60c ■ JULY 1967

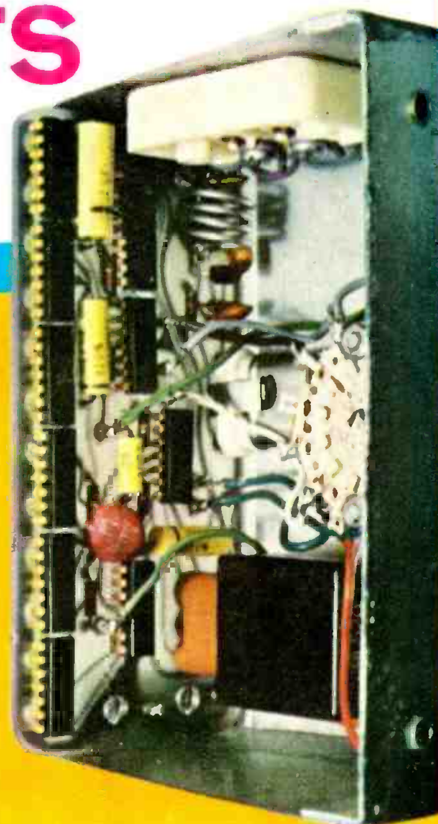
Radio-Electronics

TELEVISION · SERVICING · HIGH FIDELITY

A GERNSBACK PUBLICATION

HUGO GERNSBACK, Editor-in-chief

TEST INSTRUMENTS ISSUE



BUILD Color TV Convergence Generator

IC

BUILD for Stereo

BUILD for Lab

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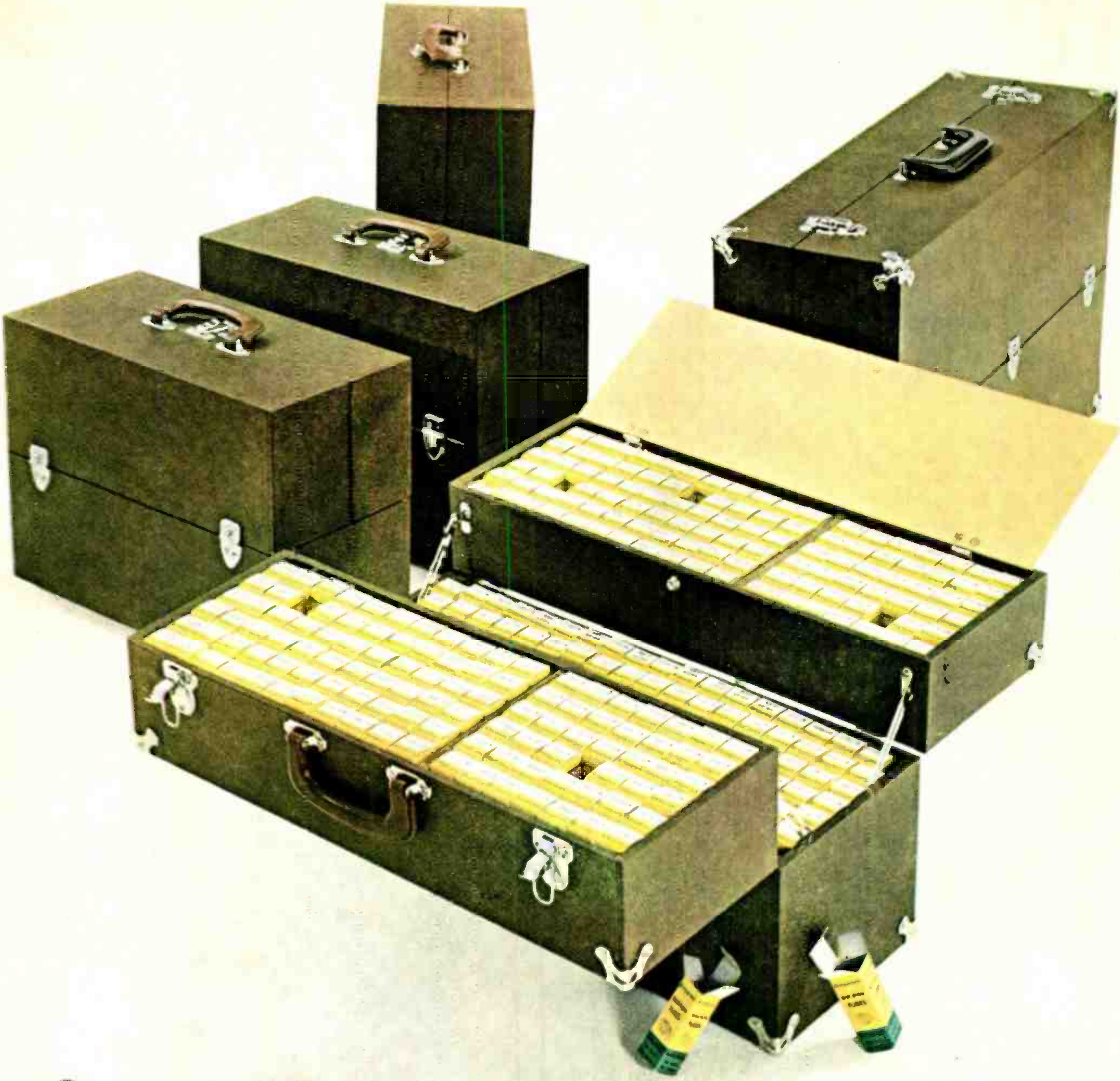
BUILD for Audio

IC



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

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

Amperex

TOMORROW'S THINKING IN TODAY'S PRODUCTS

FROM THE EDITOR

Microelectronics and Test Instruments

WHEN THE MICROELECTRONIC circuit—now called an integrated circuit or IC—made its debut in consumer electronics a little more than a year ago, it started a trend that is certain to bring about revolutions in our servicing techniques and in the design of test instruments. These tiny signal-processing modules, no larger than a small-signal transistor, are replacing complete stages using discrete components that occupy hundreds of times as much space. Thus, in the main, we can expect miniaturization in consumer electronics to an extent that we would not have dreamed of a few years ago.

A number of late-model TV sets use an IC in the sound i.f. system. Within the next few years, we can expect to find IC's in many other circuit applications. It is not difficult to imagine a single IC replacing the TV sync separator, sync amplifier and discriminator. A second IC, probably a pair of flip-flops, will replace the vertical and horizontal oscillators in the deflection circuits. At the present time, transformers or capacitors are required for coupling between IC's in many applications. However, the new resonant-gate transistor and similar advances in semiconductor technology can be expected to eliminate these in short order. Soon we will have IC's working from audio well up into the microwave region while handling large amounts of power without resorting to bulky heat sinks.

Since transistors and diodes are used in IC's to replace many of the discrete capacitors and resistors in conventional circuitry, we'll have fewer test points. Our present ohmmeters and capacitor checkers won't be enough to do an efficient troubleshooting job. We will have to develop new servicing techniques to isolate trouble in equipment using IC's.

Probably the most practical method of servicing equipment composed chiefly of IC's will be a combination of signal tracing and signal substitution. Our test instrument will be a modern-day version of the old Meissner Analyst or Rider Chanalyzer—probably the most versatile of test instruments available in the late 1930's, and early 1940's.

All solid-state and battery-operated, the TV tester of tomorrow will incorporate a complete video generator supplying composite video signals at rf carrier frequencies, along with separate sound i.f., video i.f., sync, video, color-burst and horizontal- and vertical-deflection signals for injecting into suspected stages. A wideband scope and digital-type high-impedance voltmeter will be included for signal tracing and monitoring. To complete the test-instrument lineup, we may have a similar instrument designed for AM, FM and FM/multiplex servicing. In fact, such an instrument may well be combined with our TV tester to give the service technician a very versatile test instrument.

To get a preview of our tester of tomorrow, imagine the test instruments on our cover combined with a vtvm and miniature scope. We could develop a very useful package hardly larger than a modern tube tester. Our tester's minimum size would be determined, not by the electronics, but by the minimum practical dimensions of its operating controls and read-out devices such as meters and calibrated dials. By incorporating IC's in our design our tester will be more immune against the effects of voltage and temperature changes and mechanical shock than if we were to use discrete components. Thus, testers of tomorrow will be as stable and precise as laboratory standards of today. —*Robert F. Scott*

Radio-Electronics

July 1967 VOL. XXXVIII No. 7
Over 55 Years of Electronics Publishing

EDITORIAL

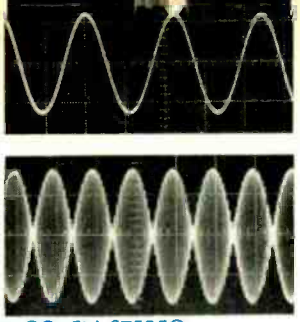
TEST INSTRUMENT PROJECTS TO BUILD

SPECIAL ON TEST INSTRUMENTS

GENERAL ELECTRONICS

SERVICING

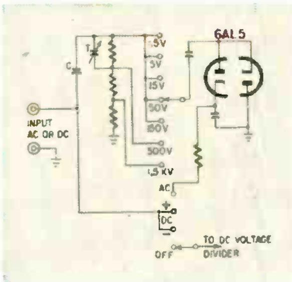
THE DEPARTMENTS



p 32—FM STEREO

p 44—AUDIO BURSTS

p 47—FM GENERATOR



p 58—INSTRUMENT CARE

p 66—HUNT SIGNALS

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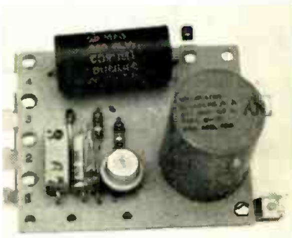
VIDEO PATTERNS

p 36—Nobody likes to watch a nonlinear TV picture. Here's a compact, portable pattern generator you can build. It makes linearity adjustments a snap.

SOLID-STATE MATCH



p 41—A "cold" gas range that's ignited by an SCR; a transistorized clothes dryer that shuts itself off when the load is dry—these are two uses of semiconductors in appliances.

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

NEWS BRIEFS

TIME SIGNALS

Standard frequency and time stations WWV (Fort Collins, Colo.) and WWVH (Maui, Hawaii) are now making voice announcements in Greenwich Mean Time (also known as Universal Time, or UT). The National Bureau of Standards stations thus have joined time and frequency stations in other countries which have been making announcements in GMT for some time.

Low-frequency WWVB (which does *not* make time announcements in voice) is one of only two stations currently transmitting the internationally recognized unit of time—the atomic second—in a coordinated system. DCF77, at Mainflingen, West Germany, transmits pulses which are synchronized to within 1 msec of those from WWVB. Both stations use the Stepped Atomic Time System; time pulses are one atomic second apart, and carrier frequencies remain constant at their nominal values.

INFRARED DATA TRANSMISSION

An unusual method of sending information is used at Expo 67—the international exposition held at Montreal, Canada this year. Stock quotations from the Montreal Stock Exchange are converted to electrical impulses and fed to a device using a crystal of gallium arsenide. The crystal changes the signals into variations in a beam of infrared light, which is transmitted almost 2 miles to the Expo 67 grounds.

A second infrared beam is used to transmit signals from an IBM computer in the Canadian pavilion to a graphic display terminal (shown in the photo) in the Man-the-Producer pavilion half a mile away.

Experimental light-beam data transmission was developed by engineers at IBM's Systems Development Division laboratories at Poughkeepsie, N.Y.

MORE ON WALKIE-TALKIE RULE CHANGE

As reported in this column in our April 1967 issue, the Federal Communications Commission has proposed to change its regulations governing 100-mW Part 15 transmitters operating in the 27-MHz Citizens band. Chief provision is to move license-free walkie-talkie operation to 5 channels in a band from 49.9 to 50.0 MHz.

If adopted, the new rules would also require the following: frequency tolerance of .01%; total dc power input under any modulation condition not to exceed 100 mW; superregenerative detector in associated receiver prohibited; transmitter must be type approved; certain limitations on spurious emissions.

Present 100-mW operation in the 27-MHz band would be permitted for 7 years following adoption of the new regulations.

MAJOR ANTENNA BREAKTHROUGH?

Ever since Marconi stretched a longwire and copied history's first DX, the problem of antenna size versus available space has given engineers and technicians headaches. An antenna which is physically small (compared to wavelength) simply doesn't capture very much signal. Hence its gain is low and it doesn't respond very well to weak signals. For convenience, however, most people prefer small antennas; TV rabbit ears are a good example. Yet such antennas are inefficient.

Three recent developments could mean a really efficient yet small antenna. Putting an rf preamp at the antenna terminals has been done for some time for a greatly improved signal/noise ratio. But the relatively recent development of inexpensive high-gain rf transistors has made possible a type of antenna which is a combination of active and passive elements. The idea they seem to share is to "marry" transistors to individual antenna elements.

Late in April the US Air Force revealed what was called a *Subminiature Integrated Antenna* (SIA). As shown in the drawing, transistors are connected between the antenna ele-

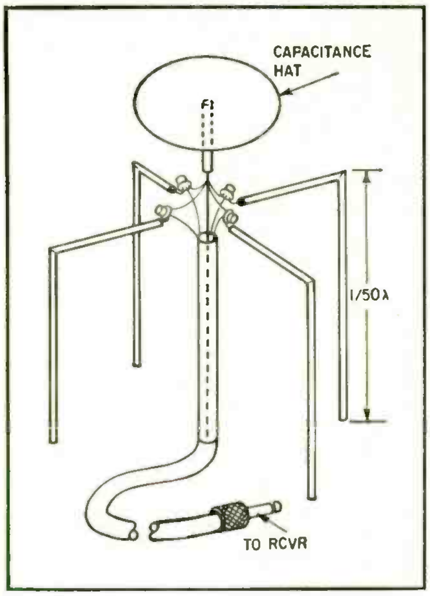
CORRECTION

In the schematic of the walkie-talkie power booster, page 60 of the March issue, there should be a connection between the emitter return and the B− bus. The dot indicating the connection should be at the point where the line from the fixed contact of S1-b crosses the horizontal line connecting C6, C7 and the emitter of the transistor.

