rejection of some signals arriving at it. These are reflected back along the line and re-enter the tuner later. Such standing waves can reduce picture sharpness and provide ghosts closely spaced to the primary picture. Sometimes this only occurs for one station, leading the technician to believe receiver tuning is at fault.

In a recent installation in the Trenton, N. J., area, color reception was perfect for channels 3, 6 and 10 from Philadelphia, but weak for New York stations. A high-gain antenna was installed and a rotor used for precise pinpointing. Now excellent reception was obtained for the New York stations, but channel 6 from Philadelphia was poor in detail, even though contrast was good. Sharp details showed faint repeat areas which gave the appearance of a blurry picture.

Having run across this symptom before, the servicing technician added a short 16-inch section to the lead-in.

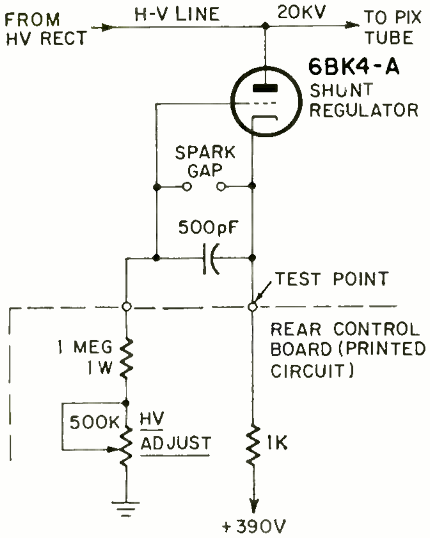


Fig. 5—Shunt-regulator circuit used in the Magnavox T932 TV receiver.

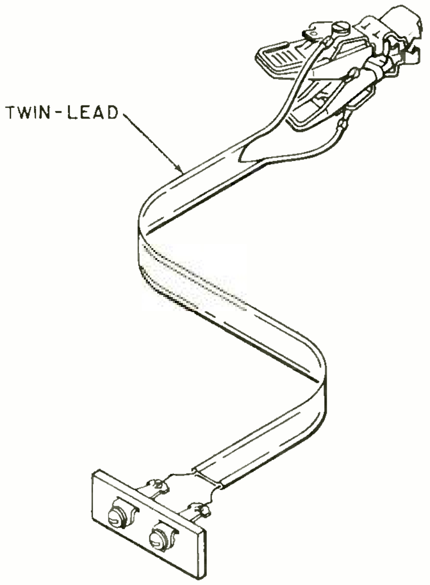


Fig. 6—Several lengths of twin lead can help solve lead-in length problems.

The result was complete restoration of picture excellence. This technique may be challenged by the newcomer who hasn't experienced this problem before. Many oldtimers, however, have long recognized the difficulties that specific lead-in lengths can cause. Often the experienced technician will carry several lead-in test sections of the type shown in Fig. 6. These vary in length from 6 inches to 2 feet, since a particular length is often best for a given installation.

Once the right length has been found, reception is rechecked on other channels, because the added length to the lead-in may alter reception on one or two other channels. When this happens, the added section may have to be increased or shortened in length to reach a compromise for the affected stations. Once the optimum length has been established, a section of proper length is soldered to the lead-in permanently. **R-E**

CHEMICALS—
The Secret Weapon In Your Shop

Cements, Cleaners, Lubes, and Solvents are Tools. Use the Right One For Speed and Efficiency.

by J. MERINO Y CORONADO*

IT SOUNDS STRANGE TO SPEAK OF "chemical tools" in electronics, but dozens of them are in use. Knowing when to use the proper chemical tool for a job can be just as important as selecting the right mechanical tool. We'll look at some of the important "groups" of chemical tools that make our work easier and more efficient.

Using lubricants

Let's begin with lubricants. A can of a good *light machine oil* is a must for general lubrication and to prevent rust in fine tools. So is a can of *medium machine oil*, the kind you use in your car. Next time you change the oil, buy a can for the shop.

Lubriplate is useful for tape recorders and record changer parts, and so is *Tuner Lube* for TV tuners.

Ordinary *grease* can be used to prevent corrosion on battery terminals. This type of grease, or grease containing graphite (used for bicycle chains) is useful for gears, provided temperature does not run very high. *Fiber grease* should be used for high-temperature conditions.

A box of *paraffin* or household wax is useful to prevent tool rust, as a humidity seal for some types of coils and i.f. transformers or to secure ferrite tuning slugs in place. Heat from a soldering iron held near the coil for a minute or two softens this wax, allowing the core to be adjusted as desired.

Silicone grease provides a heat-transferring bond when mounting power transistors.

If you service organs, *piano grease* must be kept in stock to lubricate keyboards and pedal lever systems. Never let oil or grease fall on the delicate switching system. If you do, clean it off with a camel-hair brush and solvent. Of course, ordinary and graphite grease may be used to lubricate keyboards and pedaliers; many technicians do use them, but it's better to use the right chemical tool.

A type of penetrating oil is called *chemical wrench or Liquid Wrench*. Rusted bolts in antennas or towers may be loosened two or three minutes after applying it.

Very fine instruments such as the movements of some medical electronic instruments (phonocardiographs, electroencephalographs and the like) are lubricated with *watchmakers' oil*. You don't need this special lubricant unless you service this kind of equipment.

Cleaners and solvents

Of course, every shop has the best cleaner and solvent there is—water. But plain water is not enough. Glass dial covers and TV tubes may be cleaned with it, but it's better to use first a neutral soap and a soft-rubber or foam sponge—then water.

There are many *glass cleaners* on the market, but when the tube or dial cover is covered with dirt, it's better to start with soap and water and then use the glass cleaner. Of course, you may use *detergents*, but some strong types may attack glass and fog it. Many glass cleaners and strong detergents can fog plastic. Fortunately several good glass *and* plastic cleaners are on the market. If you don't have time to experiment, better use them.

Acetone is a good solvent for speaker cement. Applied to a speaker-cone dust cover, it softens the cement so the cover may be removed with tweezers to be used again. Amyl *acetate*, a solvent used to remove nail polish, is much stronger than acetone but more volatile.

Before soldering a break in a printed circuit, a solvent must be used to remove the silicone resin or protective cover used on it. Print Kote *Solvent* is useful for the purpose, as is the *ordinary thinner* solvent used by painters. Both are applied with a camel-hair brush, and several sizes of brush should be at hand.

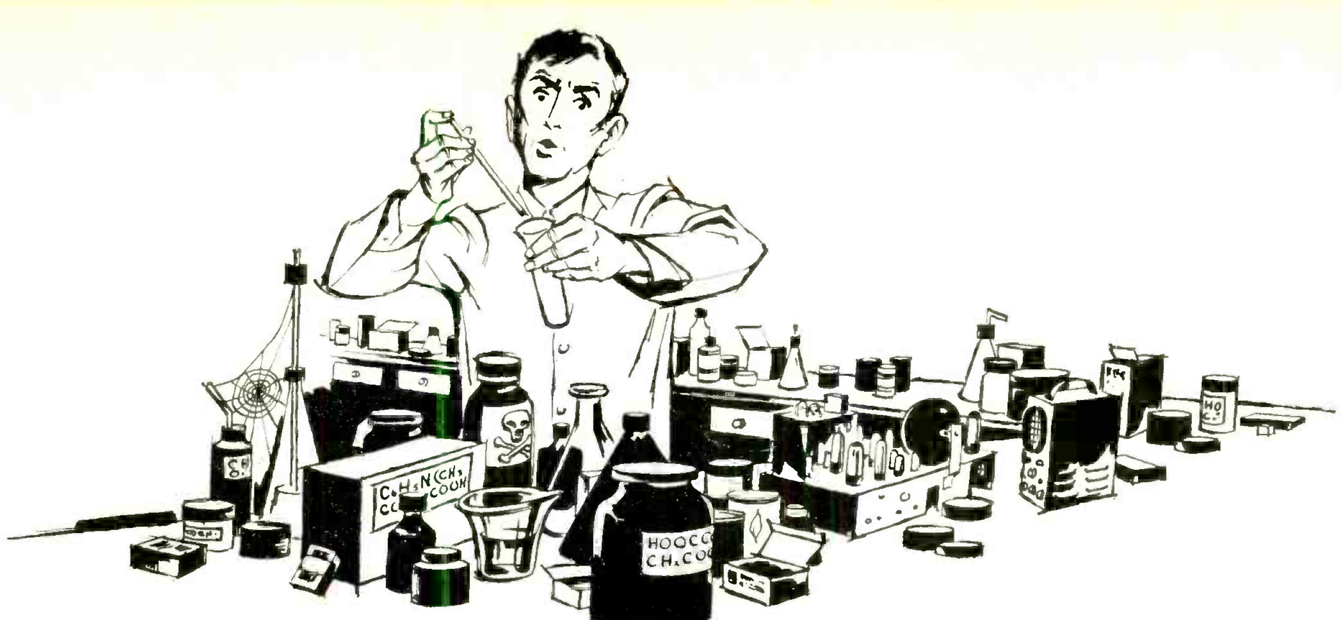
Ordinary *gasoline* is the best solvent for grease and oil on screws, bolts and other heavy-duty parts. But don't forget it contains tetraethyl lead, a poisonous compound. After using ethyl gasoline wash your hands. In some places gasoline without lead may be obtained.

Carbon tetrachloride or "tet" is an excellent cleaner and solvent. Several manufacturers specify it for cleaning tape heads and capstans. Some kinds of rubber dissolve in tet, so be sure to note equipment manufacturer's warnings.

A word of caution: continous breathing of carbon tetrachloride fumes can produce serious, permanent damge to internal organs. Be sure to use it only with plenty of ventilation.

There are several good *tape-head cleaners* on the market that do not contain tet. They may be used on most heads without danger, and a bottle is a good investment. So is *isopropyl alcohol* for the same pur-

*Research physicist, University of Mexico Professor of Acoustics, Polytechnic Institute of Mexico



pose. Avoid use of *methyl alcohol*: it is dangerous to your eyes. And don't forget ordinary alcohol is denatured. This means a chemical has been added to make it unsuitable for drinking.

A can or small bottle of *contact cleaner* should also be available. Unlike carbon tetrachloride, most contact cleaners contain a lubricant and an anticorrosive. Applied with a long, curved eyedropper or a spray extension into a volume control, the chemical will saturate the inside and clean the sliding contact. Cleaning is especially important in the expression-pedal controls of electronic organs. Located near the floor, they are subject to severe "dust storms." Volume controls used in expression pedals, unlike those in radio or TV sets, are moved many times per minute while playing a tune.

Insulating coatings

There are many brands of liquid tape" for low voltages up to 1000 volts. Some technicians brush a coating or two on tools as a protection against electric shock. But if you're working with voltages of 400 or over no liquid tape is a safe substitute for rubber, bakelite or plastic insulation. Don't take chances, especially if you're working on or near a damp or wet area.

Red insulating varnish forms a good coat over solder connections. It also serves for sealing adjusting screws in i.f. transformers, organ tuning coils, etc. For this last purpose, a drop of nail polish is good enough.

In the old days electricians used a plain solution of shellac in alcohol as insulating varnish. (This solution may also be used to cover up cabinet scratches). When brushed over wires or printed circuits it takes at least 20 minutes to dry. For this reason, most technicians prefer to use a *silicone resin coating* to restore the protective coating on printed circuits after a repair. Print Kote is one trade name for this silicone resin.

Cement types

A good general-purpose and speaker cement can be made by dissolving clean celluloid or acetate film from old negatives in a solvent made with 50% acetone and 50% amyl acetate. A drop is useful for fixing knots in dial cords, loose coil windings, or to secure pointers on a dial cord. Don't use all-purpose cement to repair broken plastic or wooden cabinets. *Plastic cement, bakelite cement* or carpenter's glue are better choices.

For very strong joints, *epoxy cement* can be used. Epoxy will bond practically anything to any surface.

Dentists use a very strong cement that can be molded to practically any shape. Used for mending broken dental plates, this cement is made with a resin and catalyst and can withstand severe temperature and humidity. It is transparent, but may be easily colored. For neat work, dentist's cement is a good choice, but it's quite expensive.

Loose rubber objects may be fastened with any *rubber-to-metal* cement. (Loose drivers or wheels that must be fastened to shafts, for example.)

Wood glue is useful for repairing wooden cabinets, or for most wood-to-wood bonding. Many wood glues can not stand severe humidity.

Miscellaneous chemical tools

Many other chemicals are useful in any shop. Some are used daily; others seldom used—depends on the work you have.

For instance, *sodium bicarbonate* or ordinary baking soda is a must if you handle car batteries. A saturated tap-water solution helps in cleaning the terminals and boxes of batteries, and stops corrosion by neutralizing the sulfuric acid of any electrolyte which spills from the battery cells. When a drop of acid falls on the floor or your hands, use the solution liberally as a neutralizer, followed by plenty of water.

Ordinary *muriatic* or *hydrochloric acid* is used for some types of soldering, but its main use is for cleaning porcelain and porcelainized fixtures. Remember that any strong acid is dangerous to your skin and *very* dangerous for your eyes. Use rubber gloves when handling strong acids.

A few words of caution: always remember to keep these chemical tools in clean, clearly labeled containers. Acids, denatured alcohol, carbon tetrachloride and any chemical you do not know is harmless should be labeled POISON in big letters. Alcohol, gasoline, solvents and the like must be kept only in small quantities and labeled HIGHLY INFLAMMABLE, or KEEP AWAY FROM OPEN FLAME.

As we have seen, there are many useful chemical tools for daily use. There are many others of minor or infrequent use, but all of them simplify and speed our work. **R-E**

ABC's of Circuit Breadboarding

Avoid costly mistakes with your electronic projects by modeling them first. You'll learn circuit theory better, spot troubles and develop design improvements

by JIM ASHE

IF YOU DON'T BREADBOARD CIRCUITS AND PROJECTS BEFORE you build the real things, you may be losing time and money. A few minutes spent breadboarding some new design or part of a construction project will familiarize you with the circuit theory, spot bugs, suggest improvements and develop your knowledge of electronics.

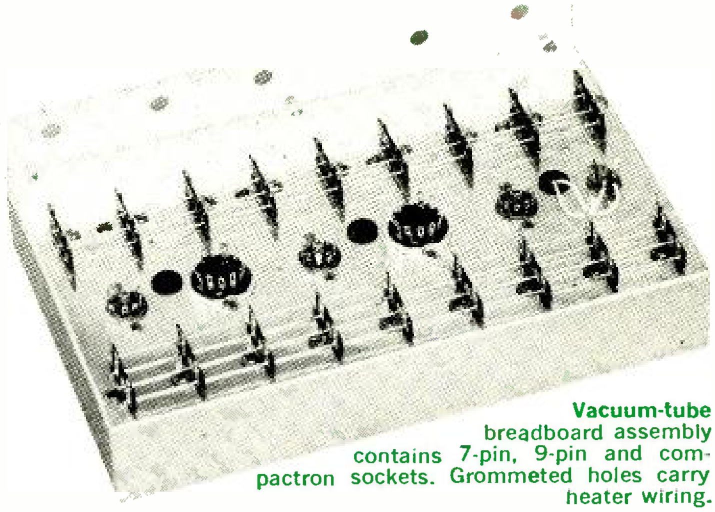
The cost of breadboarding even a complex circuit is usually pennies, since the components can be reused. And with careful work a forbidding new pulse, signal or control circuit becomes a familiar friend. Engineers breadboard their designs time and again.

Why don't you?

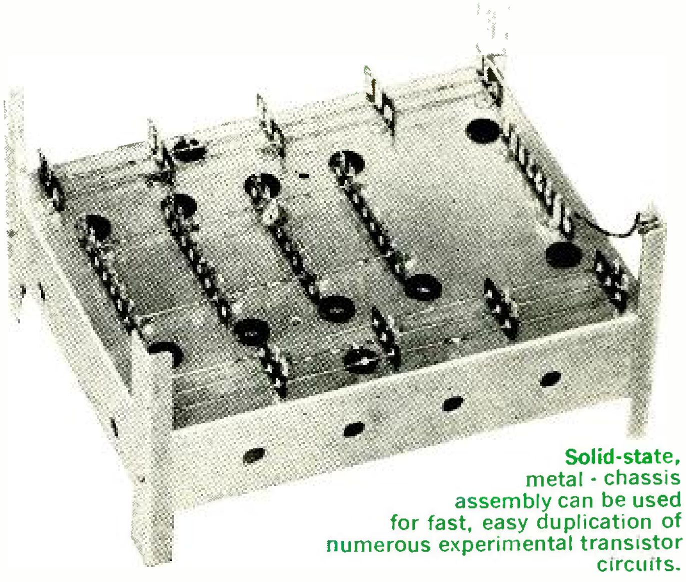
Maybe it's because you haven't come across a good description of what it's all about. Breadboarding is simply another kind of modeling, and many examples in other fields come to mind.

Electronic modeling

The architect's model costs a few dollars but shows new perspectives on a building that will cost millions. The car stylist's clay model finally appears in thousands of real duplicates, but only after a long and sometimes painful



Vacuum-tube breadboard assembly contains 7-pin, 9-pin and compactron sockets. Grommeted holes carry heater wiring.



Solid-state, metal - chassis assembly can be used for fast, easy duplication of numerous experimental transistor circuits.

evolution. Can you imagine building a complete new car to check out each styling or mechanical design idea?

Yet this same modeling concept seems to be pretty rare in ham radio, experimenter, hi-fi and other popular electronics fields. Let's look at this breadboarding idea from the special perspective of somebody interested in electronics.

Pick an electronic instrument, box or machine. It could be a standard vtvm, or if you're more ambitious you might choose a radio receiver or an oscilloscope. Only a glutton for punishment would choose a computer. Now open it and look inside. There are resistors, capacitors, transistors, IC's and perhaps vacuum tubes. There's also a lot of sheet metal, mounting hardware, pots, meters and other mechanical or electromechanical structures.

But most of it is of secondary importance. In there somewhere is the *circuit*, the collection of interconnected resistors, capacitors, inductors and active devices that actually does whatever it is we *say* the box does. This circuit is the real heart of the electronic gear and in a very real sense the rest—perhaps 80% or more by weight—is simply extra trimming.

If you're thinking about building something new, it's not good planning to invest time and money in hardware and mechanical work until you are reasonably certain the result will be acceptable. And if you are a student or trying to upgrade yourself in your field, a good practice is to avoid routine mechanical construction work. It consumes time and money but does little for your mastery of new and all-important knowledge.

This key point seems to be almost invisible in popular and technical electronics, although most professional engineers, who are great breadboarders, see it clearly. When an idea or design is proved reliable, the most economical procedure is to work directly from the design to the finished product. But proven reliability is one part skilled design, one part appropriate testing and one part understanding—a not very common mix. Sometimes the idea-to-product process is good policy, but in real life the procedure in Fig. 1 has compelling advantages.

The original idea is modeled or breadboarded, and after observing the results we may change our thinking and try again. We may go around this loop several times for new work, but finally the ideas and design come into focus. We step out of the loop with a finished product, and from there we sometimes go to a real physical project. And if all we needed was a finished *idea* we've saved ourselves the time and expense of a hardware project. Fig. 1 illustrates the approach we use in breadboarding, and on many other occasions too.

Practical breadboards

Once we have lowered our sights and set a limited goal of testing and understanding circuits rather than constructing hardware, our work becomes much simpler. Costs are reduced, too.

Elaborate circuit-construction kits have appeared on the market for this kind of work, but they do not seem to last long. Perhaps it's because kit designers have to overdo to have anything to sell. A breadboard that looks like a candidate for the junk pile will do as well as a commercial assembly, and though many of us will choose the better-looking gear, we will gain little from the additional expense. A sample breadboard arrangement is shown in Fig. 2.

This is a piece of plywood with two three, or four short rows of tacks or nails driven into it. Two lengths of bus wire or strips of tin along the outer rows serve as supply and grounding lines. A bracket or brackets are provided to mount controls that are too heavy or that require too much torque to be left lying on the board or hanging in midair. Construction of a circuit on this breadboard is very simple and results in a neat job.

To breadboard a one-transistor circuit, solder the collector resistor to the supply line, add the transistor to the end of it (socket optional) and tack in the emitter resistor on the other side. Two additional resistors are the base bias network, and a couple of capacitors stick out the ends or sides for input and output.

There are no fixed input, output or supply terminals. Connections as required are carried in by clip leads, avoiding fussing around with mating connectors that add nothing to the progress of the work. When a wire doesn't reach, tack on a bit of hookup wire. Used parts, if they are known to be good, are excellent for practice, saving much money.

At radio frequencies some positioning of parts may be needed, but usually the distances provided by leads will reduce coupling to levels as low or lower than can be expected in a finished circuit assembly.

This style of construction has proved adequate for a variety of circuits. One was a remarkably successful regenerative detector project, which did not seem to suffer from any of the disadvantages that appear unavoidable in this open, nonrigid construction. Evidently some old perspectives about circuit construction need rearranging in the light of today's tiny solid-state electronics.

Careful construction is necessary to avoid an effect like that of a collection of springs. No soldered joint should carry appreciable stress or things will fly apart upon resoldering. Bend wires as needed to achieve contact, and then solder for electrical connections only. You will quickly develop an easy familiarity with this style of construction.

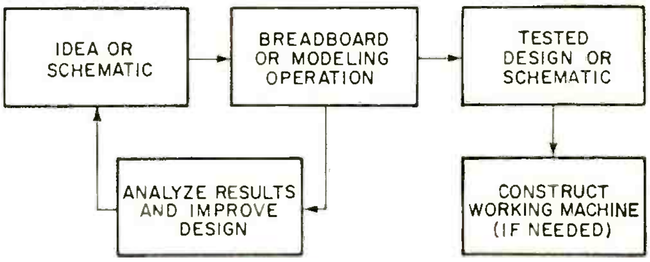


Fig. 1—Smart approach to project building calls for first building a model instead of a direct idea-to-product process.

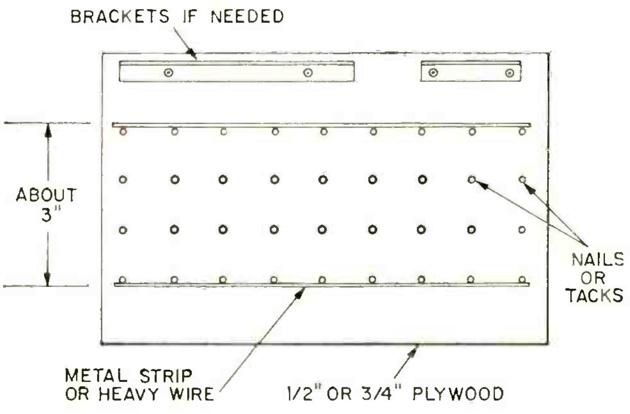


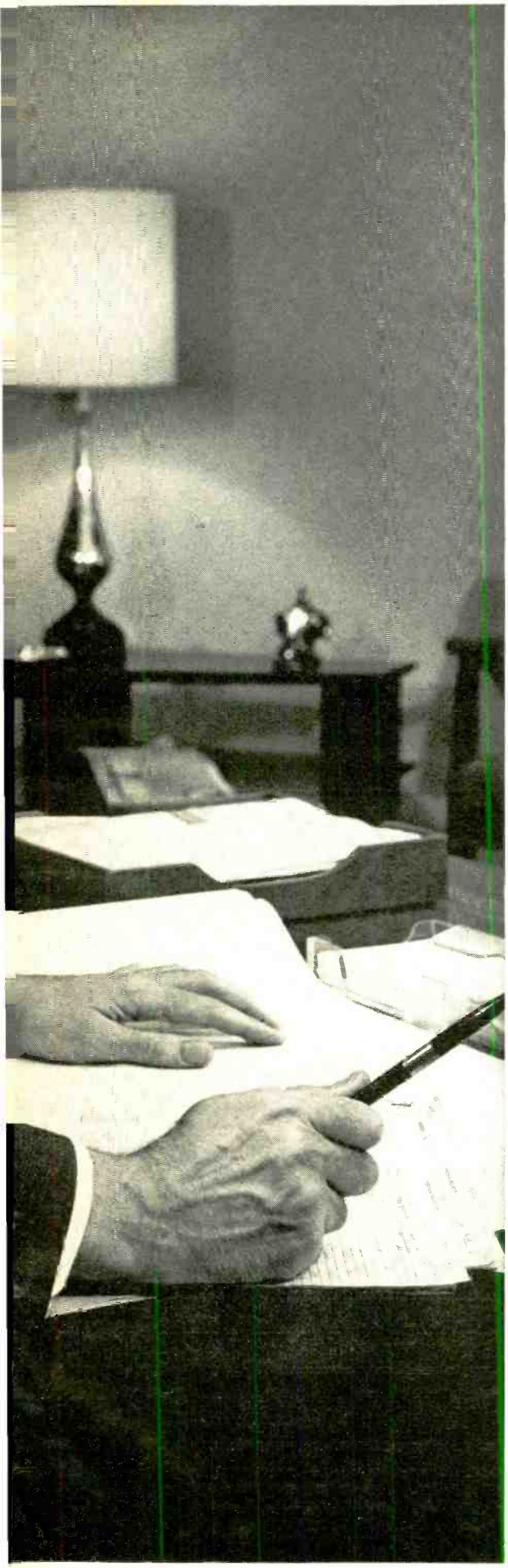
Fig. 2—Breadboard setups can be simple, like this plywood with nails, or more elaborate like the photos on the left.