We thank Mr. Bernard C. Lafreniere, of San Diego, Calif. for calling this to our attention.

Circle 9 on reader's service card

NEWS BRIEFS continued



ments and the coaxial lead-in. A top hat of capacitance is also connected to a common junction. This hookup makes it practical, it is claimed, to reduce antenna length from ¼ to 1/50 wavelength and still have reasonable signal pickup. A TV or FM receiver version could be 2 or 3 inches long. Because of the transistor's beta, the SIA has a lower resonant frequency than a passive element alone. Characteristic impedance is close to that of standard coaxial cables, and can be matched by adjusting the transistor transconductance. Bandwidth of the solid-state antenna is greater than that of a passive version. The new antenna can be made in horizontal or vertical configurations, bidirectional or omnidirectional.

SIA was developed during a 4-year program by the Air Force. Inventor is Edwin M. Turner of the

"Would you mind turning that off, Al? You know I can't stand people watching me when I work."

Radio-Electronics

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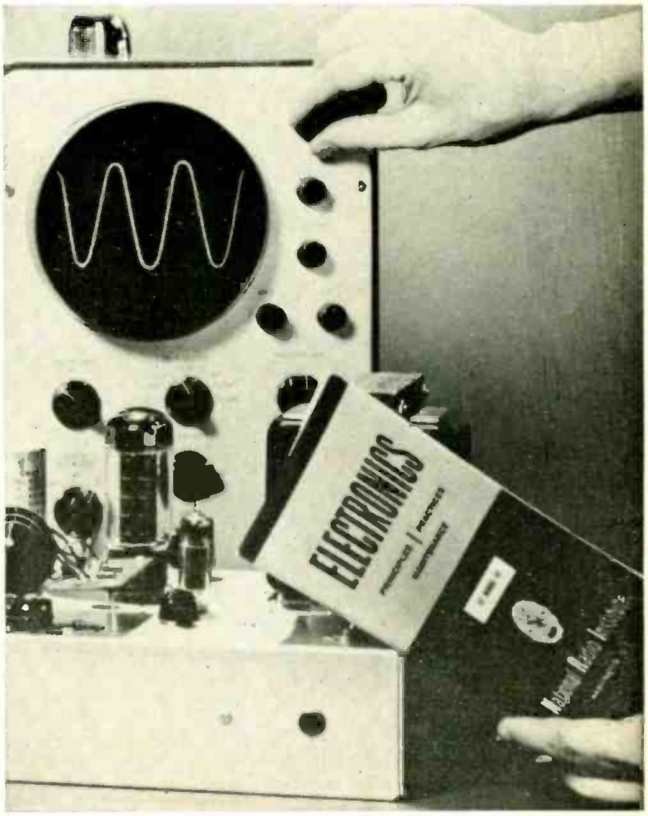

Air Force Avionics Lab, Wright-Patterson Air Force Base, Dayton, Ohio. He estimates an SIA for TV reception could be about the size of a penlight battery, and could be manufactured for $2 to $3.

An antenna that seems similar was demonstrated at the October 1966 convention of the Audio Engineering Society in New York City. Described as an "omnipolar high-gain vertically polarized antenna of small dimension" it appeared to be a plastic tube about 14 inches long and 1 inch in diameter. Its developer—William S. Halstead, of Multiplex Development Corp.—said that inside the tube was a spiral of wire which formed a monopole antenna element. At the base of the tube (shown at the right in the photo) Halstead stated there was an FET preamp driving the coax back to the receiver.

The Halstead antenna was devised for mobile reception of SCA subchannels from FM stations. It was claimed to have a gain of 4 dB over a reference dipole, with equal response to both horizontally and vertically polarized transmissions. It has maximum response when in a vertical position, and minimum when 45° away from vertical.

In January 1967 the antenna was placed in service on the Eastern Air Lines *Air Shuttle* run between Washington, New York and Boston. It became part of a system operated by Newsrad, Inc., which furnishes news and weather reports to airline passengers. Tape cartridges containing the newscasts are played in the studios of New York's WOR-FM and transmitted via their SCA subchannel. Signals are then picked up by the Halstead antenna and the Newsrad receiver in a plane just before it lands at LaGuardia Airport in New York City.

In September 1966 several demonstrations of a new antenna were held in the small Ohio town of Lewisburg (near Dayton). The antenna—known as the *Americus SkyProbe*—was developed by John M. Eagle of UniScience Laboratories, Inc. at Lewisburg. As shown in the photo, the antenna is built inside a plastic tube. In one demonstration, it was connected to a TV receiver with 300-ohm twin-lead and then dropped into the bottom of a metal water well 139 feet deep. Observers reported good reception of vhf TV stations 20 miles away, and fair reception of vhf stations 50 miles away and a uhf station at 20 miles.

Eagle states that his antenna is "not a diapole" [sic], but can receive both color and uhf beneath the earth's surface. He claims that classic theories of TV and radar reception are "incorrect or incomplete"; that the earth's magnetic field carries "video and audio"; and that neither antenna size nor height is a "controlling factor" in reception.

The SkyProbe antenna has been advertised and sold in stores in Ohio. Ads claim it is solid-state, but no further details were available from UniScience.

None of the above cases have shown protection from multipath or ghosting. Each seems to use semiconductor gain to compensate for antenna inefficiency. END

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Tell us what you want to see in it. Your suggestions may make it a better magazine for the rest of the readers as well as yourself. Write to the Editor, RADIO ELECTRONICS, 154 West 14th St., New York, N. Y. 10011.

Why does one of these men earn so much more than the other?

More brains? More ambition?

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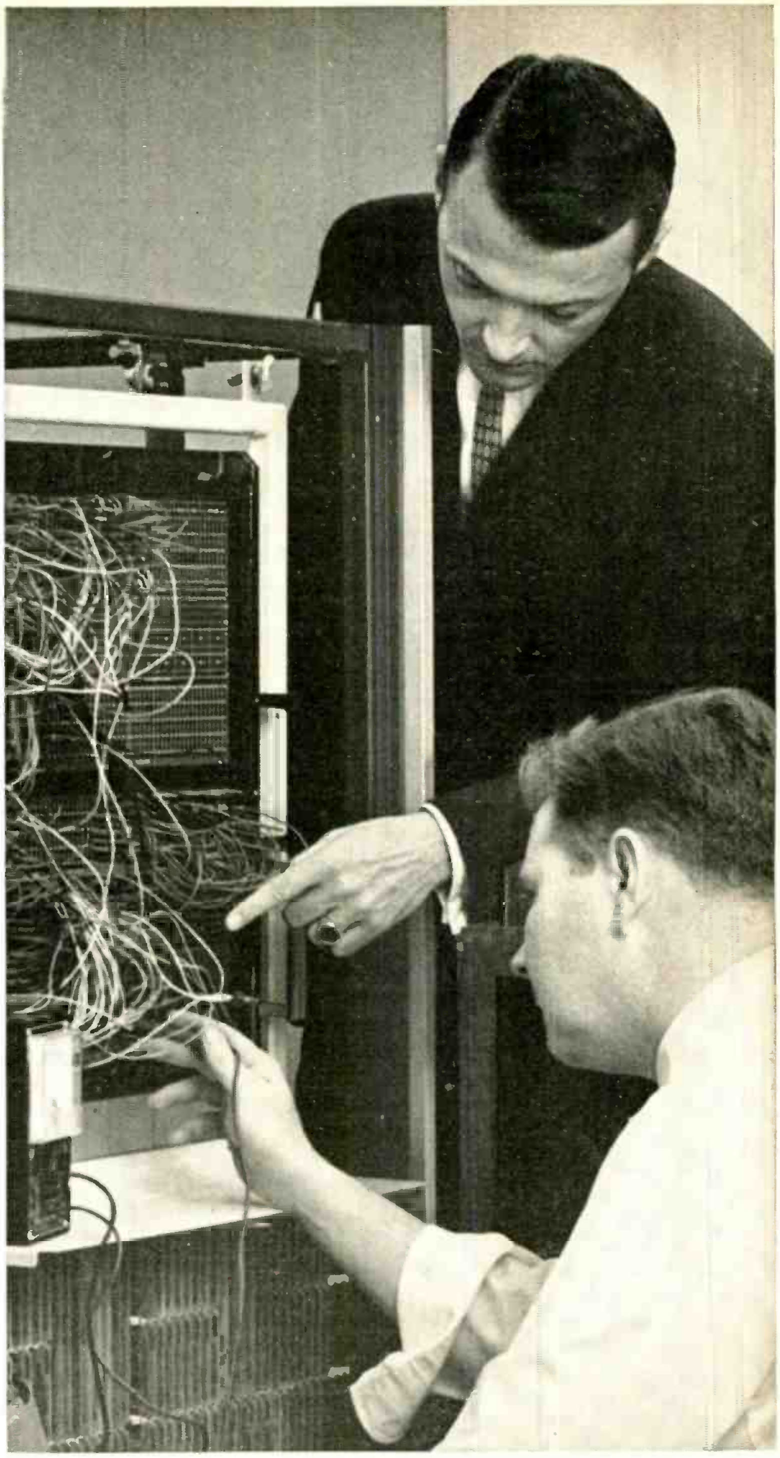

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Correspondence

POPULAR AUTHOR CONFESSES

Dear Editor:

Some people are having problems with my tach circuit as described in the August 1966 issue. In constructing the tach, I tried to eliminate the calibrating input by increasing the value of resistance R1. This modification was valid for the parts specified but apparently rendered the unit marginal enough so that it would not tolerate certain parts substitutions. The calibrating input, however. did not get eliminated nor certain items changed in the text to go along with the new value of R1. All I can say is, "Sorry about that." But all is not lost, there is a remedy.

The first thing to do is reduce the value of R1 to 270 ohms. This value in series with the resistance in the choke winding will be about 300 ohms which will put approximately 20 mA through the Zener. A 5,000-ohm variable resistor draws about 1 mA, which is 1/20 of what the Zener draws and can be considered negligible.

Next, the calibrating resistor should be changed to 7,500 ohms at 5 watts which again will put approximately 20 mA through the Zener. This makes conditions under operation and calibration almost equivalent except for the waveform. To check the effect of waveform, square waves of 35 volts peak to peak and sine waves of 115 volts were connected to the calibrating input: there was negligible difference in readings.

Another change was to make the low-range full-scale reading 1.250 rpm instead of 1,000 rpm. This allows for a 1,200 rpm calibration check on each range. A small but definite advantage.

None of the circuits built as described above have ever had anything but excellent results. I am sure others will find this true also.

D. H. SWEET

Bernardsville, N. J.

FOREIGN POLICY

Dear Editor:

I am sure that many are aware of the influx of foreign-manufactured products and the use of foreign parts in sets of American brands. Many US companies have built or are building major manufacturing facilities in foreign lands.

Will this result in fewer Americans being used in this industry? With fewer Americans employed, will their buying power be curtailed—making less demand for tangibles such as cars, refrigerators. homes and television sets?

No one will deny the importance of worldwide business prosperity, but we might become so engrossed in exporting prosperity that suddenly we might find America has become stagnant. It may be well for us to return to the thinking of a decade ago—"Buy American." What do you in the field think of this matter?

HAROLD JONES

Bowling Green, Ky.

CLEAN SWEEP (GEN)

Dear Editor:

I built the 455-kHz sweep gen by Harold J. Weber on page 34 of the April 1964 issue. I have found it to be more than a sweep generator as I use it to check curves of the i.f. circuits. It helps me in studying transistor radio i.f. circuits.

I made a few changes so the unit is smaller. I replaced the 6X4 with two IN2071 diodes and removed all the marker circuit and used a 6C4 as the oscillator tube. I use external markers to make sure the curve is set at 455 kHz.

I still enjoy reading every RADIO-ELECTRONICS magazine I receive. I hope you can come up with the same sweep unit in 10.7-MHz frequency.

CHARLES GRISAPI

Long Island City, N.Y.

AC AMMETERS

Dear Editor:

Jack Darr's story on circuit-breaker testing in February 1967 RADIO-ELECTRONICS was of interest. I was quite surprised at his remark that ac meters are scarce in radio and TV shops. I've been using them since I started servicing (30 years ago).

Mine were wired up by Dad before I took to the electronics trade. With a large potentiometer in series with the power line and an ac voltmeter and ammeter, you can start from zero and go to the full line voltage. Using the instrument this way. with any receiver plugged in and knowing its ratings, you know if there are any shorts. Three years ago, I improved the method by using a variable line transformer and mounting the unit on my bench panel.

All I can say is that ac meters were never scarce during my years of service.

PETER LEGON

Malden, Mass.

END

Formerly **SERVICE CLINIC**

In the Shop . . . With Jack

By JACK DARR

> This column is for your service problems—TV, radio, audio or general and industrial electronics. We answer all questions individually by mail, free of charge, and the more interesting ones will be printed here.
>
> If you're really stuck, write us. We'll do our best to help you. Don't forget to enclose a stamped, self-addressed envelope. Write: Service Editor, Radio-Electronics, 154 West 14th Street, New York 10011.