Table I—Batteries for Breadboarding

Eveready Number	Voltage and recommended current	Size (inches)	Catalog Price	
1015	1.5V, 25 in A	35/64 dia x 1 31/32 long	$0.17	Pencell
1050	1.5V, 150 in A	1 21/64 dia x 2 25/64 long	$0.20	Std. D cell
276	9V, 30 in A	2 9/16 x 2 x 3 5/32	$1.36	
731	6V, 500 in A	5 3/8 x 2 7/8 x 4 15/16	$1.96	
732	12V, 250 in A	5 3/8 x 2 7/8 x 4 15/16	$1.96	

"Get more education or get out of electronics

...that's my advice."



Assemblies like that of Fig. 2 can be made up from chassis and lug strips, as shown in the photos. They look better—perhaps electrically they are better—and they cost more. One is a solid state, the other a vacuum-tube breadboarding assembly.

Around the breadboard

If you automatically reach for an ac power supply every time you think of a circuit experiment, you're missing the best part of the whole idea. Batteries have come back into style and are ideal for breadboarding work.

Their simplicity, isolation from power lines, general availability, electrical properties and stability are all well suited to breadboarding. You can assemble some batteries into a small box with switch and terminals, or choose a few handy sizes such as the larger transistor batteries. Avoid miniatures. The ultra-tiny penlight cells and general-purpose 9-volt radio batteries may seem attractive but they have no capacity. Look for lantern batteries or others of rather hefty construction.

Alkaline energizer batteries are nice if you are working with heavy loads and high currents. This is unusual in most breadboarding, and they probably are not worth the extra cost. Some suggested batteries available at economical prices are shown in Table I.

If you really have your mind set on power supplies, there should be a couple of them, or else one power supply and some batteries on your workbench.

Typical breadboards will contain somewhat less than all of an electronic system. Working on a receiver design, you may breadboard the tunable oscillator, simulate the agc system, test the audio amplifier, or do other tests on only a part of the overall system. This excellent engineering practice has a couple of very important, unavoidable bits of theory connected with it.

The first is that electronic circuits and their inputs frequently interact. If you duplicate the interaction, the breadboarded part of a circuit cannot detect the difference between your setup and the real thing. Driving or input sources typically have a source resistance and reactance, which can usually be duplicated by a little additional circuitry on the breadboard.

For example, suppose you are breadboarding a tape playback pickup circuit. How do you match the properties of the head? Simply by adding the equivalent circuit of the head to the breadboard (Fig. 3).

Similar arguments apply at the output side of the circuit. A loudspeaker is easily simulated by a resistor, but if you are checking an i.f. amplifier stage you may want to include the transformer as shown in Fig. 4. Some careful thinking will usually enable you to reconstruct real circuit conditions with reasonable accuracy.

A convenient arrangement for breadboarding operations is to set your generators, meters and other test gear about 4 inches above the working surface of the bench. A simple shelf assembly will achieve this. The fronts of the instruments become far more accessible, and the hazards of dragging a shirt sleeve across all the loose ends projecting from the breadboard are nearly eliminated.

Breadboarding tips

The purpose of a breadboarding project is to test your thinking, not to replace it. Good breadboarding is a fairly cerebral activity, one of the reasons for its low cost. The first requirement is a goal, or purpose, for building the breadboard. This is expressed most effectively by a schematic of the circuit, carrying notes about the circuit's anticipated performance. Results can usually be added to the schematic and corrections made as indicated.

Later a fresh schematic is drawn, giving a clear, concise summary of your results and finished design. The breadboard is dismantled, scrap materials and paper discarded, and the deck is cleared for your next job.

Fig. 3—Tape-head equivalent circuit can be breadboarded by using an inductor, resistance and capacitor to simulate tape head inductance, resistance and wiring capacitance. A resistor will simulate a loudspeaker at the output. The bottom resistor in divider network should be 10 ohms, not 10K.

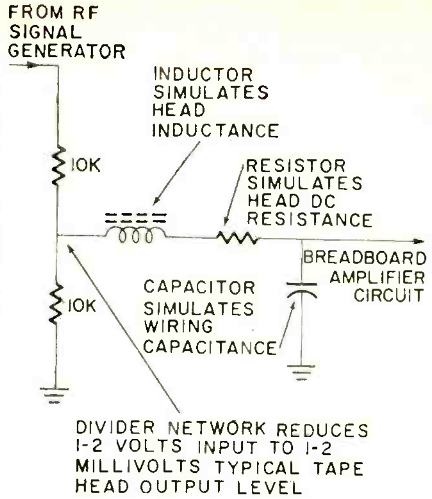
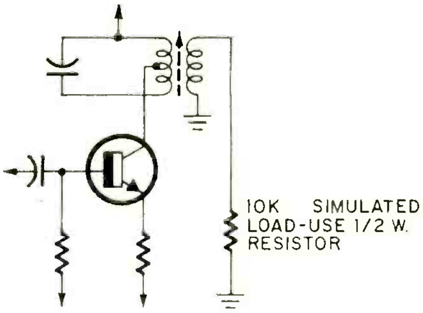


Fig. 4—Breadboard simulation of an i.f. amplifier might include use of an output transformer, and a resistor to duplicate the input resistance of a diode detector.



When you have your breadboarded circuit assembled on the bench, can you find your way around it easily? A bit of memorization will enable you to work more rapidly, and direct your attention to the problem rather than annoying details of color charts and data books. Memorize the color code in Table II, and learn how it is applied to resistors, capacitors and inductors.

Table II
Color Codes

Color	Number
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9
(Silver)	10%
(Gold)	5%

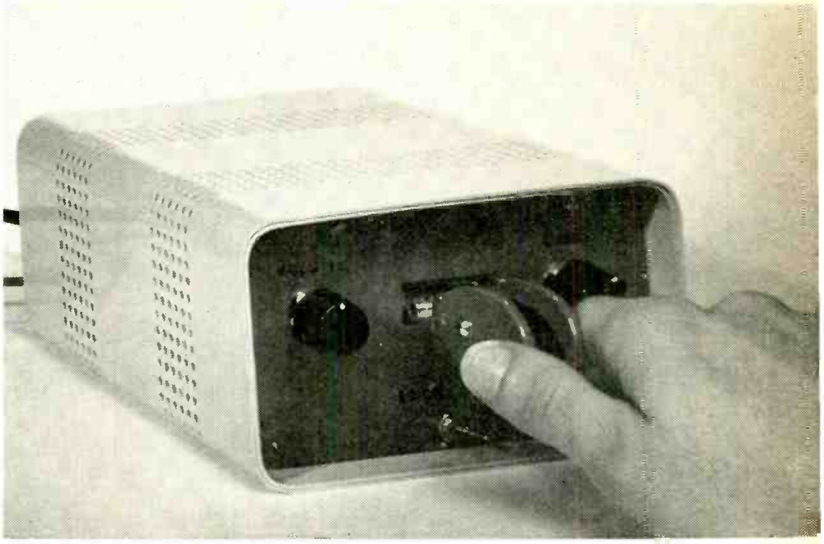
Table III
The Magic

Number Sequence
1.0
1.2
1.5
1.8
2.2
2.7
3.3
3.9
4.7
5.6
6.8
8.2
(10)

Since you may be breadboarding elaborate circuits once you've collected some materials and experience, you soon begin to appreciate being able to spot instantly that 3900-ohm (orange–white–red) resistor the schematic shows in the second transistor's collector circuit. Memorize the basic transistor lead configuration, too: emitter–base–collector, seen from top, goes clockwise.

Another handy bit of memory work is the series of magic numbers appearing in Table III. These are the same 12th roots of 10 numbers used for 10% values of resistors, capacitors and inductors. Compare this sequence with the resistor, capacitor and inductor values in catalogs. Another 12 values are added to this sequence to specify all standard 5% values. Perhaps in a few years all R, C and L values will be in this system. **R-E**

BUILD—
Perfect Electronic Keyer



An automatic Morse code keyer loaded with IC-controlled features.

PEK FEATURES

- Character and space memory (completes if key is released)
- Dashes always three times longer than dots.
- Squeeze keying gives dot–dash or dash–dot continually when both sides of key are closed. (Start depends on which side is closed first.)
- Loudspeaker and side-tone monitor jack for connection into receiver audio.
- Keying relay output for connection into any transmitter keying circuit.
- Lock-key to short across relay for transmitter tune up.
- Logarithmic speed control for linear change at fast and slow ends.

by W. O. HAMLIN, W6ENU

THE PERFECT ELECTRONIC KEYER CAN GIVE YOU PRECISE, fully automatic Morse code operation. Dashes are always three times longer than dots, and the design features self-completing dots and dashes, making it unnecessary to hold the key closed until either is completed

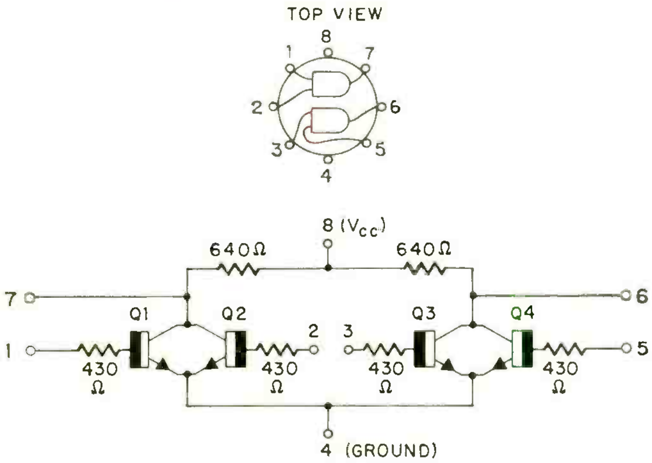
Closing one set of contacts on the double-contact key generates a string of dots as long as the position is held, and the other contacts provide dashes. Operating speed is controlled by a potentiometer. When both contacts are held, a string of alternating dots and dashes (or dashes and dots) is formed. This makes it easy to form common letters such as C.

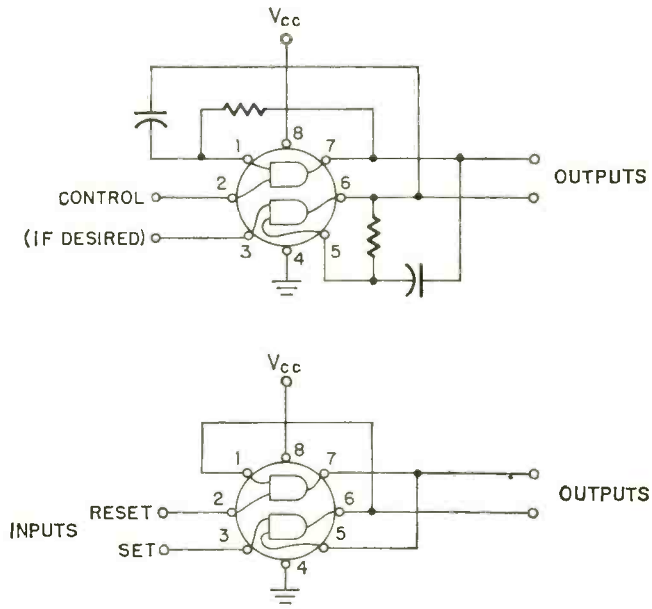
Unlike earlier keyer designs, a dot or dash is started the instant the contacts are closed—not at some indefinite time later. The PEK's built-in tone monitor is optional, since many ham rigs have side-tone monitors.

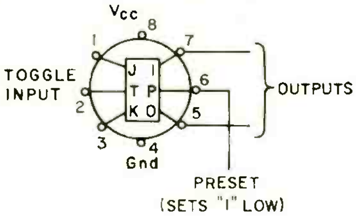
Building the PEK is a snap. Since 95% of the PEK's circuitry is inside the 11 inexpensive integrated circuits (IC's) used, even a novice can wire the PC board in about one hour.

Fig. 1—Dual two-input gate, the 914 IC, is shown below with its base diagram on top. PEK uses both NOR and NAND circuits.

Fig. 2—Cross coupling of 914 provides a freerunning multivibrator (top, right) or a "memory" flip-flop.







J	K	I	O
HIGH	LOW	HIGH	LOW
LOW	HIGH	LOW	HIGH
LOW	LOW	CHANGES STATES	
HIGH	HIGH	NO CHANGE	

Fig. 3—JK flip-flop used in PEK, the 923, is shown in a top view. Unit is strobed at its input to change its states. **Truth table** for 923 JK flip-flop, shows all logic conditions. High is a positive voltage, low is near-zero.

Fig. 4—Complete schematic diagram of the PEK keyer. IC's and a printed circuit board simplify construction. Note that the IC just to left of Q1 is IC-1, not IC-2.

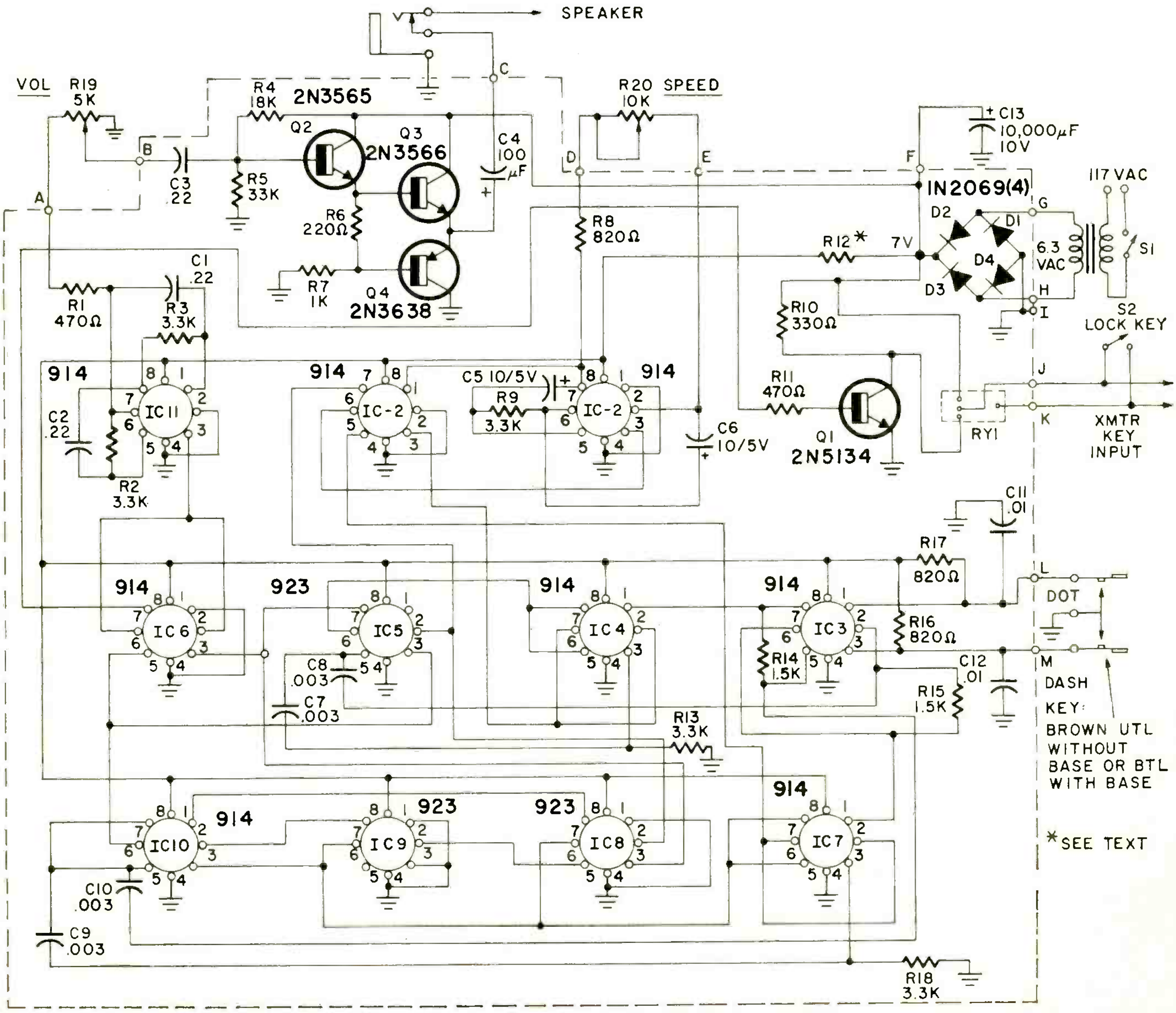
PARTS LIST

C1, C2, C3—0.22 μF capacitor
C4—100-μF, 10V capacitor
C5, C6—10-μF, 5V capacitor
C7–C10—0.003 μF capacitor
C11, C12—0.01 μF capacitor
C13—10,000—μF, 10V electrolytic capacitor (Sprague 39D 109G016JT4 or equivalent)

All fixed resistors ½ watt, 10%
R1, R11—470 ohms
R2, R3, R9, R13, R18—3300 ohms
R4—18,000 ohms
R5—33,000 ohms
R6—220 ohms
R7—1000 ohms
R8, R16, R17—820 ohms
R10—330 ohms
R12—(see text)
R14, R15—1500 ohms
R19—5000-ohm linear potentiometer
R20—10,000-ohm, CCW logarithmic potentiometer

Semiconductors
D1–D4—1N2069 diodes or equivalent
Q1—2N5134 transistor
Q2—2N3565 transistor
Q3—2N3566 transistor
Q4—2N3638 transistor
IC1–IC4, IC6, IC7, IC10, IC11—914 dual RTL gate integrated circuit (Fairchild or ITT)
IC5, IC8, IC9—923 JK flip-flop integrated circuit (Fairchild or ITT)

MISC—Hathaway G-P1A6 relay (distributed by Compar.) Key: Brown Bros. UTL (without base) or BTL with base. Box: LMB model CO-3. Box: LMB model CO-3.
A set of two PC boards for building the keyer, a keying relay and a complete set of transistors and IC's is available for $24.95 postpaid. A Brown UTL key is $11.95. Write: Solid-State Services, 1720 Kimberly Drive, Sunnyvale, Calif. 94087 (Atten: W6ENU).



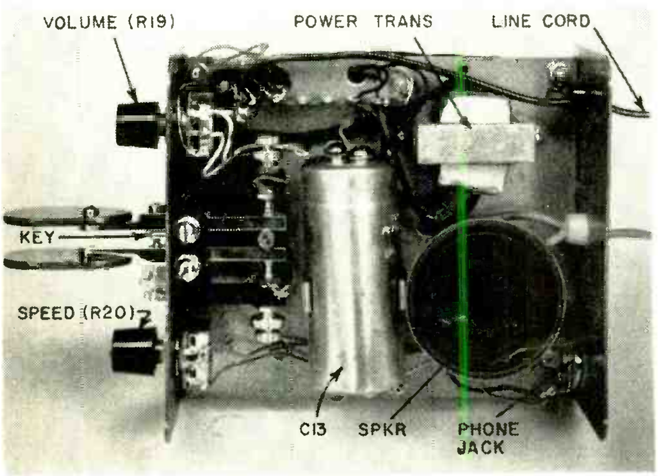
(BOTTOM VIEW OF IC'S)

Keyer logic elements

First, let's look at the IC logic elements that make up the PEK. Two types are used: 914 dual two-input gates, and 923 JK flip-flops. Fig. 1 shows the dual-gate circuit and its basing diagram. Transistors Q1-Q2 form one gate and Q3-Q4 form the other. Because resistors as used for loads and at the transistor inputs, these are called RTL (resistor-transistor-logic) circuits.

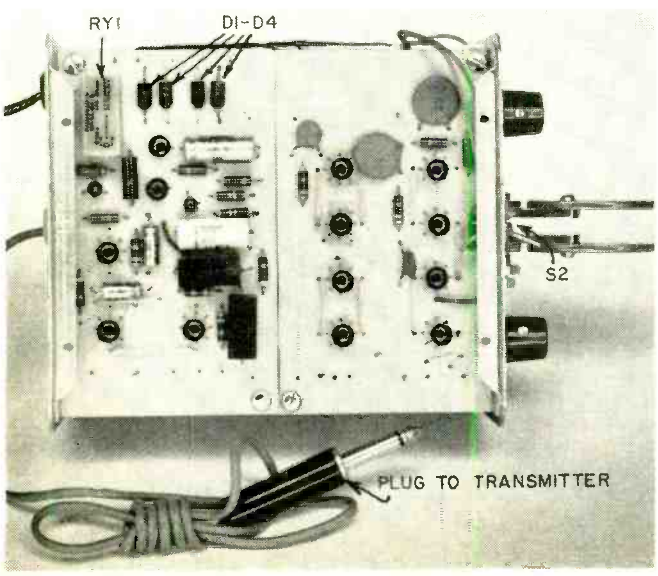
The basic circuit is called a NOR gate when the input is a positive signal. NOR means "not OR." By definition, an OR gate gives an output signal (voltage) when there is a signal at either input (either input *or* both inputs). The *not* OR situation arises when a positive input voltage causes a gate transistor to conduct so that the output voltage is a negative (inverted) signal. Since either transistor can produce the same output results, the OR definition is satisfied.

In computer logic terminology, the opposing type of circuit is the AND circuit. Both one *and* the other input must have signals to obtain an output. The NOR circuit can satisfy this definition by operating in reverse, and with inverting output it is called the NAND circuit. There is no output when both inputs are positive. That is, both transistors are conducting and the output voltage is low. One transistor *and* the other must be turned off before the output level changes. Notice that the change in definition of NOR to NAND requires a change in signal definition from a high to a low voltage level. The PEK uses both NOR and NAND logic concepts, as we'll describe later.



Top view of the PEK shows positioning of speaker, transformer and filter capacitor used. A crutch tip holds the speaker.

Printed circuit boards or perf-board arrangement can be mounted on lower side of the cabinet. Layout is not critical.



A dual-gate IC such as the 914 can be cross-coupled to form a bistable flip-flop as shown in Fig. 2. In a flip-flop, when one side is on the opposite side is always forced off. Since a bistable flip-flop stays in one of these states until forced to change by an external signal, it can be used for a "memory."

If the gates are cross-coupled with capacitors and dc bias is applied to the transistor bases, the on-off condition cannot be sustained. Instead, the two sides go on and off alternately, or oscillate. This is called an astable, or free-running, multivibrator. In the PEK, it is used for the timing oscillator and side-tone monitor.

The logic and base diagram for the 923 JK flip-flop is shown in Fig. 3. The device gets its name from the function of its J and K inputs. It must be "strobed" at the J input by a fast fall-time wave to trigger (change states). The truth table shows all logic conditions possible. "High" is a positive voltage; "low" is a near-zero voltage. For example, when the J input is high and the K input low, the output is a high voltage and the 0 output is a low voltage after the toggle input has been strobed. The JK's outstanding feature is that when both inputs are low it changes state each time it is strobed. This results in a frequency division of the strobing signal.

Note that in either type of flip-flop, when one output is high the other must be low, and vice versa. The preset "P" always sets the flip-flop the same way: when it is high the "1" output is low and the "0" output is high. Using these principles, the JK flip-flop in the PEK is used for frequency dividing to set the dot, dash and space relationships.

How the keyer works

The complete schematic of the PEK is shown in Fig. 4, and the waveforms in Fig. 5 help explain its operation. Keying pulses originate in the clock oscillator, IC1. Dots and dashes are generated independently from the same clock by the divider circuits: IC5 for dots, and IC8 and IC9 for dashes. Both portions of the circuit work identically, except the dash portion has an additional divider and decoding gate to make the dash three times longer than the dot.

Here's the circuit operation: IC3 is the input gate connected to the key. When the key is in neutral, the outputs of both gates (pins 6 and 7) are low. When the key is moved to the dot position, pin 1 is grounded, causing the output at pin 7 to go high. This sets the upper half of IC4 so that its pin 7 goes low. This removes the preset voltage on pin 6 of IC5, a JK flip-flop, permitting it to divide the clock signal. It also sets the input to the lower IC4 gate low, and its output (pin 6) goes high. This voltage is inverted in IC2 so that pin 3 in IC1 goes low, thus starting the "clock" oscillator. Therefore the lower half of IC2 acts as a clock control.

The output of the clock (IC1, pin 7) first goes negative and is inverted in IC2. This applies a positive signal to the toggle input (IC5, pin 2). When clock IC1 switches to the alternate cycle, its output goes positive, so that input to IC5 goes negative. This causes the JK flip-flop IC5 to change states, and its output at pin 7 goes from a low to high voltage, remaining high until the input action repeats itself.

Because IC5 flips only on positive-going signals of the clock, in effect it is dividing the clock frequency by one-half. This is the period of the dot. Pin 5 of IC5, which was low during the dot, goes high on the second flip of IC5 and sends a positive-going pulse through C7 and R13. This resets IC4 to its off state if the key has been opened, so that pin 7 is driven high. Thus, IC4 controls the dot circuitry. As long as pin 7 is high, dots will be turned off, and when low they will be turned on.

Dash dividers IC8 and IC9 and the clock are controlled by IC7 in the same manner that IC4 controls dots. The clock waveform is divided twice, so the output of IC9 is one-quarter the clock frequency. The wave from IC9 is connected to an OR gate, the top half of IC10, along with the output of the first dash divider, IC8. The resulting output is shown in Fig. 5. IC10 therefore acts to decode the outputs of IC8 and IC9 into a dash.

Since independent circuits are used for dot and dash generation, dot-dash memory is inherent in the system. One problem exists, however: dot and dash dividers IC5 and IC8 would start dividing immediately after a dot or dash is selected by the key, since their toggle inputs are tied together.

This is prevented by a dash-signal inhibit connection from the dash output of IC10 to pin 3 of IC5, and a dot inhibit connection from the dot output of IC5 to pin 3 of IC8. These connections are analagous to an interlock.

"Squeeze keying" is accomplished by feedback from C8 and C10. When a dot is completed, the positive reset pulse through C8 holds off any dot generation at IC3 (pin 3), but feeds through R15 to start a dash on pin 1 of IC7. Likewise, C10 performs the same function at the completion of a dash by holding off more dashes at pin 5 of IC3, but starts a dot by feeding through R14 at pin 1 of IC4. Therefore, continuous alternation of dots/dashes will occur as long as pins 1 and 4 of IC3 are held at ground by the key contacts.