WELL, WE'RE GOING TO HAVE TO WORK on transistor video amplifiers, so we might as well get started. They're beginning to show up in both color and b-w, and are not hard to service—*if* you use the right methods and test equipment. Check signal input and output; if you find a stage where the signal won't go through, *then* stop and check voltages. In video stages this means using a scope and a low-capacitance probe.

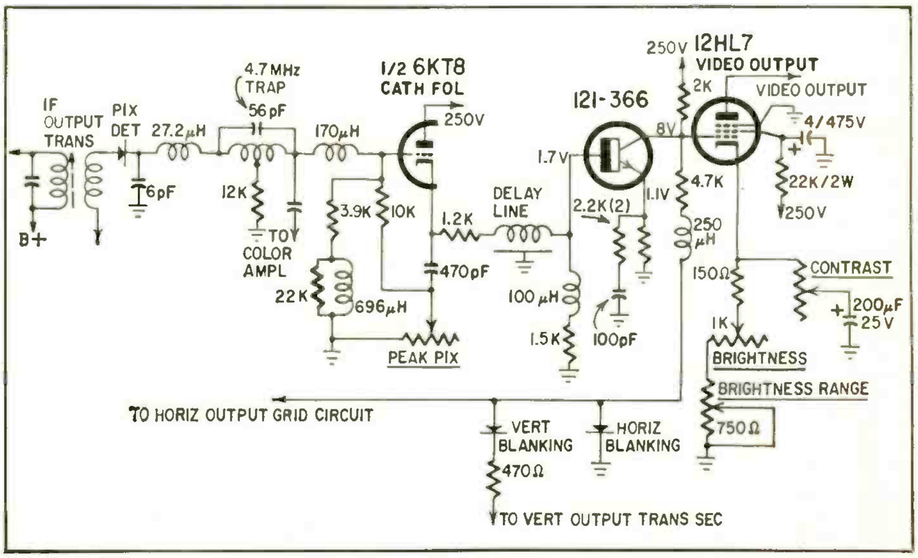
The Zenith 23XC36 color chassis (see diagram) uses a three-stage video amplifier with the transistor in the middle like a sandwich. (No onions on mine, please.) Notice that the video detector output is a positive-going signal, using the sync as reference. This signal goes to a cathode-follower stage (no inversion), and then to the 121-366 transistor, hooked up as a common-emitter, class-A amplifier. From the collector, it goes directly to the grid of the 12HL7 high-power pentode, video-output stage. This inverts the signal again, and it comes out on the picture-tube cathodes with a positive-going signal, which is needed at this point.

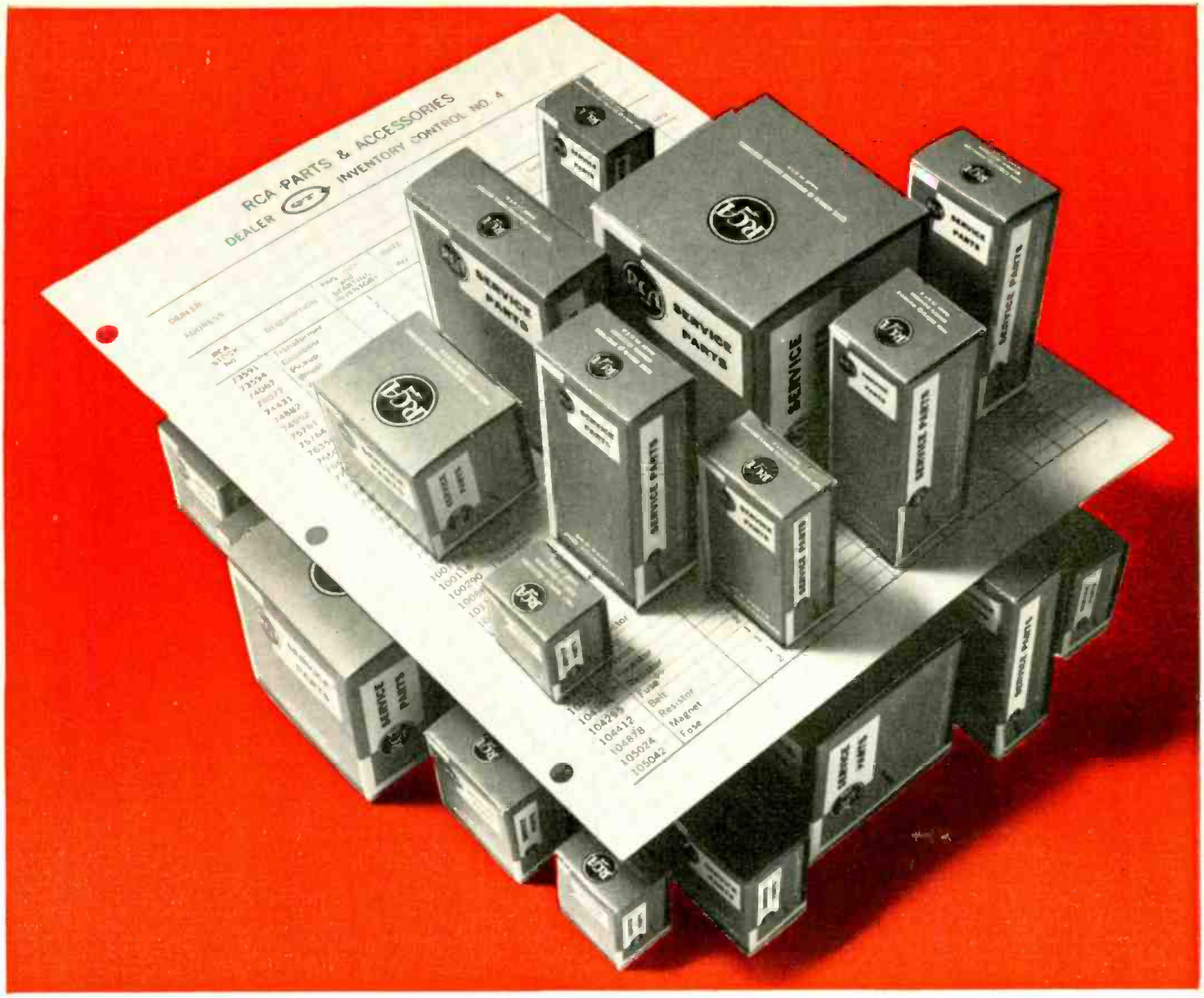
The transistor has to work class A, for undistorted signal output. Collector voltage comes from the 250-volt line, through the customary voltage divider, 82K, 4,700 ohms and a mess of other things. The transistor is an npn, with +8.0 volts on the collector, at no signal input. Base voltage is picked up at the cathode of the 6KT8, at +1.7 volts, and the emitter develops +1.1 volt through its 1,500-ohm resistor.

The normal signal output from this transistor is about 9 volts p-p, with negative-going sync. The base signal will read about 3 volts p-p. When checking this stage with the scope, look for an approximate gain of three times and signal inversion between base and collector. The cathode-follower stage preceding it does not invert, of course.

If the transistor is shorted or cut off, you'll get no gain, or a very weak signal output, or none at all. *Then* check voltages, especially the emitter–base bias. As in all common-emitter stages, a quick check of the whole stage can be made by reading emitter voltage first. If it's normal, chances are the whole stage is okay, for any voltage upset will affect

continued on page 22





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Coming Impact of UHF

This demand for licensed operators and service technicians will be boosted again in the next 5 years by the mushrooming of UHF television. To the 500 or so VHF television stations now in operation, several times that many UHF stations may be added by the licensing of UHF channels and the sale of 10 million all-channel sets per year.

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And there are other exciting opportunities in aerospace industries, electronics manufacturers, telephone companies, and plants operated by electronic automation. Inside industrial plants like these, it's the licensed technician who is always considered first for promotion and in-plant training programs. The reason is simple. Passing the Federal government's FCC exam and getting your license is widely accepted proof that you know the fundamentals of electronics.

So why doesn't everybody who "tinkers" with electronic components get an FCC License and start cleaning up?

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There is one way, however, of being pretty certain that you will pass the FCC exam. And that is to take one of the FCC home study courses offered by the Cleveland Institute of Electronics.

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President

the emitter voltage drastically.

Notice the two little diodes between the collector return circuit and ground. They're horizontal and vertical blankers, and can cause some odd symptoms if bad. If the horizontal shorts, most of the screen will be blanked out, starting from the left side. If the vertical blanker shorts, you will get the same symptom, but starting at the top of the screen.

If either or both of these diodes are open, you'll have a picture, but the brightness and contrast controls won't have any effect on it. This simulates a heater–cathode short in the picture tube—but remember, you've got three cathodes in this picture tube, and you'd have to short 'em all to get this kind of symptom. So, don't let your old b-w habits throw you—look for trouble back in the video amplifier stages, and not in the CRT. At least, not at *first*.

You'll find a different transistor used in other models of this series. The main differences will be stage voltages. Sets using the 121-366 transistor will be as shown in the diagram. If the 121-587 transistor is used, as in the 20X1C36 chassis, the voltages will be +1.5 at the base, +2.3 at the emitter and +14 volts on the collector. The circuit is basically the same otherwise.

I've kept on mentioning inversions for a reason. It's almost impossible for a tube to short grid-to-plate, because of the construction. However, a transistor *can* short base-to-collector! So, you get the equivalent of a "straight wire" through that stage! Despite the upset in voltages, etc., some signal may get through; if it does, you'll lose one signal inversion, and come out with a negative-going signal on the cathodes of the picture tube, and—you guessed it—a negative picture!

This can make for some really weird effects in color since the Y or brightness signal will be upside down, but the colors may not be affected too much. To get a positive test for this, turn the color off and look for a negative b-w picture. In b-w circuits, of course, the sync is usually taken off at the video output. Thus it will invert at the same time, and be unstable, giving us another clue.

To trace out, start with the scope at the video detector, and count inversions. Or start at the CRT cathodes, where we know darn well the sync should be positive-going, and work back. There will probably be a good-size loss of gain at the point where the fault is located, so watch for that as well as for inversions.

To sum up, the best way to check a transistor stage is to find out if a signal goes through it. If you get even half the normal signal input and output, you can probably go on to other points. You can also stop and check the bias voltages, if the gain is quite a bit below normal. For goodness' sake, be sure to check the *input* signal level before you jump to any rash conclusions about the transistor.

Voltage reading reversed?

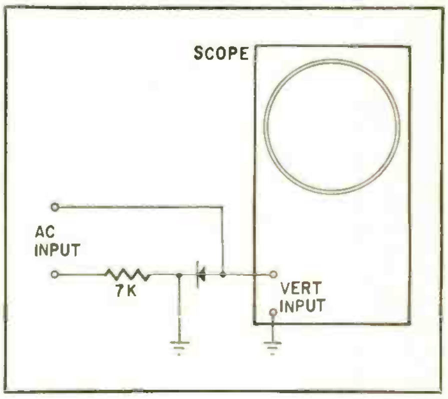
I can't make head or tail of the voltages I'm reading around the 12AX7 vertical oscillator/agc keyer tube in a Zenith R2229R TV. I've got poor sync, and the horizontal hold is critical. Picture's not too bad.—C. N., Winona, Minn.

I'm afraid you've fallen into a fairly common trouble, found in a few diagrams. Either in the drawing up of the service data or in the actual wiring of the chassis, the two halves of this twin triode have been reversed! Pin numbers given for one triode are actually those of the other, and vice versa!

Check your voltage readings in this way, and you'll come out a lot better! Your trouble, by the way, sounds very much like a weak 6BE6 tube in the sync separator. Replace it, and check the setting of the FRINGE-LOCK control.

Rectifier testing with scope?

I hooked up my scope as shown to test a selenium rectifier. There was a loud 60-Hz hum in the scope, and out went the fuse! No damage to the scope, and the rectifier is a perfectly good one. What happened?—J. P., Bronx, N. Y.



Something went to ground, like heavy ac! I believe I'd open up that scope and check some line bypass capacitors, from the ac line or power-transformer primary to ground (case) of the scope. There must have been *some* kind of a path to ground, for this to have happened.

Incidentally, I don't follow your

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NEXT

You'll also find articles on hi-fi and stereo (a stereo FM adapter you can build, and a complete listing of over 600 stereo FM stations in the US and Canada) and general electronics (ever wonder about the *right* way to run lead-in; we've got the answers).

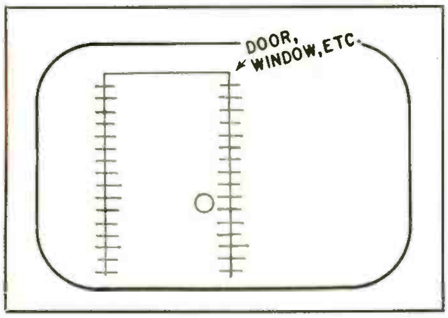
MONTH

The August issue of RADIO-ELECTRONICS will have all this and more—chock full of all-around electronics articles. If you're interested in what's new in electronics, then you'll want to read the August issue of
RADIO-ELECTRONICS.

way of testing rectifiers! I prefer the old substitution method; if the dc output voltage is low, substitute another rectifier and see if this brings the voltage back to normal. It's far simpler! You can, of course, check a rectifier with an ohmmeter for a direct short.

Horizontal streaking

I'm getting short horizontal streaks across the vertical lines in the picture on a Zenith 25MC36 color chassis, as in the sketch. Otherwise, the set is working okay: plenty of high voltage, color and so on.—F. S., Bowling Green, Ohio.