The function of IC6 is to mix the outputs of the dot and dash generators and invert them so both a plus and a minus code signal is available to interface with transmitter circuits. The addition of a transistor amplifier and keying relay is the simplest way to meet any keying requirement.

Assembling a PEK

A pair of PC boards are available, along with the IC's and transistors used (see parts list). Pegboard construction can be used since the layout is not critical, but wiring runs should be kept as short as possible.

It may be necessary to shield the circuit from transmitter rf fields. Frequency response of the IC transistors exceeds 100 MHz, but induced rf signals over a few hundred millivolts can cause spurious triggering. Place the unit in an aluminum box, and bypass the leads going to and from the box with the capacitor values shown in Fig. 4. The monitor speaker is a 2¼-inch transistor radio type, pushed into a chassis-mounted crutch tip (available in drug or hospital supply stores).

An inexpensive 6.3-volt filament transformer is used with a bridge rectifier for the power supply. (The 6.3 volts may be available from an accessory plug on your equipment.) The 3.6 volts required by the IC's is obtained by dropping the rectified 6.3 volts through a resistor. Current drain is about 125 mA.

The value of dropping resistor R12 will vary according to the tranformer's internal resistance or the source resistance in the equipment. For a low-resistance source, the dropping resistor should be about 21 ohms. Measure the output voltage with the circuit drawing current to set it between 3.2 and 4 volts; decrease resistance for less than 3.2 volts measured and increase resistance for more than 4 volts.

Testing and troubleshooting

With the dc supply voltage adjusted as described above, and the key in the neutral position, the relay should be open. Moving the key so that pin 1 of IC3 is grounded should produce a string of dots, and grounding pin 3 of IC3 should generate a string of dashes. Potentiometer R20 varies the PEK speed. If the operation seems improper, check the chart of Fig. 6, which gives circuit test-point voltage readings. An L on the chart stands for a low voltage and indicates readings for a saturated collector. This L voltage should be less than 0.3. An H stands for high voltage (collector of a transistor which is off). The H voltage should be between 0.6 and the power supply voltage, depending upon the resistance loading at that point. **R-E**

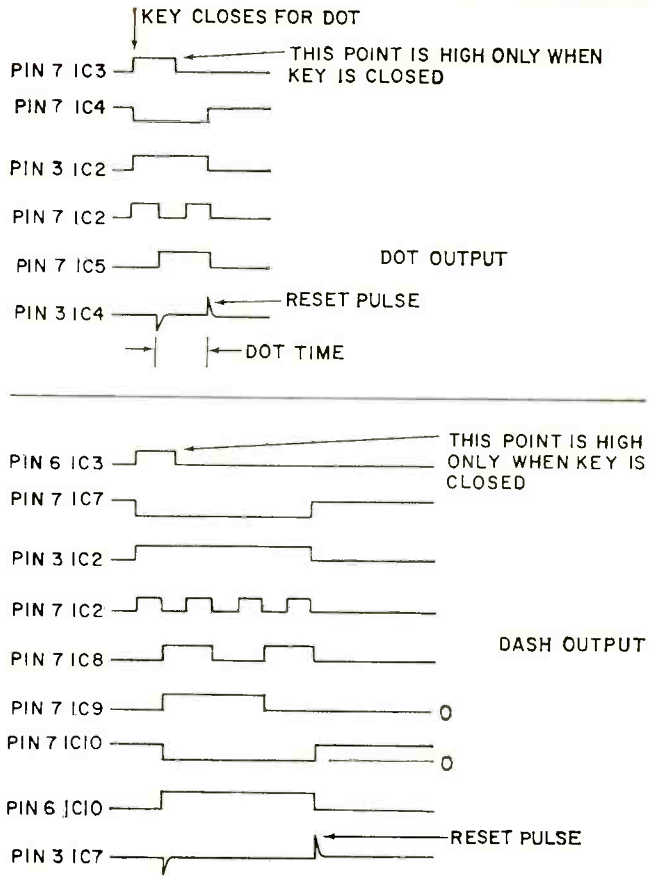


Fig. 5—Dot output for various IC's is shown on top above and the dash output below the line.

VOLTAGE READING CHART

IC	PIN NUMBER	KEY POSITION		
		NEUTRAL	DOT	DASH
2	3	L	H	L
	5	L	L	H
	6	H	L	L
3	1	H	L	H
	3	H	H	L
	6	L	L	H
	7	L	H	L
4	2	L	H	L
	3	L	L	L
	5	H	L	H
	6	L	H	L
	7	H	L	H
7	1	L	L	H
	2	L	L	H
	3	L	L	L
	5	H	H	L
	6	L	L	H
	7	H	H	L

L: LESS THAN 0.3V H: MORE THAN 0.6V

Fig. 6—Voltage chart can be used to check correct operation of the circuit. Value of H varies with supply loading.

Channel Separation Nomogram

By MAX H. APPLEBAUM

WHEN A STEREO-FM RECEIVER IS working properly, channel separation should be equal to or greater than the 30 dB the FCC requires of stations. Here is a nomogram you can use to measure and calculate separation.

Manufacturers often use the following method to measure separation:

1. Feed a stereo signal (left or right channel only) into the antenna input of the receiver. The input signal should be about 1,000 μV.
2. Adjust the receiver loudness control to obtain 0.5 volt measured with a vtvm connected across the speaker terminals.
3. Switch the signal, at the generator, to the other channel. Keep rf at 1,000 μV.
4. Read the resultant output level, on the vtvm, across the *original* speaker terminals.

The separation in dB, for that channel, is 20 $\log_{10}$. This is a ratio of the output level of the desired channel to the output level of the undesired channel. It is simply the ratio of the voltage measured in step 2 to that of step 4.

A simpler method is to feed in the signal as described in step 1 and measure the channel separation directly, without decoding the composite stereo signal. You can do this by viewing the waveform on a dc scope connected to the receiver second detector.

Fig. 1 shows the ideal composite signal with the 19-kHz pilot carrier removed. Such a waveform indicates infinite separation. In practice, however, this is impossible to obtain. Fig. 2 shows the signal which you'd normally see at the second detector. The amplitude of a signal of the *left* channel due to an input of the *left* channel only is represented by A. B represents the amplitude of a signal on the *right* channel due to an input on the *left* channel only.

Since these dimensions (A and B) are directly proportional to the voltages they represent, you can calculate the separation with this formula:

$$\text{Separation} = 20 \log_{10} A/B$$

Referring to the nomo, the calculation is now completed by extending a straightedge from the value of A on its column to the value of B on its column. The separation in dB is found where the straightedge crosses the center column.

In the example shown, A = 2, B = .05 and the separation is found to be 32 dB. **R-E**

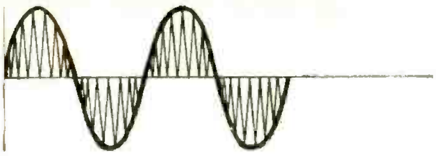


Fig. 1

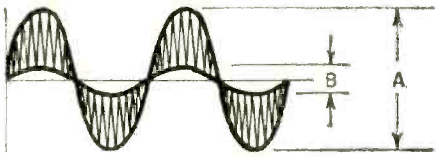
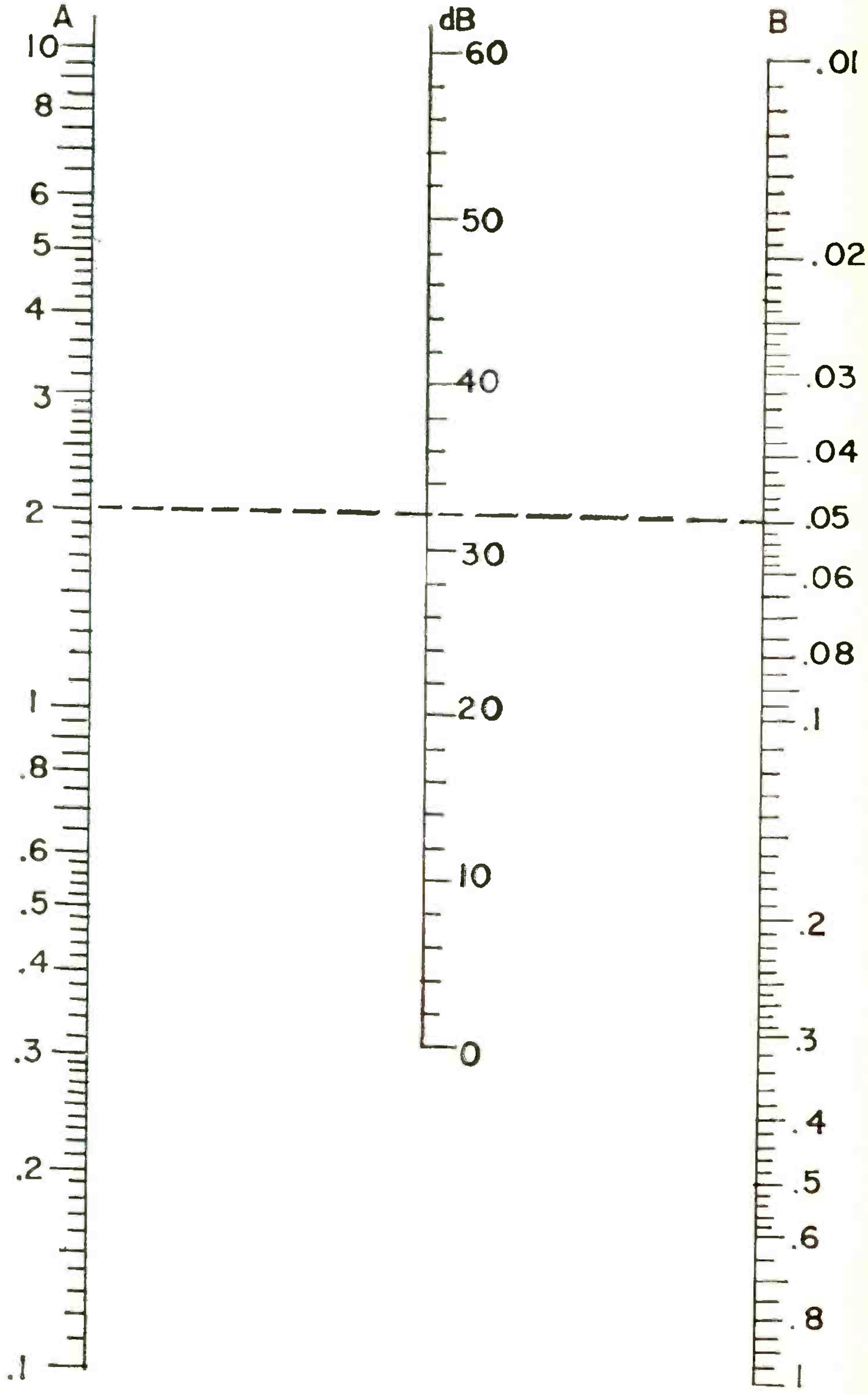


Fig. 2

NOTE: *The nomogram may also be used to calculate separation when the measurements are taken as described at the beginning of this article. Remember that scales A and B must always be in the same units.*



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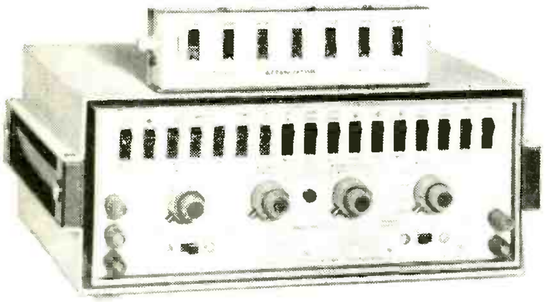

NEW Kit IG-57A

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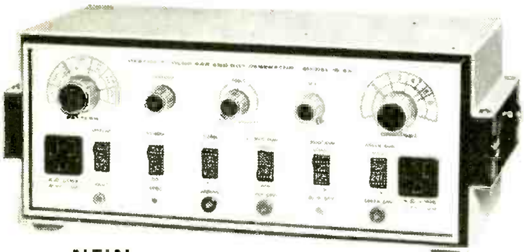
NEW, Improved Heathkit IG-57A Solid-State Post Marker/ Sweep Generator . . . Now With Built-In Video Sweep Modulator

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



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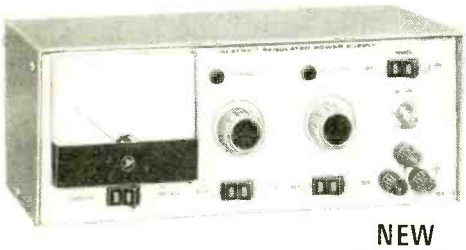
NEW Heathkit Color Bar-Dot Generator . . . Advanced Integrated Circuitry Produces 12 Patterns Plus Clear Raster, Eliminates Divider Chain Instability Forever