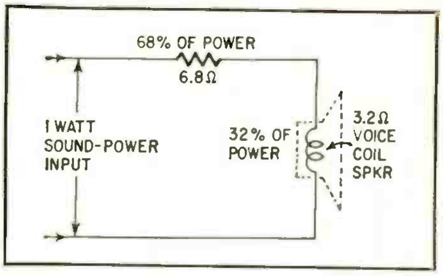
This is probably caused by something with a breakdown in the high-voltage section. Check the 1,500-ohm 1-watt resistor in the HV lead from the 3AT2 tube to the CRT. This has been known to break down and arc. Since the "dc" voltage supply here actually has a pretty good pulse on it, these pulses will arc over the break in the resistor, and cause the streaking. Replace it with a 2-watt type.

Solid-state speaker matching

Transistor radios have speaker voice coils with odd values. I have several replacement speakers with 3.2-ohm voice coils. Could I add a suitable resistor, say 6.8 ohms, to make up a 10-ohm impedance, and use this? Also, what effect would it have to substitute 3.2-ohm speakers for the original 8- or 10-ohm types?—N. D., Quebec, Canada.

Replacement speakers for odd-value voice coils are sometimes hard to get. (Not too long ago, I had to locate one with a *150-ohm, center-tapped* voice coil!) Nevertheless, in all transistor radios, you should use an exact duplicate.

Voice coils in tube radios aren't nearly as critical; in fact, we have a fairly wide tolerance here. However, if we mismatch even a comparatively small amount in transistor radios, we are asking for trouble (and getting it). This upsets the operating constants of the power transistor and usually leads



to early failure! You see, the *load* impedance, which consists here of the speaker and the output transformer, determines the collector current!

Also, there is one bad fault with the idea of adding series resistance to voice-coil circuits. If we are dissipating, say, 1 watt in the speaker, part of it will be dissipated across the speaker voice coil, but the rest will be lost in that resistor! See the diagram.

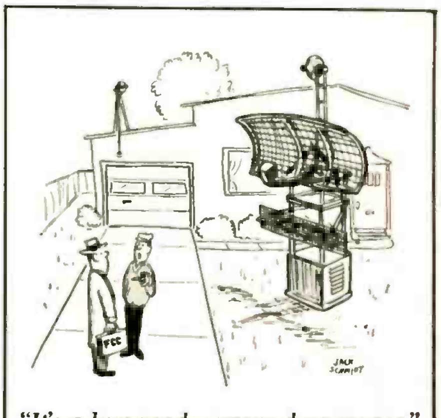
With the figures given, you'd be getting only a third of the power across the speaker itself! You would get "sound," but your volume would be mighty low.

Scope problem

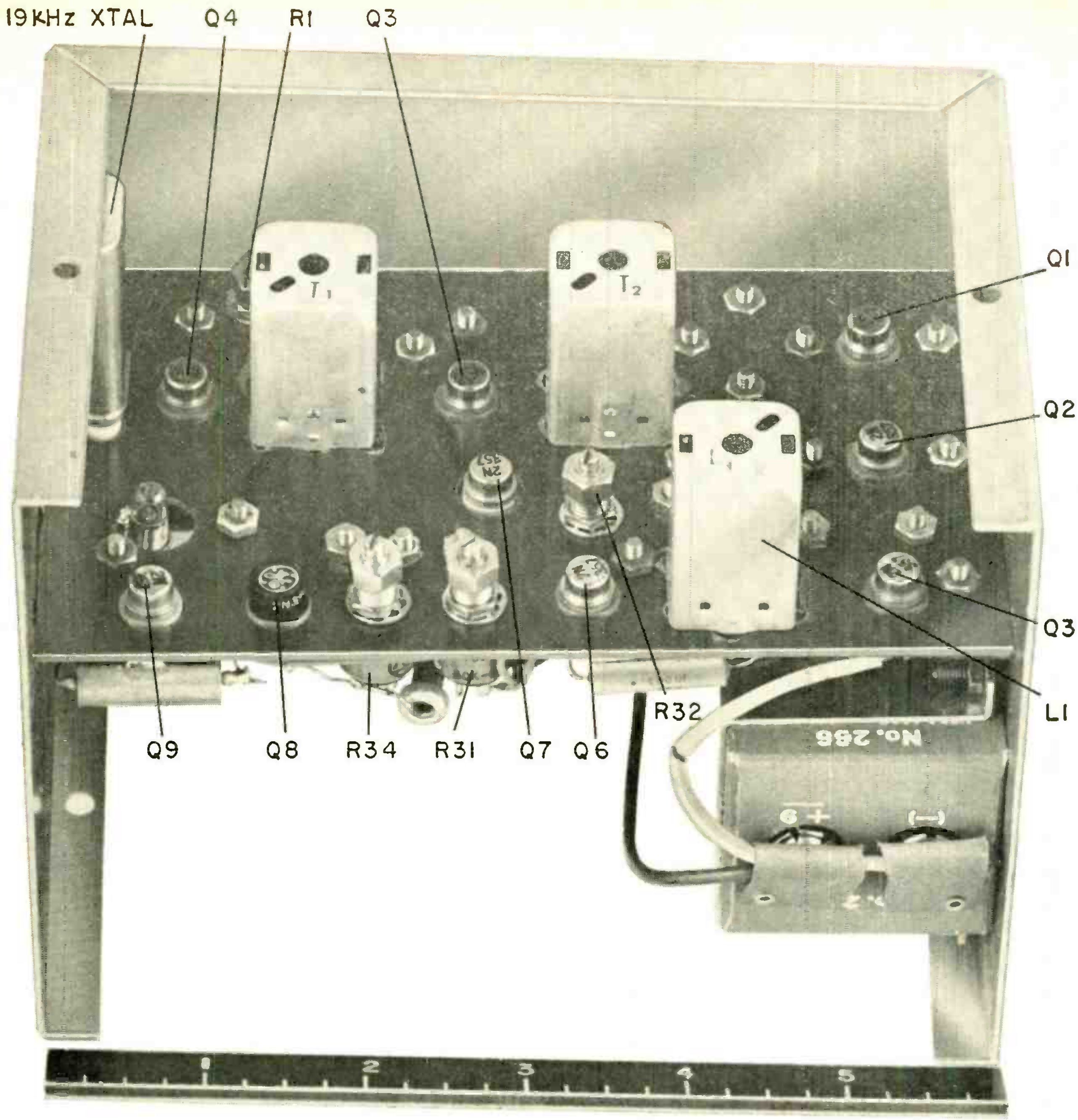
I have a Heathkit O-12 Lab scope using a 5UP1 tube. Could I use the same circuit you showed in Charles Cohn's article "Intensify Your Scope" (RADIO-ELECTRONICS, *February 1965, p. 36)?—L. W., Coffeyville, Kans.*

I'm afraid not. This one was intended for use with scope tubes having PDA (*Post-Deflection Acceleration*) electrodes, and your 5UP1 tube doesn't have one. Such tubes (5CP1, etc.) have an added accelerator electrode, inside the bulb, in front of the deflection plates; a higher voltage applied here makes the spot brighter by adding acceleration to the beam. This is exactly like TV picture tubes' ultor anodes.

In your 5UP1 tube, the HV is fed into the tube base; all acceleration is provided by the plates themselves. END



"It's a homemade garage door opener."



Transistor Stereo Generator

This precision instrument lets you easily align and troubleshoot FM stereo tuners and adapters

By JOHN B. PAYNE III

THE USUAL FM-STEREO MULTIPLEX adapter can be simple in design. Since it performs quite a complex function, however, it must be carefully adjusted to give optimum performance. Few FM-stereo broadcast stations provide adequate test signals for adapter alignment. Therefore, the adjustment of an mpx adapter by the technician or hobbyist is almost impossible without a multiplex generator.

This project results in a unit that is solid-state, compact and self-powered, capable of reliable operation for many months. Neither circuit layout nor transistor types are critical.

Amplitude response is flat within 0.5 dB from 50 Hz to 15 kHz; the composite waveform is as good as that available from a broadcast station. The generator furnishes only composite stereo output—not rf—which can be fed directly to a multiplex adapter or used to modulate an rf generator for receiver alignment. The most critical measure of performance is channel separation. From 50–15,000 Hz, this generator offers better than the 30 dB required by the FCC for FM stations.

Circuit description

The 19-kHz Hartley crystal oscillator (Q4 in Fig. 1) is one of the most critical circuits of the generator. Its accuracy and stability must be .01% (2 Hz) to equal FCC-required station performance. C2 and the primary of T2 constitute a high-Q resonant circuit tuned to 19 kHz. The signal at terminal 2 of the primary is 180° out of phase with the collector end (terminal 1). Positive feedback from terminal 2 produces oscillation at the crystal series-resonant frequency. This pilot frequency can be trimmed over a 2-Hz range by C1. Emitter resistor R1 is used to adjust the gain of Q4 and hence the level of oscillation.

The diode bridge across the secondary of T2 doubles the 19-kHz pilot signal to 38 kHz by full-wave rectification. This rectified signal drives amplifier Q3, whose collector is tuned to 38 kHz by T1. A low-distortion 38-kHz sinusoidal signal appears across the secondary and is fed to two diode bridge networks (known as Cowan-bridge modulators). These diode bridges enable R and L input signals to be combined to form the composite multiplex signal (minus pilot).

Signals applied to the R and L input terminals pass through emitter followers Q1 and Q2 and appear unattenuated at the inputs to the two bridge networks (these are points A and C, respectively).

The two diode networks act as a switch which alternately connects point B (and D) to points A and C at a 38-kHz rate. During the first half of the 38-kHz cycle, the top of the T1 secondary (point 3) is positive with respect to the bottom (point 4). Current flows through R8, R9 and diodes D5–D6 and D7–D8, forward-biasing the diodes. This causes the R signal at point A to appear at the bridge output (point B). During this cycle, diodes D9–D10 and D11–D12 are reverse-biased, producing an open circuit between points C and D. The second half of the cycle reverses the polarity across the secondary of T1. The L signal at point C now appears at bridge output D. The upper bridge is reverse-biased. This sampling process is similar to time-division multiplex.

If the signal of Fig. 2-a is applied to the R input (with L = 0), the bridge output (point B) will be as shown at Fig. 2 b. This waveform contains the original input-signal spectrum plus a double-sideband suppressed-carrier signal centered at about 38 kHz. If the signal of Fig. 2-c is applied to the L input (with R = 0), the sampled signal at D will appear as shown in Fig. 3-d.

Fig. 2-b and 2-d are purposely drawn above each other to show how the zero-output time of one channel is the signal-output time of the other. The output of both diode bridges (B and D) are connected together in Fig. 1. If both input signals are applied simultaneously, the output at point X (com-

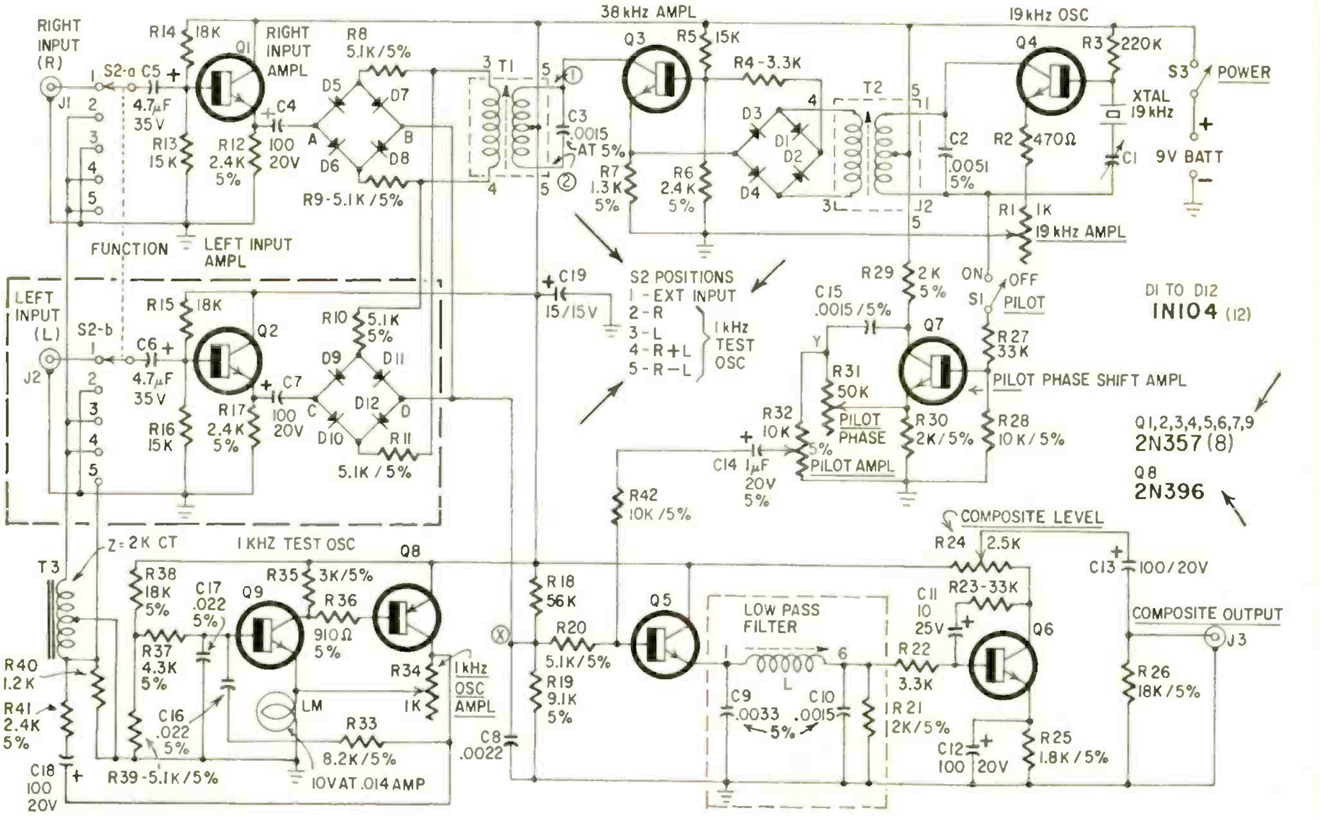


Fig. 1—A simplified version of the generator would omit the left input amplifier, shown within a dashed line.

PARTS LIST

R1, R34—pot, linear taper, 1,000 ohms
R2—470 ohms
R3—220K
R4—3,300 ohms
R5—15K
R6, R12, R17, R41—2,400 ohms, 5%
R7—1,300 ohms, 5%
R8, R9, R10, R11, R20, R39—5,100 ohms, 5%
R13, R16—15K
R18—56K
R19—9,100 ohms, 5%
R21, R29, R30—2,000 ohms, 5%
R22—3,300 ohms
R23, R27—33K
R24—pot, linear taper, 2,500 ohms
R25—1,800 ohms, 5%
R14, R15, R26, R38—18K, 5%
R28, R42—10K, 5%
R31—pot, linear taper, 50K
R32—pot, linear taper, 10K
R33—8,200 ohms, 5%
R35—3,000 ohms, 5%
R36—910 ohms, 5%
R37—4,300 ohms, 5%
R40—1,200 ohms
All resistors ¼ watt, 10% unless otherwise noted
C1—7-45 pF, ceramic trimmer
C2—.0051 μF, 5%, mica
C3, C10—.0015 μF, 5%, mica
C4, C7, C12, C13, C18—100 μF, 20 volts, tantalum
C5 C6—4.7 μF, 35 volts, tantalum
C8—.0022 μF, disc
C9—.0033 μF, 5%, mica
C11—10 μF, 25 volts, electrolytic
C14—1 μF, 20 volts, tantalum
C15—.0015 μF, 5%, mica
C16, C17—.022 μF, 5%
C19—15 μF, 15 volts, tantalum
T1, T2—output transformer for 38 kHz (J. W. Miller 1355 PC or equivalent)
T3—miniature audio transformer, only 2,000 ohm center-tapped secondary used (Speca DT-10-20 or equivalent)
L—locked oscillator coil for 19 kHz (J. W. Miller 1354 PC or equivalent)
S1, S3—spst toggle switch
S2—2 pole 5-position rotary switch
D1 through D12—1N104
LM—miniature lamp, 10 volts, .014 amp (G-E 344 or equivalent)
BATT—9 volts, NEDA 1605 (Burgess M6, Eveready 266, RCA VS-322 or equivalent)
Q1, Q2, Q3, Q4, Q5, Q6, Q7, Q9—2N357 or npn equivalent
Q8—2N396 or pnp equivalent
XTAL—19.000 kHz, ±2 Hz (CTS-Knights type H17T or equivalent)
J1, J2, J3—BNC type coaxial panel connector

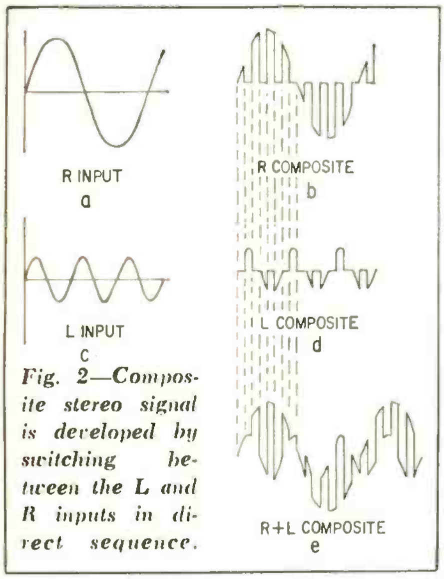


Fig. 2—Composite stereo signal is developed by switching between the L and R inputs in direct sequence.

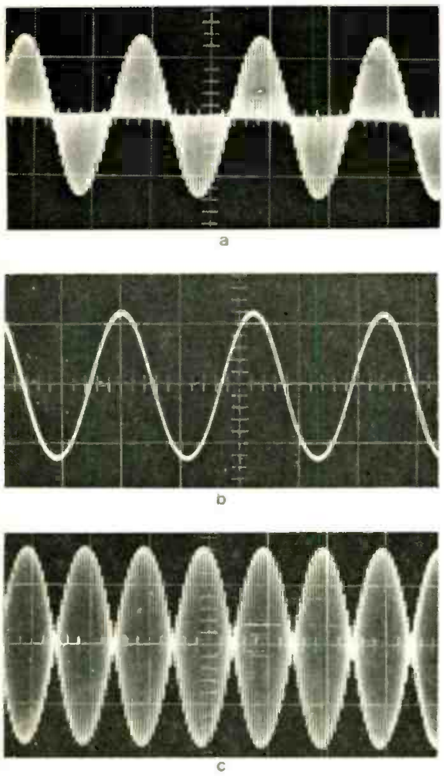


Fig. 3—The function switch outputs: (a) R or L only, (b) R+L, (c) R—L.

mon to B and D) will appear as the sum of the two signals, as shown in Fig. 3-e. This is sometimes called interleaving.

The sum of L+R forms the normal audio modulation having a frequency spectrum from 50 to 15,000 Hz. This provides the required compatible monophonic signal. The difference (L—R) appears as double-sideband components from 23 to 53 kHz centered at about 38 kHz.

With the secondary of T2 floating (i.e., center tap not grounded) the 38-kHz subcarrier is automatically suppressed to below 1%, as FM stations must do.

The 19-kHz pilot is added to the multiplex signal by summing network R20–R42 at the input of emitter follower Q5, to form the complete composite waveform. This pilot signal is derived from the primary winding of T2, in the crystal-oscillator circuit. Pilot phase relative to the subcarrier is controlled by R31 and phase-shift amplifier Q7. Amplitude is controlled by R32. S1 turns off the pilot.

Low-pass filter L–C9–C10–R21 attenuates harmonics of 38 kHz generated during the switching process. Output stage Q6 is a feedback amplifier that provides a gain of 20 dB and transforms the output to a low impedance. The gain of the amplifier is proportional to the ratio R23/R22. Output level is set by R24.

An optional internal 1-kHz audio oscillator (Q8 and Q9) is provided. It consists of a Wien-bridge network which oscillates at a frequency determined by R33, R37, C16 and C17. Lamp LM stabilizes the oscillator output amplitude.

If FUNCTION switch S2 is placed in the R position, only the right (L = 0) channel is modulated by the test oscillator. Position L connects this test signal to only the left (R = 0) channel. The composite output signal for either R or L is shown in Fig. 3-a. These two test positions generate signals for testing and adjusting channel separation of an adapter. The test signal produces a maximum composite output signal of 4 volts pp (1.4 volts rms). In the R+L position both inputs are connected together and modulated by the test signal, generating a monophoinc signal as shown in Fig. 3-b.

Transformer T3 is the secondary of a balanced interstage coupling transformer used to invert oscillator phase. When the function switch is in R—L position these two signals (of equal amplitude and opposite phase) modulate the two channels. The composite output (Fig. 3-c) consists of only the stereo subcarrier with the monophonic or R+L output suppressed 40 dB.

An EXT INPUT position is provided on the function switch. An external input signal of 1.5 volts p-p (0.53 volt rms) produces an output of 5 volts p-p (1.76 volts rms) for 100% modulation.

Construction

The chassis is a 6 x 3 1/12-inch copper-clad circuit board. The copper material lets you solder the transistor sockets in place easily and simplifies all ground connections. Stray pickup is no problem if T1, T2 and L are shielded (the recommended transformers come in shielded cans). All circuit junctions are made to either standoff insulators or transistor socket pins.

If cost or space is a problem, the instrument can be simplified by eliminating audio oscillator Q8–Q9 and L-input channel Q2, D9, D10, D11 and D12, and associated circuitry shown in Fig. 1 by the dashed line. If these circuits are eliminated, selector switch S2 will no longer be required. Also, PILOT switch S1 can be eliminated.

Alignment and checkout

This procedure requires an audio vtvm, an oscilloscope and an audio oscillator. All ac voltage levels are given in both peak-to-peak and rms so adjustments can be made using either a scope or a vtvm.

The alignment process is this:
Initially set:

1. FUNCTION switch S2 to EXT INPUT.
2. PILOT switch S1 to OFF.
3. C1 for maximum capacitance.
4. R1 for minimum resistance.
5. R31 at midposition.
6. R32 slide arm to ground end (zero output).
7. R24 slide arm to top end (maximum output).
8. R34 for minimum resistance. Then
9. Remove the crystal from its socket.

Table of Transistor Voltages (dc)

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
Collector	9.0	9.0	9.0	9.0	9.0	4.8	6.0 / 9.0*	4.8 / 1.5*	8.8 / 8.8*
Base	4.0	4.0	2.0 / 1.3*	3.4 / 1.8*	2.2	2.0	1.75 / 0.0*	8.8 / 8.8*	1.7 / 1.6*
Emitter	3.9	3.9	1.9 / 1.2*	3.3 / 1.6*	2.0	1.9	1.65 / 0.0*	9.0 / 9.0*	1.5 / 1.4*

All values are with generator properly aligned.
* Controls initially set as indicated in instructions 1 through 8 (see text).

Turn the instrument on (no warmup required). With the above settings, transistor dc voltages should be as given in the table.

The 19-kHz crystal oscillator is adjusted first. Replace the crystal. Adjust emitter resistor R1 for a collector voltage of 6.5 p-p (2.3 rms) on terminal 1 of T2. Adjust the slug from the top of T2 for maximum collector voltage and readjust R1 to maintain 6.5 volts p-p. This prevents Q4 from saturating, and thus produces a pure 19-kHz pilot signal.

Q3, the 38-kHz amplifier, is tuned by adjusting transformer T1. The top slug is adjusted for maximum signal at the collector of Q3 (terminal 1 on T1). This voltage should be about 12 p-p (4.2 rms) for minimum distortion. If this level is not correct, adjust R1 until it is.

If a 19-kHz frequency standard or counter is available, adjust C1 for exactly 19.000 Hz. Alternately, the pilot signal transmitted by an FM-stereo station can be used. At worst, the frequency of the recommended crystal will still be within the desired range if C1 is set to about half its value. Recheck the level of oscillation and readjust R1 if necessary.

The test-oscillator frequency will be close enough to 1 kHz for the values given. The only adjustment required is the level of oscillation. Turn the function switch to R+L. Adjust R34 for a signal level of 5.5 volts p-p (1.92 volts rms) at the collector of Q8 (top end of R34). This level of oscillation will produce minimum distortion. After each adjustment wait about 20 seconds for the resistance of lamp LM to stabilize. Make additional adjustments if any are necessary.

Observe the level of oscillation as the function switch is rotated through each position. If the level decreases by more than 0.2 volt p-p (.07 volt rms), increase the level of oscillation slightly with R34. Fig. 4-a shows a distorted 1-kHz signal due to too high a level. Fig. 4-b shows the correct level.

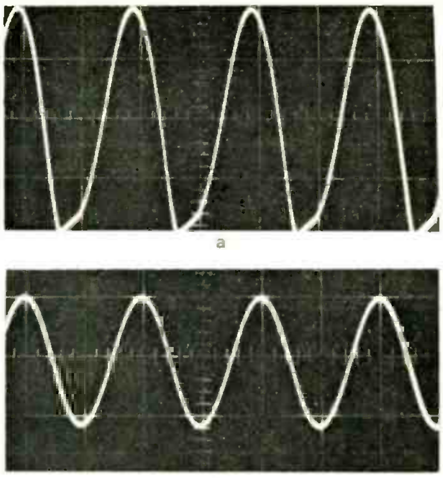


Fig. 4-a—When R34 is misadjusted, waveform from 1-kHz oscillator is distorted. b—R34 set correctly, trace is sine wave.

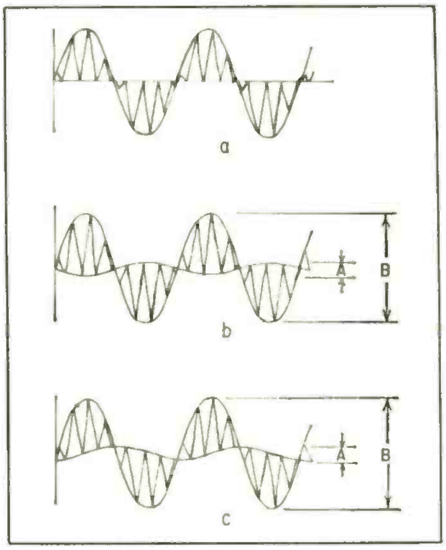


Fig. 5—Channel separation: (a) no crosstalk, (b) crosstalk due to amplitude distortion, (c) due to phase distortion.