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



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NEW Heathkit Ultra-Deluxe "681" Color TV With AFT . . . Power Channel Selection & Opt. RCA Hi-Lite Matrix Tube

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

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

Heathkit "295" Color TV

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

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

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

NEW Deluxe Heathkit "581" Color TV With AFT

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

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

Heathkit "227" Color TV

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

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

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

NEW Heathkit Deluxe "481" Color TV With AFT

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

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

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

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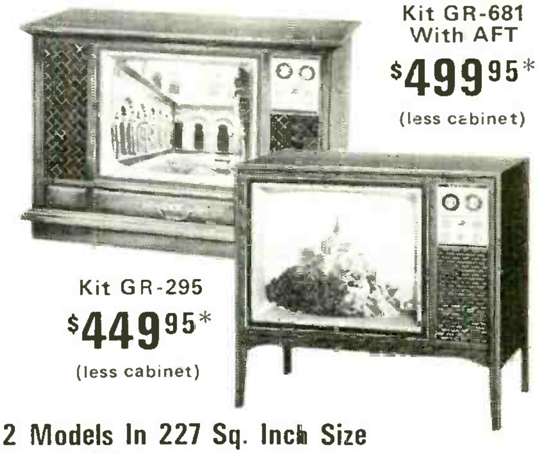

NEW
Kit GR-681
With AFT
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(less cabinet)

Kit GR-295
$449.95*
(less cabinet)

2 Models In 227 Sq. Inch Size

NEW
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Circle 33 on reader service card

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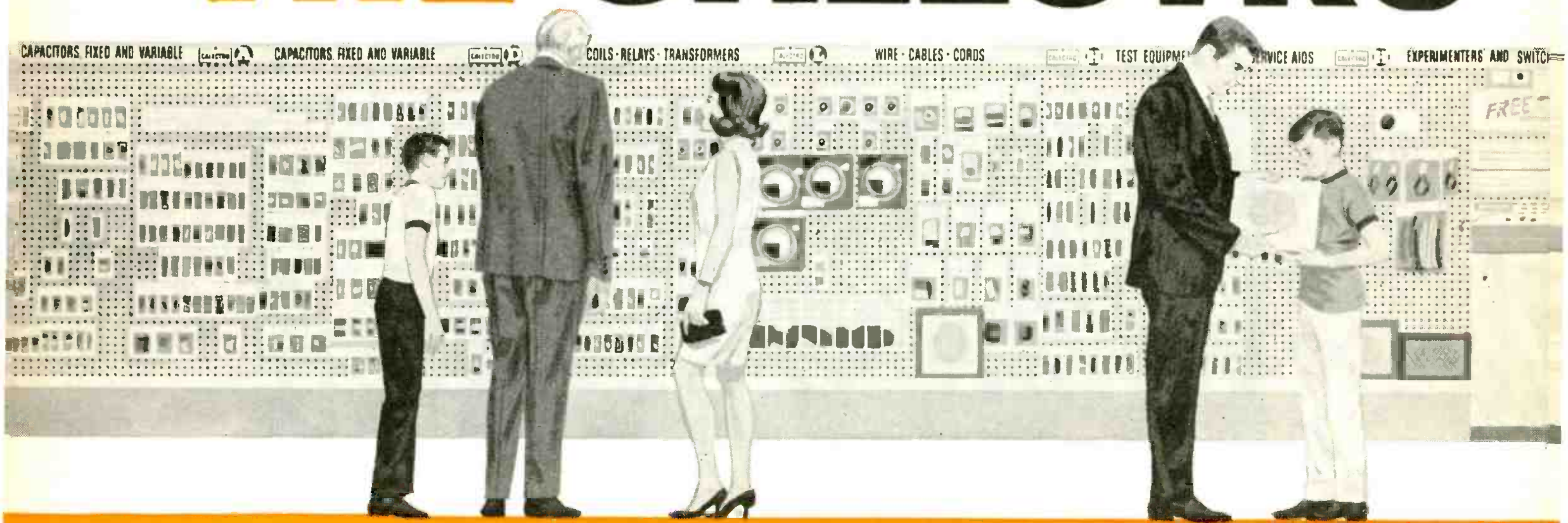

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Holds 4, 6-volt "C" cells; connect with wires
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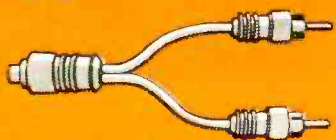

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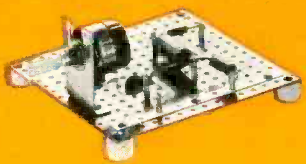

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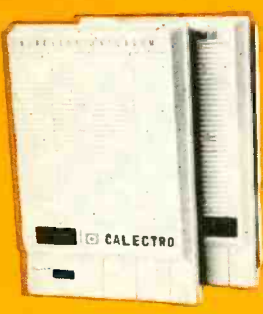

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TV WIRE STANDOFF HOLDERS
Wood screw type. 3½" long. Insulator fits "flat-line," foam and co-ax cable.
Cat. No. 32-050 Pkg. of 4 $.42 Net
Same as above, but 7½" long
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Attractively packaged 2 per pack, showing values, color codes and formulas.

Type	Rating	Sizes Available	Price	Unit
Carbon	½ Watt —10%	10 Ohm-10 Meg	$.19	Pkg. of 2
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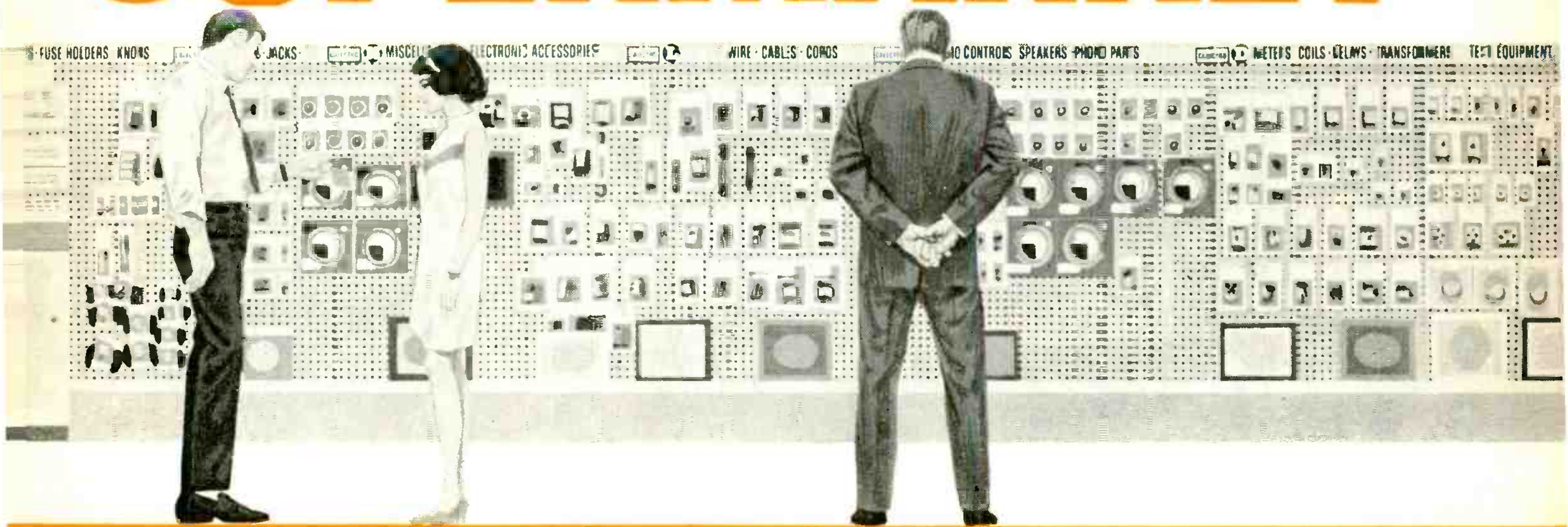
A1-063	680pF	.25	Pkg. of 2
A1-064	0.001uF	.19	Ea.
A1-065	0.005uF	.19	Ea.
A1-066	0.01uF	.19	Ea.

SUPERMARKET



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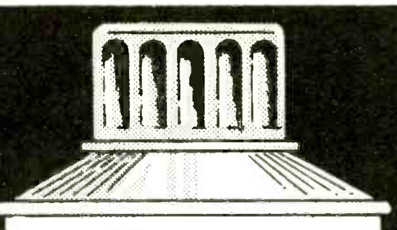

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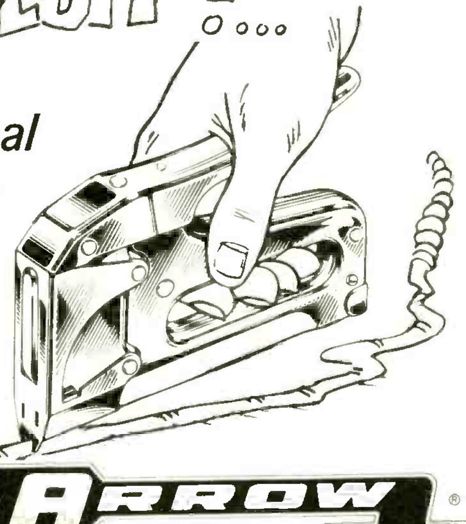

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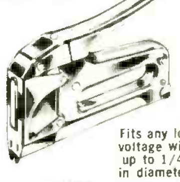
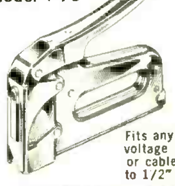


Fits any low voltage wire up to 1/4" in diameter.

Model T-75



Fits any low voltage wire or cable up to 1/2" dia.

ARROW FASTENER COMPANY INC.
271 Mayhill Street, Saddle Brook, N. J. 07663

Circle 41 on reader service card

← Circle 38 on reader service card

NEW PRODUCTS

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

ENGINE ANALYZER KIT, *Model KG-303*, uses a full-sized 2½" meter which has 4 rpm ranges from 0-6000 rpm, two dwell-angle ranges from 0-60°, plus a 0-16V voltmeter range. It may be used on 4-, 6- and 8-cylinder engines with

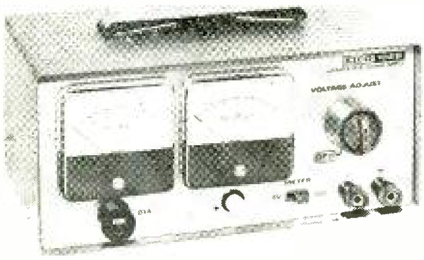
6- or 12-volt positive or negative ground ignition. This analyzer is able to test points, distributor and spark advance, and fuses. It can also be used as a continuity tester. 6½" high, 3½" wide and 2½" deep. $19.95.—**Allied Radio Corp.**, Chicago, Ill.

Circle 46 on reader service card

CASSETTE RECORDER, *Model RK-99*, offers 117-Vac and battery operation as well as complete record and playback facilities. Features include piano keyboard controls, record safety interlock (preventing accidental tape erasures), and cassette "pop up" removal. Ac bias recording system with automatic level control permits distortion-free recording. Input for radio, phono or tape recorder; output for external speaker or earphone. Recording time: 2 hours. $49.95.—**Lafayette Radio Electronics Corp.**, Syosset, N.Y.

Circle 47 on reader service card

POWER SUPPLY, *Model 1025*, all-transistor power source with built-in meters to provide continuous monitoring of both output current and voltage. Output voltage is variable from 0 to 30 volts. Max continuous load current is 150 mA in the 0-12V range, 200 mA from 12 to 24 V, and 300 mA from 24 to 30 V. Maximum ripple at full load is



0.005%. Power supply is fuse-protected against short circuits. Kit is $34.95; factory-wired $49.95.—**EICO Electronic Instrument Co., Inc.**, Brooklyn, N.Y.

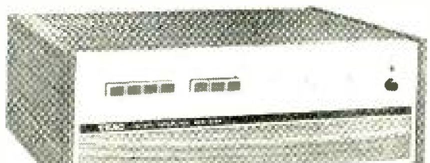
Circle 48 on reader service card

AUTO TUNE-UP METER, *Model ID-29*, weighs 2½ lb in polypropylene case; is completely portable. This meter uses no batteries and measures dwell, rpm's and dc volts on any 4-cycle, 3-,

4-, 6- or 8-cylinder engine with standard ignition. Signal and power received directly from engine under test. $29.95. —**Heath Co.**, Benton Harbor, Mich.