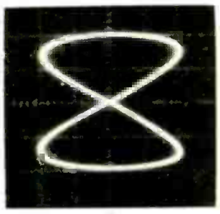
Place FUNCTION switch S2 to EXT INPUT and connect an audio generator (set to 10 kHz) to either the R or L external input. Set the oscillator input level to produce a composite output of about 4 volts p-p (1.4 volts rms). With PILOT switch S1 OFF, the waveform should be similar to that shown in Fig. 5 (a, b or c). Adjust L1 to minimize the baseline or crosstalk modulation shown as amplitude A in Fig. 5-b and -c. If the variation of L is not sufficient to minimize A, then R21 should be increased or decreased by about 1,000 ohms as required.

If an external oscillator is not available, the internal test oscillator can be used. Place the function switch to either R or L. This will, however, reduce the separation slightly at the higher modulation frequencies.

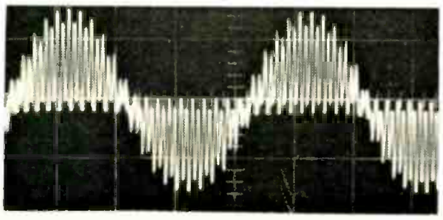
The Lissajous-pattern technique is a simple and accurate method for adjusting the phase of the 19-kHz pilot relative to the subcarrier. Connect the collector of 38-kHz amplifier Q3 to the horizontal input of an oscilloscope. Connect point Y (top of R31–R32) to the vertical input. The oscilloscope pattern should be a figure 8. Adjust phase control R31 until the crossover point is perfectly centered, as shown in Fig. 6-a.

To adjust the pilot amplitude, place the FUNCTION switch to EXT INPUT and turn on PILOT switch S1. With the output level control set for maximum output, advance pilot amplitude pot R32 for an output level of 0.5 volt p-p (0.18 volt rms). This will provide a pilot level of 8–10% modulation, for an output composite signal of about 5–6 volts p-p.

A simple way to check for correct phasing of this pilot signal is to observe the composite output signal with the pilot signal present. The waveform should appear as in Fig. 6-b when the function switch is in either the R or L position. The amplitude of the 19-kHz modulation appearing on the base line should be exactly the same for both positions of the function switch.



a



b

Fig. 6-a—This figure 8 shows proper pilot phase with respect to the subcarrier (see text). b—Composite output for either the R or L input only.

To route the L and R signals to the proper receiver channels properly, a phase adjustment must be between the pilot and the stereophonic subcarrier. At the instant when only a positive left signal is applied, the stereophonic subcarrier and its sideband signal must cross the time axis simultaneously and in the positive direction.

To identify the R and L channels, connect the 19-kHz pilot signal from point Y to the L external input and set function switch S2 to EXT INPUT. Disconnect one end of capacitor C8. The waveform observed at point X will resemble either a or b of Fig. 7. The L input is shown at a, while the R input is shown at b. Reconnect C8 after the channel identification has been made.

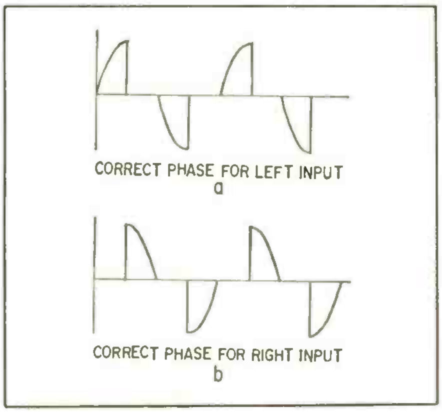
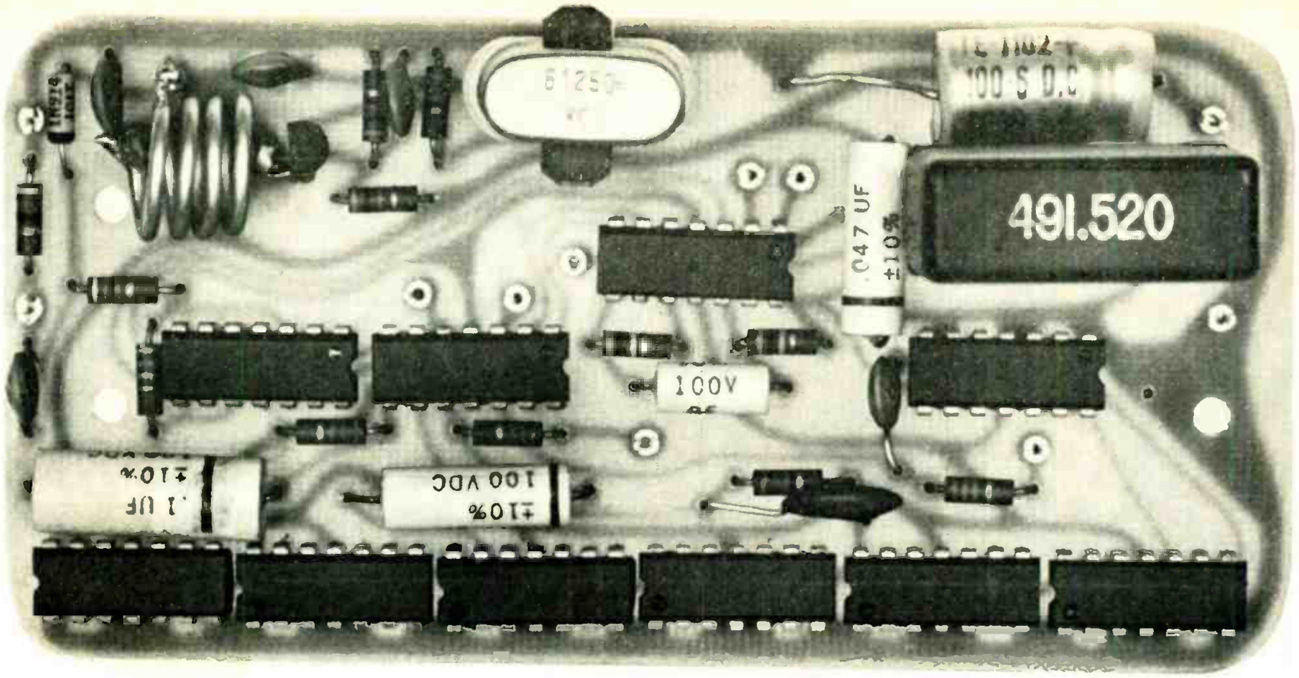


Fig. 7—How to identify channels: Correct phase for (a) L only input, and (b) for R.

If you've followed these instructions carefully, you should now possess a stereo generator that will give you years of reliable service. END



Build DOTnBAR – A Professional Quality Pattern Generator

By DON LANCASTER

WHO SAYS A BAR GENERATOR HAS TO BE expensive, bulky, or hard to use? Behold the RADIO-ELECTRONICS DOTnBAR, a battery-operated, 2-pound instrument you can build for $35 to $50. By using computer techniques and low-cost integrated circuits, the DOTnBAR is more stable than nearly any other instrument available today. Patterns lock the minute power is applied. They are so stable that no internal sync adjustments are needed. Only three D cells are needed for the power supply.

The DOTnBAR (see photo on front cover) is easy to put together and the parts are readily available. Circuit boards and a professionally finished front panel are available.

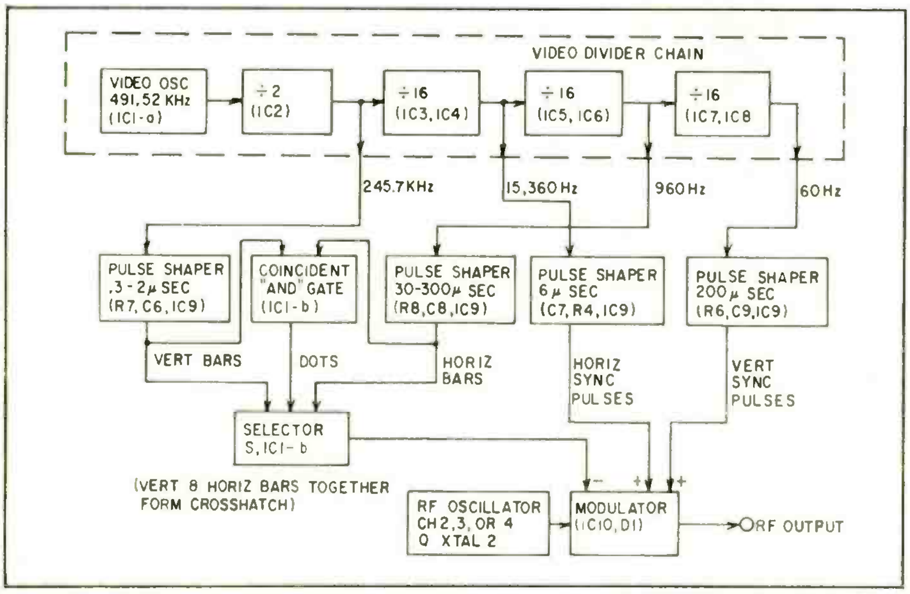


Fig. 1—Heart of the generator, as shown in this block diagram, is the divider chain.

For a stable television pattern, all picture elements must be locked to each other, and they should be derived from a single reference source. The DOTnBAR's exceptional stability is due to the use of *binary* flip-flops (which divide by 2). They sync the pattern. Unlike the familiar relaxation divider, a binary requires no adjustments and no regulated power supplies. Best of all, it cannot jump sync or divide by some different number.

To simplify the divider function, 512 horizontal lines are used (rather than the US standard of 525). With a vertical scanning rate of 60 Hz, the resulting horizontal line frequency is 15,360 Hz. Although a bit lower than the broadcast standards, this feature will cause only a small variation in horizontal hold and width settings on TV receivers.

Because flip-flop dividers work best when dividing by multiples of 2, the DOTnBAR uses two identical 256-line fields, no interlace, and no equalizing pulses.

Fig. 1, a block diagram, shows circuit function. The crystal-controlled 491.52-kHz video oscillator starts the action. Its output is divided by 2 to produce 245.76 kHz. This figure is then divided by 16 to produce the horizontal scanning frequency of 15,360 Hz. Following this, another division by 16

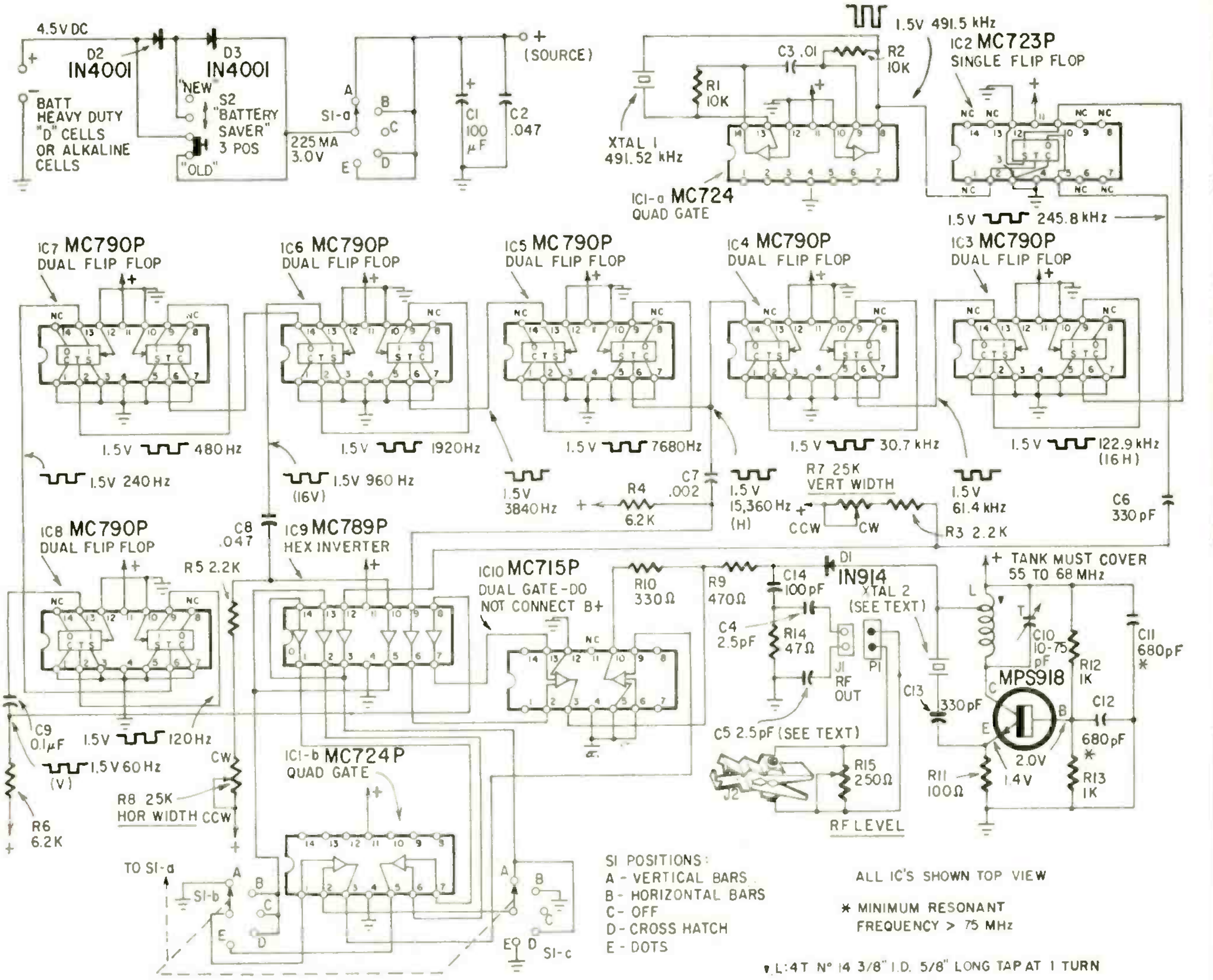


Fig. 2—Without the use of integrated circuits, the DOTnBAR would be two or three times as complex.

PARTS LIST

BATT—heavy-duty D-size flashlight cells (3): NEDA 13C (Burgess 210. Eveready 1150, Ray-O-Vac 3LP; also see text)
C1—100 μF, volts, electrolytic
C2, C8—.047 μF, 50 volts, mylar
C3—.01 μF, 50 volts, mylar
C4, C5—2.5-pF gimmicks (see text)
C6, C13—330 pF, ceramic disc
C7—.002 μF, ceramic disc
C9—0.1 μF, 50 volts, mylar
C10—10-75 pF, ceramic trimmer (Erie 557-000-COPO-109R equivalent. Newark Electronics catalog No. 19F2974 @ $1.06)
C11, C12—680 pF, ceramic disc (see text)
C14—100 pF, ceramic disc
D1—1N914
D2, D3—1N4001 or equivalent
IC1—MC724P MRTL quad two-input gate ($1.08)
IC2—MC723P MRTL J-K flip-flop (Motorola, $1.35)
IC3,4,5,6,7,8—MC790P MRTL dual J-K flip-flop ($2.00)
IC9—MC789P MRTL hex inverter ($1.08)
Q—MPS918 transistor (Motorola) ($1.30)
Note: Data sheets and distributor lists on all IC's and transistors available from Motorola Semiconductor, Box 955, Phoenix, Ariz. 85001
J1—chassis-type TV connector (Mosley 303 or similar)
J2—clothespin-type TV connector (GC KLIPPER or similar)
L—four turns No. 14 bare copper wire spaced out ⅝ in. on ⅜-in. form (see text)
P1—mating plug for J1
R1, R2—10K, ¼ watt
R3, R5—2,200 ohms, ¼ watt
R4, R6—6,200 ohms, ¼ watt
R7, R8—25K pot, linear taper
R9—470 ohms, ¼ watt
R10—330 ohms, ¼ watt
R11—100 ohms, ¼ watt
R12, R13—1,000 ohms, ¼ watt
R14—47 ohms, ¼ watt
R15—250 ohms, miniature potentiometer, linear taper, (CTS U201R251 or equivalent)
S1—3 poles, 5 positions, nonshortening selector switch
S2—dp3pos slide switch (Wirt G-128 or equivalent)
XTAL 1—491.520-kHz series-resonant crystal (Texas Crystals No. TC-21 @ $1.25. Texas Crystals, 100 Crystal Drive, Fort Meyers, Fla. 33901)
XTAL 2—55.25 (Ch. 2), 61.25 (Ch. 3), or 67.25 (Ch. 4) MHz crystal, fundamental or third-overtone type, similar to CTS (James Knights) No. H-173
Case—3 x 4 x 5-inch aluminum case (Bud CU2105A or Zero Z-64-80A-48 or equivalent)
Chassis—(optional) 13 x 8 x 1/32-inch aluminum sheet (see Fig. 5)
Front panel—(optional) Metal-photo hard anodized aluminum dial plate, available from Reill's Photo Finishing, 4627 N. 11 St., Phoenix, Ariz. 85014. In silver color, $2.75; red or copper, $3.25, postpaid in US
Circuit board—2 5/16 x 4¾ x 1/16-inch single-sided PC board (see below)
Spacer—(optional) 4¾ x 1½ x ⅛-inch (see text)
Misc.—Crystal sockets; ⅝-in. knob (2); 1¾-in. knob; 3-cell battery holder, size D; pop rivets (12); 4 × in. threaded spacers (4); No. 6 rivet-on spacers (4); No. 10 nylon cup washers for feet (4); 300-ohm twin lead
Wire—(3 feet); No. 14 BX or Romex house wire (etched and drilled PC board available from Demco, Box 16297, San Antonio, Texas 78216)

results in a frequency of 960 Hz. the same as sixteen times the vertical field frequency. One final division by 16 gives us the 60-Hz vertical-field scanning rate. Each divider output consists of a fast-rise square wave, and all are locked to the others.

The horizontal and vertical scanning signals are routed to separate pulse shapers to generate horizontal and vertical sync pulses. These are 6 μsec wide for the horizontal and 200 μsec for the vertical.

Frequencies of 245.76 kHz and 960 Hz are also sent to pulse shapers. They are adjustable, however, so you can control the overall line widths and dot size. Output of the 245.76-kHz pulse shaper consists of *vertical* lines, while output of the 960-Hz pulse shaper consists of *horizontal* lines. These horizontal and vertical lines are sent to a pattern-selector switch and a coincidence circuit which produces an output *only* where the lines cross. Consequently, a 256-dot pattern results. The pattern-selector switch chooses between horizontal lines, vertical lines, both for crosshatch, or the coincidence-circuit output for a screenful of dots.

For rf output, a crystal oscillator working on TV channel 2, 3 or 4 is used. This carrier is then modulated by both sync and pattern pulses produced by the pulse formers.

A pot on the rf output feedline maintains best signal-to-noise ratio to TV receiver.

The circuit

Fig. 2—the schematic—looks a lot more complicated than it really is. Outside of the transistor and ten IC's ($16.50 worth), there's really very little to it. XTAL 1 and the 2 gates in IC1-a form the video oscillator. IC2 then performs the first binary division, producing an output square wave at 245.76 kHz. The rest of the video divider chain—IC2 through IC8—consists of flip-flops, two per package. Each flip-flop divides by 2; each $2 package by 4. The desired frequencies are picked off as they occur during three consecutive divisions by 16.

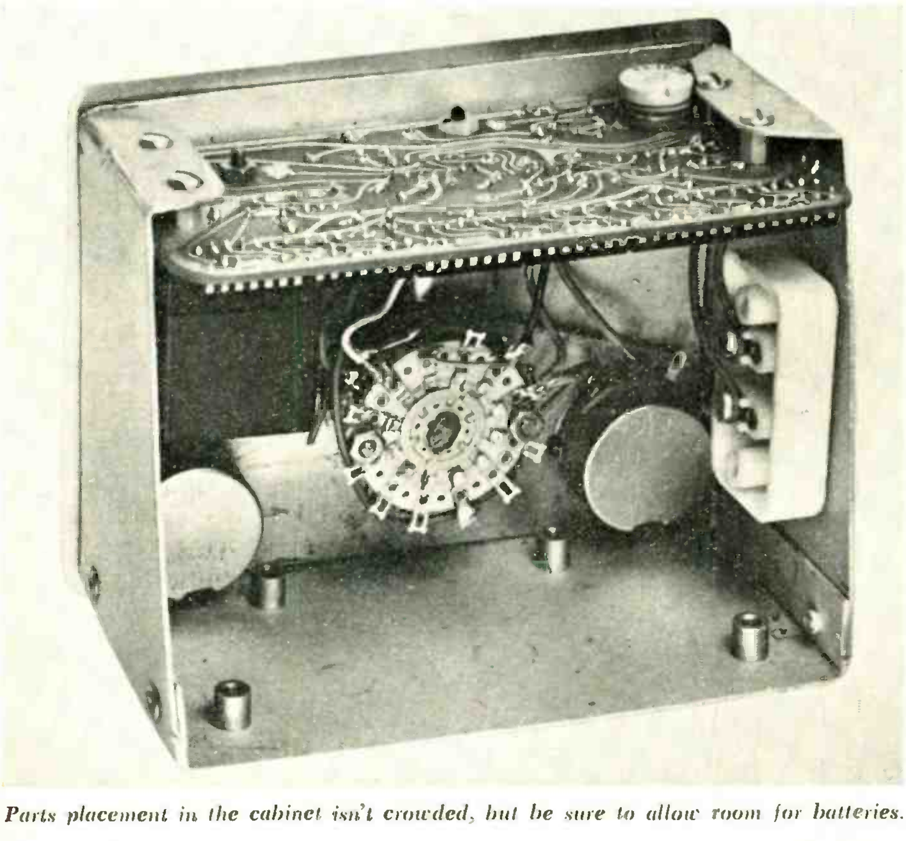
Sync-pulse shaping is accomplished by R4, C7, R6, C9 and IC9. The output sync pulses are then routed to modulator stage IC10.

VERT WIDTH control R7 and HOR WIDTH control R8 shape the 960-Hz and 245.76-kHz signals, together with R5, C8, R3, C6 and IC9. The dot coincidence is performed by the lower right gate of IC1-b. Selector switch S1, together with the remaining gate in IC1-b, chooses the desired pattern. A fifth switch position turns the DOTnBAR off.

Q and XTAL 2 are an rf oscillator, operating at channel 2 (55.25 MHz), 3(61.25 MHz) or 4(67.25 MHz) depending on your choice. Usually, you'll want to pick an unused channel in your area. Resonant tank L1-C10 tunes the oscillator to suit the selected crystal.

Diode D1 is the rf modulator. The amount of current through D1 is determined by IC10 and resistors R9 and R10. In the absence of sync or pattern pulses, the *series* combination of R9 and R10 determines the diode current, and hence the black output level. A sync pulse grounds R9, increases the diode dc current, decreases the impedance of D1, and *increases* the rf output. A pattern pulse *opens* R10, which turns D1 *off*, producing very little output rf and a resultant white line or dot.

Composite rf appears across R14 and is delivered to the receiver antenna via a piece of 300-ohm twin lead and a clothespin connector. Coupling from R14 is with two 2.5-pF capacitors—C4 and C5—used to reduce rf level. These capacitors are "gimmicks"—made by simply leaving insulation *on* the hookup wire that contacts the screwheads on chassis connector J1 (see photo below). They're as near to a zero-cost, zero-effort pair of capacitors as you'll probably ever come across.



Parts placement in the cabinet isn't crowded, but be sure to allow room for batteries.

Batteries

Ordinary D-size flashlight cells do not have quite enough capacity for any reasonable battery life in this application, so *heavy-duty* D cells are recommended. The NEDA type 13C (Burgess 210, Eveready 1150, Ray-O-Vac 318) costs about $0.16 each. With such batteries you'll get about 8 hours of continuous operation.

If you prefer, you can go to fancier cells to reduce your per-hour cost. For instance, alkaline D cells such as the NEDA 13A (Burgess AL-2, Mallory MN-1300) will give you 40–50 hours of operation per set. Professional service people might also consider rechargeable nicad batteries. The 2,000 mA-hr rated D-size (Burgess CD-7 or Eveready C2) is ideal.

A battery-saver switch, consisting of S2 and two silicon diodes, is included in the generator. When the cells are fresh, you can run the DOTnBAR with *both* diodes in series with the battery, giving you a supply voltage around 3.2. As the batteries age, you cut out first D2 and later D3, thus maintaining about 3 volts for the circuit. If you always use the saver position with the *maximum* number of diodes in series that still gives you output patterns, you'll more than double battery life.

Construction

A circuit board is a must for this project as the IC's alone require nearly 140 tightly packed connections. You can buy this board predrilled and ready for assembly, but if you prefer you can lay out and etch your own board, using the full-size layouts shown in Figs. 3 and 4. Use a small iron and fine solder while soldering the IC's in place. Note that the second row of IC's has its identifying notches pointing in the opposite direction from the first row. IC10 receives no B+. The IC's are not interchangeable.

The rf oscillator requires a bit of care in assembly. Bypass capacitors C11 and C12 must be high-quality disc units that do not resonate below 70 MHz. *Do not substitute Q.* The coil is made of No. 14 solid copper wire. Wind four turns on a ⅜-inch form and space the turns out to ⅝-inch. You can strip a piece of BX or Romex electric cable to get this size. The coil is self-supporting and mounts directly on C10. The oscillator tank consists of these two components; they must cover a 55- to 68-MHz range. C10 mounts on the *foil* side of the circuit board. A solder terminal and wire jumper form the tap for L1.

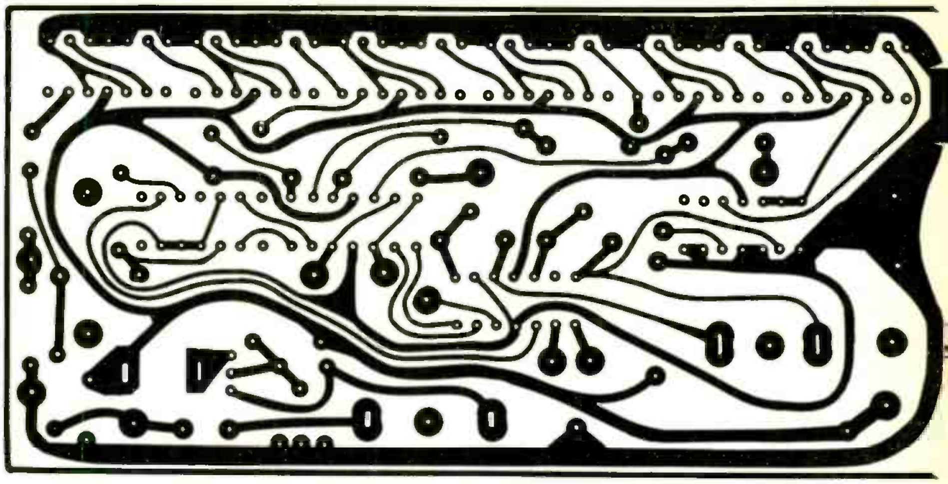
You can use a 3 x 4 x 5-inch metal box or similar deep-drawn aluminum case for your unit. If your plans call for the deep-drawn case, the photos show the chassis and the circuit-board mounting. Use the front panel and circuit board as drilling templates. If your S1 is multideck, you'll have to shorten the spacers to avoid mechanical interference with the batteries.