Circle 49 on reader service card

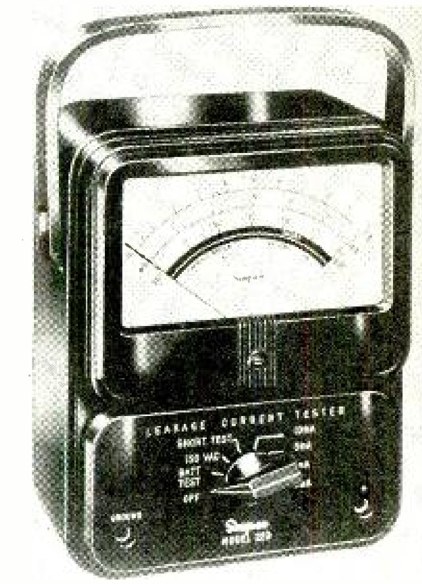
INTEGRATED AMPLIFIER, *Model AS-200*, is designed specifically for tape recording. It allows simultaneous recording and monitoring with three tape



decks and facilities for playback from five tape decks. The differential amplifier (a computer type circuit) eliminates output capacitors and their distortions. This amplifier delivers 50 watts per channel at 8 ohms, and 60 watts per channel at 4 ohms. Harmonic distortion is 0.5%. Features include: two loudspeaker outputs for main and remote stereo speaker systems, tone-control selector switch, pushbutton input selectors, and high and low filters. $299.50.—**TEAC Corp. of America**, Santa Monica, Calif.

Circle 50 on reader service card

AC LEAKAGE TESTER, *Model 229*, designed for testing 117-V/ac appliances and electrical equipment. Performance comes within ±1.0 dB of normal perception curve, and leakage currents as



small as 5 mA can be measured. Built for use on production lines and "in-field" service applications. Ac ranges cover 0-0.3, 1, 3, 10 mA; and ac voltage from 0 to 150 volts.—**Simpson Electric Co.**, Chicago, Ill.

Circle 51 on reader service card

TAPE ERASER, *Model 30-140*, can be used by hand or as table model. Hand-

held, the eraser is passed over the tape reel in a circular motion. As a table

Circle 106 on reader service card

model, tape reel is placed on the post and rotated. Can also be used for cassette recorders. Includes momentary switch and cord. $18.30.—**GC Electronics**, Rockford, Ill.

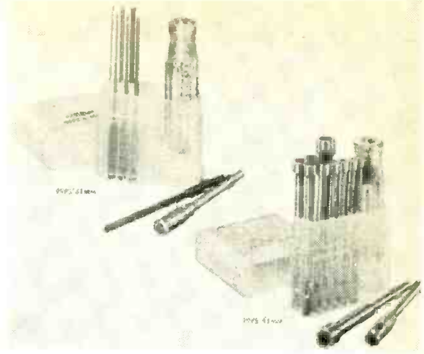
Circle 52 on reader service card

C-B TRANSCEIVER, *Model 14-523*, portable, 5-watt, 23-channel unit. Double superhet receiver has mechanical filter, an S and rf meter on the

rubber safety front panel. Final-stage efficiency is 65% delivering over 3.2 watts rf. Sensitivity is 0.5 mV. Variable squelch. ANL. agc. Weight: 3½ lb.—**Claricon**, Elizabeth, N.J.

Circle 53 on reader service card

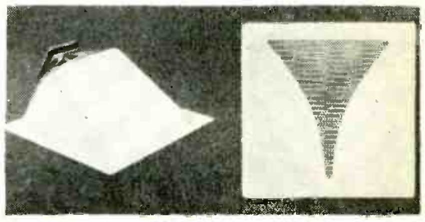
METRIC HAND TOOLS, in size ranges from 3 mm to 17 mm. The line includes 18 midget, regular and hollow-shaft fixed-handle nutdrivers particularly useful in the assembly and servicing of European and other foreign-designed equipment. Two compact, pocket-size sets are available: *Set No. 99-PS-41-MM* contains 7 hex socket, interchangeable blades with hex sizes from 1.27 mm to 5 mm, plastic handle and 4" exten-



sion. *Set No. 99-PS-51-MM* consists of 10 interchangeable nutdriver shanks with hex openings from 4 mm to 11 mm; handle and 4" extension.—**Xcelite Inc.**, Orchard Park, N. Y.

Circle 54 on reader service card

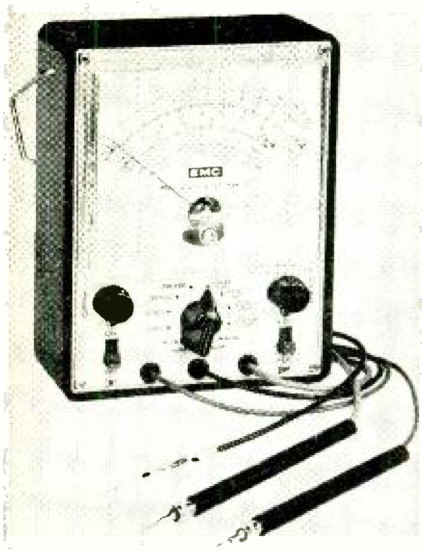
STEREO BACKGROUND MUSIC SPEAKER *Model AP-9C*. Flush-mounting ceiling speakers eliminate space and



decor problems. Each speaker sends sound forward in a broad pattern providing even tonal quality throughout a room. Can be used with home stereo systems; only one moderately powered stereo amplifier is needed.—Karlson Research and Mfg., W. Hempstead, N.Y.

Circle 55 on reader service card

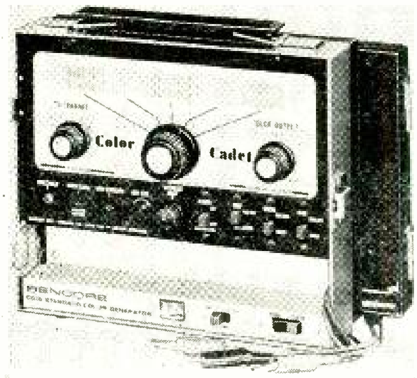
SOLID STATE VOLT-OHMMETER, *Model 116,* is 5¼" x 6¾" x 2⅞". This volt-ohmmeter achieves low loading (dc input is 11 megohms; ac input impedance is 1 megohm) as well as a sensitivity



that is 500 times as great as a standard 20,000-ohms-per-volt volt-ohmmeter. The solid-state circuitry and 4½" 200-MA meter are protected against burn-out. Peak to peak voltage ranges: 0 to 3.3, 33, 330, 1200 volts. Rms ac voltage ranges: 0 to 1.2, 12, 120, 1200 volts. Dc voltage ranges: 0 to 1.2, 12, 120, 1200 volts. Resistance ranges: 0 to 1,000, 0 to 100,000, 0 to 10 meg., 0 to 1000 meg. Kit is $29.95; wired model $39.95. —Electronic Measurements Corp., New York, N. Y.

Circle 56 on reader service card

COLOR GENERATOR, *Model CG18,* is an unusually compact unit providing 10 RCA color bars, full-line crosshatch, dots, and individual vertical and horizontal lines. The timer controls are on the front



panel, and range has been doubled to prevent the timers from jumping time. Special features include: interlace control to stop dot bounce, crystal-controlled 4.5-MHz sound carrier for adjusting fine tuning, and automatic shut-off when lid is closed.—Sencore Inc., Addison, Ill.

Circle 57 on reader service card **R-E**

Circle 107 on reader service card

Circle 108 on reader service card

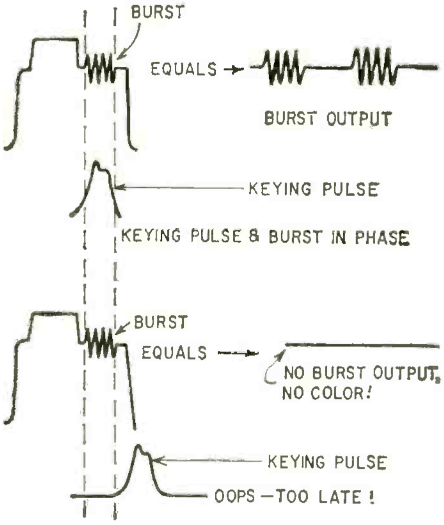
Service Clinic

By JACK DARR
SERVICE EDITOR

Horizontal phase vs color

Why does the adjustment of the horizontal-hold control affect the color while still holding the picture? I've seen this on a couple of sets.—E. K., Woodland Hills, Calif.

Color burst is taken from a *keyed* stage, and works exactly like keyed agc and sync separators. Unless the keying pulse from the flyback is exactly in phase with the color



burst, you won't get any burst output, and away goes the color.

The horizontal hold has a far wider "hold range" than does the burst. Burst itself is actually only about 2–3 μsec wide, sitting on the back porch of the horizontal sync, which itself is only 15 μsec. You've got to be right on the nose with your gating pulse, or the burst will find the "gate" slammed shut in its face!

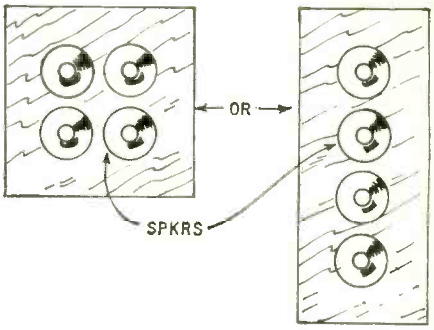
Adding Speakers

I need some information. I want to add a speaker to a transistor amplifier, and the specs call for a 30-32-ohm impedance. Only one speaker like this is listed, and it's a 4-incher. I need a bigger one, preferably 12-15 inches.

What's a safe hookup, using regular speakers?—F. B., Tacoma, Wash.

There are several ways you can do this: four 8-ohm speakers in series, two 16-ohm speakers in series, etc. Anything that will add up to the 32 ohms you need.

If you can't find a big speaker, here's a sneaky way to do it. Use four 8-inch, 8-ohm speakers in either of these arrangements. The "in-line" layout will give you something like a

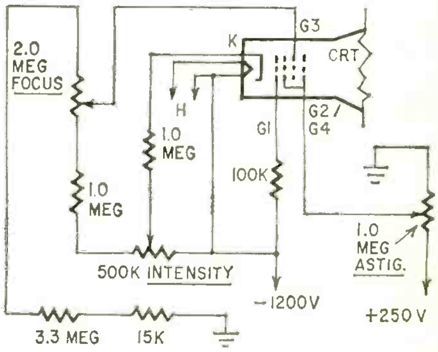


sound column, and the square layout will work almost like one 16-inch speaker. All voice coils must be in phase, of course.

Scope intensity-control burnout

I have an old Knight scope that I've overhauled. It keeps burning out the intensity control! What do you think?—A.B. No. Miami Beach, Fla.

Here's a partial schematic of the voltage-supply network of a Knight 83YU144. Note the high *negative* voltage applied to the cathode and



heater, and the positive voltage applied to the screen (G2/G4).

Your intensity control will be in either the cathode—as it is here—or the control grid. In some scopes, there are bypass capacitors around this network; look for one. Otherwise, I'd suspect a heater–cathode short in the tube, or a wiring short if it's an old instrument. Try using a heavier wattage pot, say 2–3 watts for this particular control. **R-E**

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

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

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

AUDIO EQUIPMENTS, mono/stereo, including phonographs in the *AVT Series* and *EDT Series* plus headphones and listening center kits are illustrated in non-technical terms with photos in a 20-page catalog entitled "NEWCOMB". Items featured are useful especially for classroom purposes.—**Newcomb Audio Products Co.**, Sylmar, Calif.

Circle 61 on reader service card

STEREO CARTRIDGE PLAYERS, 8-track, come in 5 models: all with a tape speed of 3¾ ips, frequency response, 40–15,000 Hz and signal-to-noise ratio, 50 dB. Three models feature power outputs of 10 watts and two include two 5¼" high-compliance speakers. Full description and specs of these units are described in *Form CU-2174*. 4 pages.—**Telex Communications Div.**, Minneapolis, Minn.

Circle 62 on reader service card

OUTLET PLATES, **UHF/VHF/FM** include *Magna-Grip* that holds antenna wire snug under pressure to assure proper lead contact for better signal reception. While wire cannot be pulled from plug, plug can be pulled from wall socket at any angle without damage to the wire or wall plate. Five models in the Colortap/Rotortap Series are described in Catalog "Get A Grip on A Profitable Market," 4 pages.—**Blonder-Tongue**, Newark, N. J.

R-E

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Circle 111 on reader service card

Circle 112 on reader service card

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- **Automatic Antenna Rotators**
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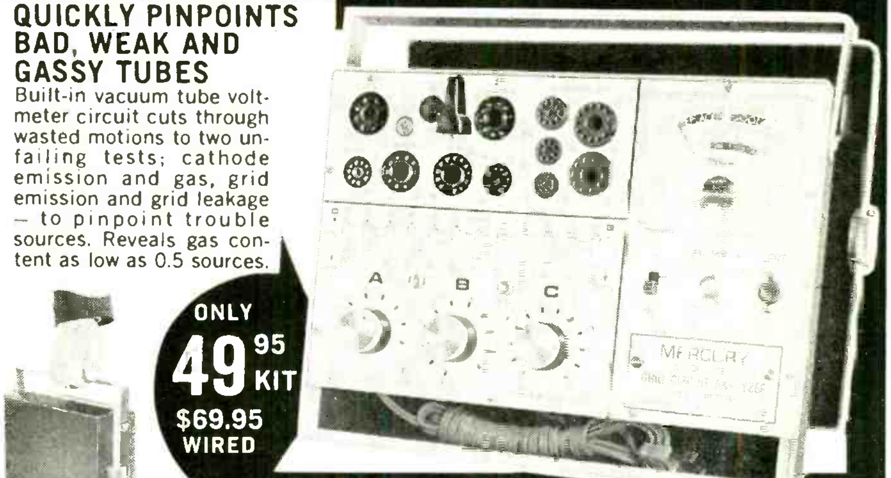
- **Transistor Curve Tracer**
  Want to know the characteristics of that unknown bargain-basement semiconductor? Use this instrument with your scope to find out. Build it with ICs.

- **Programmed Course**
  Automatic-fine-tuning is here today in many of the new color sets. Here's a painless way to see how it works and how to keep it working.

- **Fuzz Box**
  Another add-on for your guitar amplifier. Use it to add another dimension to your electric music.



TECHNOTES

G-E KE COLOR TV CHASSIS

Whenever power supply diodes CR109 or CR110 fail, shunt a 0.001-μF, 1-kV capacitor (G-E part ET-22X58) across each diode. The capacitors provide added protection against possible damage by voltage surges.—*G-E Service Talk*

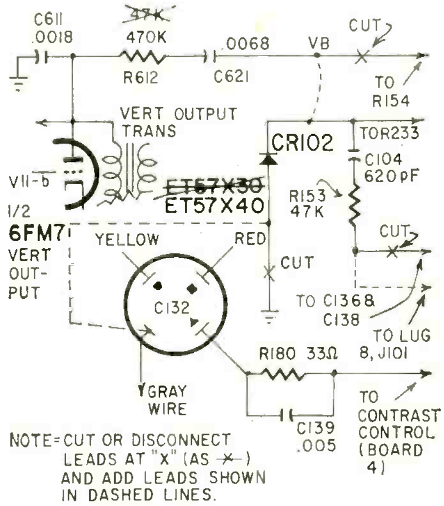
GENERAL ELECTRIC KC-KD CHASSIS

Raster shading where the right half of the raster appears substantially darker than the left may be observed during periods of no video modulation (camera changes, etc.). This shading may be accompanied by a retrace "snake." In either case make the following changes.

1. Change diode CR102 to a G-E type ET57X40. Move the anode (ground) end of CR102 to the positive terminal of C132-B (the uncoded lug of electrolytic C132).

2. Disconnect the end of R153 from the junction of C136 and C138 and connect it to lug 8 of jack J101.

If vertical retrace lines appear,



make the following changes.

1. Change R612 from 47,000 to 470,000 ohms, ½ watt. Disconnect the wire going from circuit-board terminal VB (or C612) to R154. (R154 is now excess and may be removed.)

2. Reconnect wire from VB to the cathode end of CR102.—*G-E Techni-talk* **R-E**

NEW BOOKS

RCA TRANSISTOR, THYRISTOR, & DIODE MANUAL, SC-14. Commercial Engineering, RCA Electronic Components, Harrison, N.J. 07029. 8 x 5¼ inches, 656 pp. Soft cover, $2.50.

A useful volume for anyone working with semiconductors. Some 200 pages of text explain solid-state fundamentals clearly and in detail; chapters cover numerous device applications—TV. linear systems. power, switching and more. The technical data section provides detailed data and design curves for some 900 devices. Circuits section presents circuits and parts list for 38 solid-state devices—from code oscillator to FM stereo multiplex decoder.

FEEDBACK AMPLIFIERS AND OSCILLATORS, by Robert E. Sentz and Robert A. Bartowiak. Holt, Rinehart and Winston, Inc., 383 Madison Ave., New York, N. Y., 10017. 6 x 9 in., 218 pages, soft cover, $3.95.

This is another in the Electronics Technology Series slanted toward technical institutes and junior colleges. Requires a good grounding in electronic fundamentals and math. The various types of feedback and factors influencing feedback are described in the first three chapters. Other chapters analyse most types of oscillators. including crystal, negative-resistance. RC, LC and uhf and microwave oscillators. **R-E**

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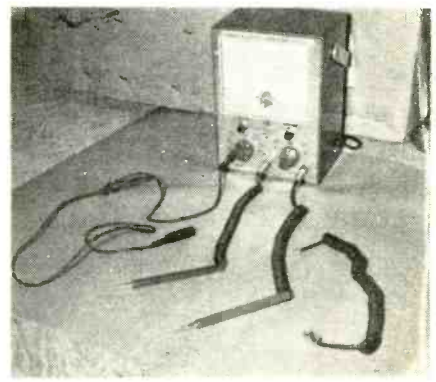
Circle 122 on reader service card

Circle 124 on reader service card

TRY THIS ONE

COILED-CORD TEST LEADS

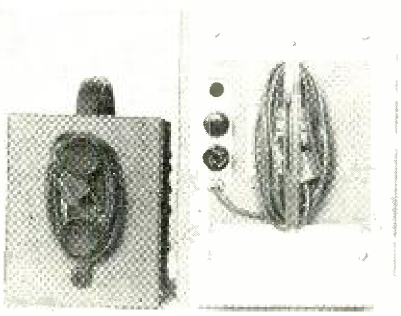
Delicate test instruments may suffer severe damage when their lengthy leads snag on tools or equipment on test benches and land on the floor.



A partial cure for this hazard is to replace the regular-length test leads with the much shorter, coiled leads used on camara flash units. The coiled leads stretch out to where they're wanted, then retract out of harm's way. Should they lose their spring, rewinding the coiled turns in the opposite direction restores their springiness.—*Harry J. Miller*

STOWING LINE CORDS

Are you at a loss as to what to do with a dangling power cord when storing or moving a piece of test equipment? A simple remedy is to install a cabinet drawer handle on the rear panel of the test equipment. The



power cord is then neatly wrapped out of the way around the handle. The drawer handles, which can be purchased at any hardware store, come in various shapes, sizes, and colors. The photo shows two types of handles that are easy to use.—*Harry Gondo*

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When the life goes out of a rubber idler wheel in a phonograph, and the drive surface becomes glazed and slips, clean the drive surface with a service cleaner, then give it a couple of coats of rubber paint—the kind used for refinishing the surface of rubber mats, tires, etc. When this is dry, it will give the idler sufficient "tack" to drive the turntable without slipping, while a new idler is on order. It isn't recommended as a more permanent cure since, when life goes out of the idler's rubber, it loses resilience, and consequently, tends to transmit more and more motor noise to the turntable.—*Frank H. Tooker* **R-E**

TRY THIS ONE'S WANTED

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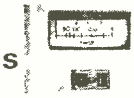

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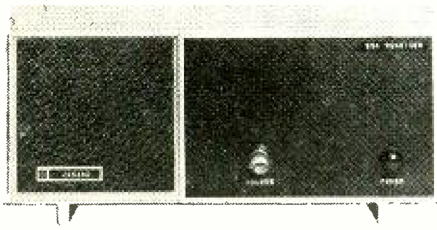

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Welcome to The Confused Club. I checked schematics and connections on two or three convergence-yoke and board assemblies. They are *functionally* the same—they do the same things—but they do it in different ways. I traced out the circuits and kept meeting myself coming back.

I doubt if we'll ever be able to use convergence assemblies from one make on sets of another through the use of an adapter plug, etc. It's often confusing enough changing *models* of the *same* make on a test jig.

Minor differences upset things. One make will use a small transformer to feed certain pulses into the convergence circuits; another will feed them through a capacitor. Some use two shaper diodes, others use four, and so on.

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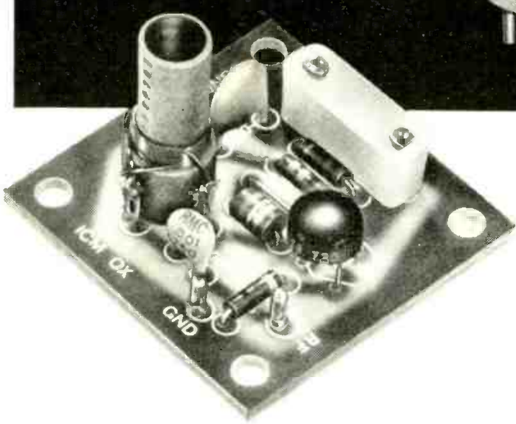

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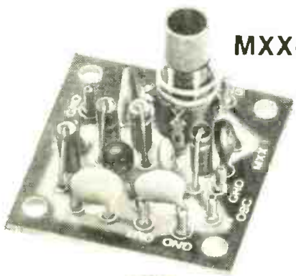
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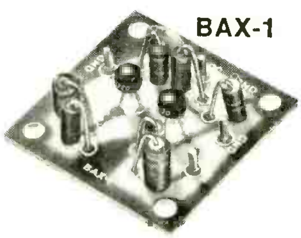
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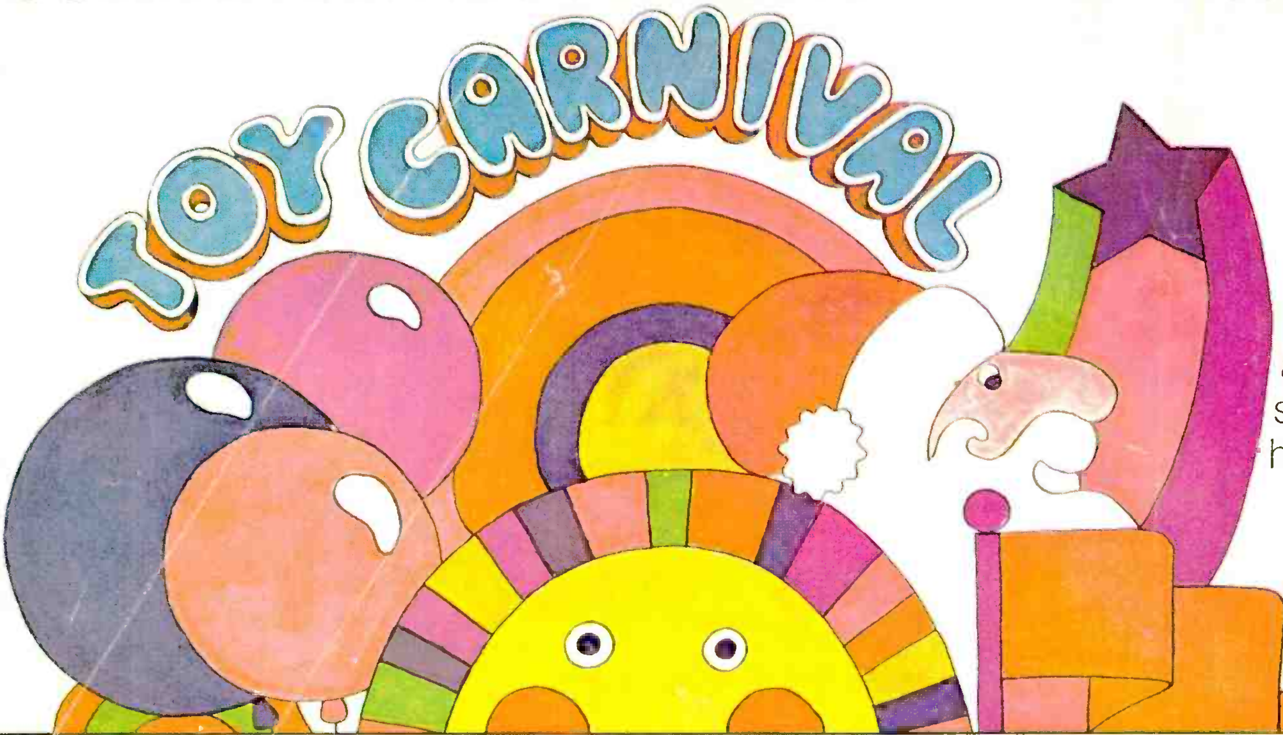

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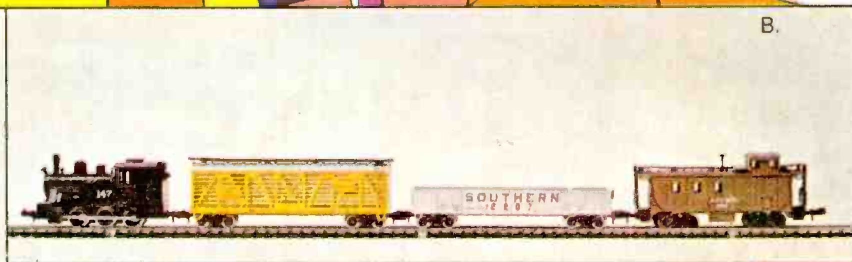

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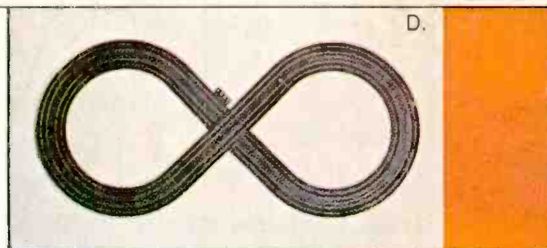

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