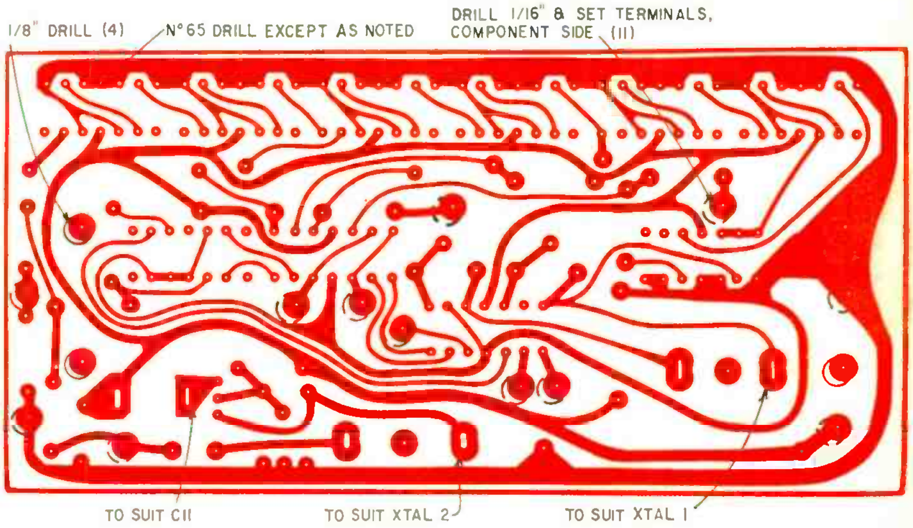
The chassis supports the circuit board upside down with four threaded spacers and No. 4 hardware. A ⅛-inch thick piece of aluminum is mounted behind the chassis to pull back the bushings of S1 and the pots. This lets the knobs hug the front panel, but still allows you to make use of the antirotation tabs on the controls.

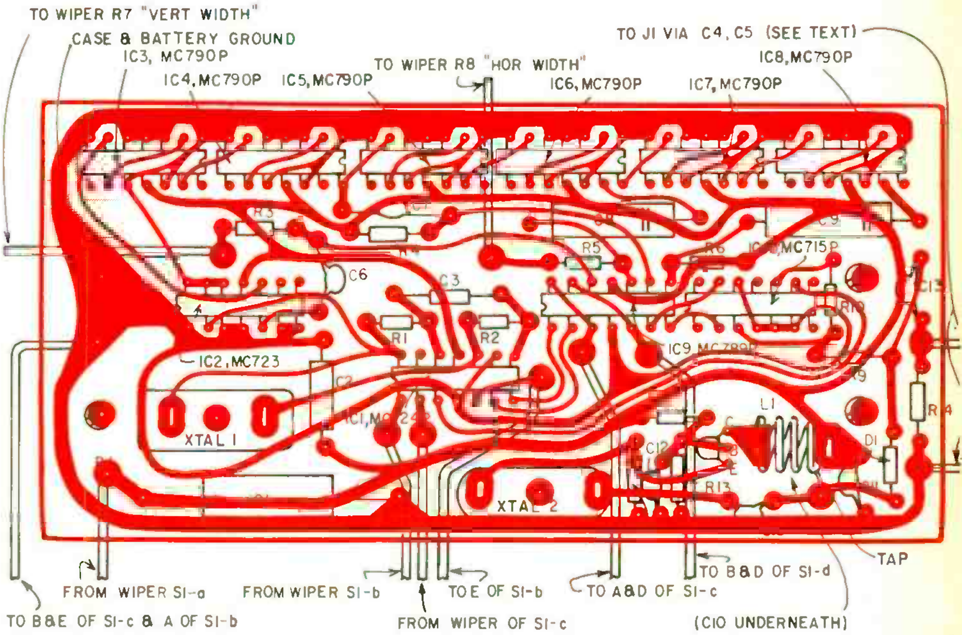
A 300-ohm chassis-type TV connector is mounted on the left side of the chassis and can be reached through a rectangular access hole in the case. Remember *not* to strip the leads going under the terminal screws.

A three-cell battery holder is pop-riveted to the rear panel. So is the battery-saver switch, mounted vertically so that the maximum *upward* switch travel corresponds to both diodes being in the circuit. Watch the clearance between battery, chassis and case. You can use the case as a ground return as the PC board automatically picks up this connection.

You might like to use several wire colors to keep track of the leads to S1. Your output cable can consist of 3 feet







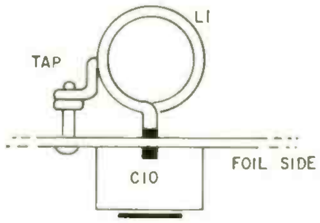


Fig. 3 (top)—Here is the life-size pattern for the PC board that's used in the generator.

Fig. 4—Board holes and foil patterns (middle) and component-mounting locations (bottom).

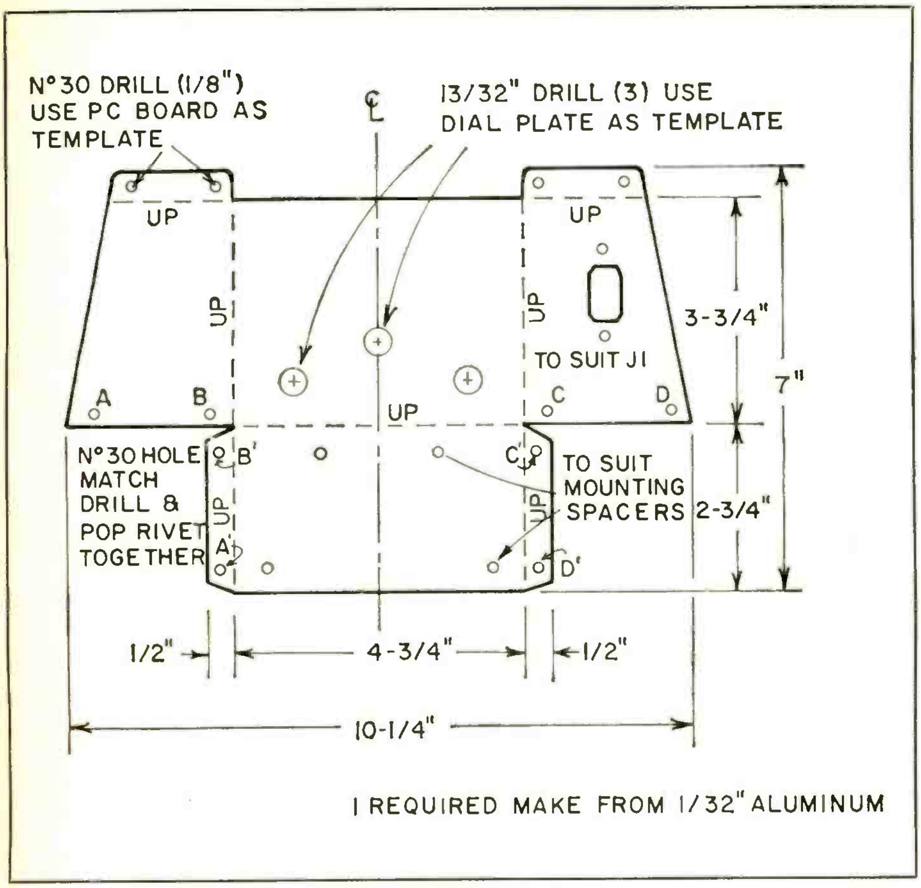


Fig. 5—If you use a deep-drawn case, you'll need a chassis like this, made of aluminum.

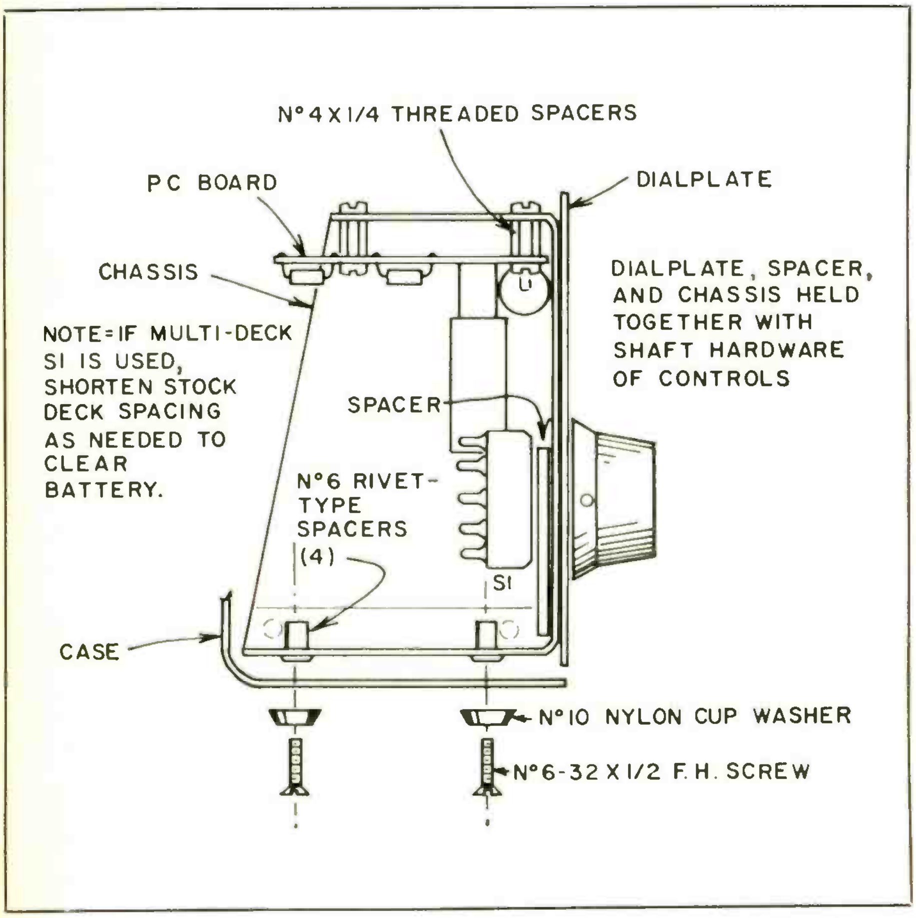


Fig. 6—Assemble case, chassis and PC board like this. Be sure switch clears battery.

Build DOTnBAR - A Professional Quality Pattern Generator

of twin lead with a connector that fits J1 on one end and, on the other, a clothespin connector. Mount a small 250-ohm pot (R15) on the clothespin to give you a point-of-use rf attenuator.

Preliminary checkout

Monitor power-supply current with a dc vom and *briefly* switch the DOTnBAR to the crosshatch position with the battery-saver switch up (both diodes in the circuit). If the current is not approximately 225 mA, *stop immediately*, and carefully check out the circuit to find the short, the open, or the IC that's in backward.

Once you have the proper meter current, clip the DOTnBAR to a working TV tuned to the proper channel, and switch to the crosshatch position. Adjust trimmer C10 till the oscillator starts. Set C10 halfway between the start and dropout points. Then adjust the TV fine tuning for the brightest vertical line and, if you have to, touch up the horizontal stability control. Finally, adjust the DOTnBAR width controls to get a typical crosshatch pattern.

Operating hints

Always use minimum rf output to the receiver, to prevent possible overloading. Once adjusted, C10 should not need readjustment unless you change crystals. The width controls may occasionally need touching up, or you might like to purposely vary them for special effects and multiple dot patterns.

You'll find the picture a bit larger than broadcast programs in both directions—horizontally because of the 15,-360-Hz sweep frequency, and vertically because of a narrower blanking bar. It amounts to ¼ inch each way on a 20- or 21-inch set. Remember that the horizontal stability may need retouching on a few sets, particularly low-cost portables, so always run a final stability check on an actual station.

You can add a gated rainbow by building an adjustable, crystal-controlled, 3.5641-MHz oscillator and injecting this signal as a subcarrier into the junction of R9–R10 with a small capacitor. I've purposely left off this feature as it adds significantly to the DOTnBAR's cost and is normally not needed for the majority of color setup and convergence work, particularly for in-home service.

Always use the battery-saver switch as far up as possible. If the pattern ever becomes skitterish or drops out, switch down to the next position. Remember that the DOTnBAR needs no warmup time, and you're only wasting battery life if the instrument is on and not being used. END

SOLID STATE IN ELECTRIC APPLIANCES

Part 2—The revolution is under way, with transistors and diodes finding new jobs in labor-saving devices

By THOMAS R. HASKETT

LAST MONTH YOU LEARNED HOW SEMIconductors are popping up everywhere in new appliances. Probably the most widespread use is in the control of temperature and motor speed. Lighting dimmers are popular, too.

Are there other jobs being done with transistors and diodes to make human labor easier? You're darned right there are.

Heating and air conditioning

The simple thermostat that controls a furnace, boiler, or electric heating element has one disadvantage—time lag. Like an overcorrecting agc system, it hunts. The room temperature is usually either too hot or too cold.

Honeywell uses solid-state circuits to provide proportional, or even, control of electric heaters. Fig. 1 is a block diagram of the system. The sensor is a thermistor which furnishes an error signal to the bridge and amplifier. This signal is then passed to the trigger circuit which fires the SCR or TRIAC to control power to the heating elements. Additional modules can be slaved to the master, to control heat over a wider area. The timer circuit schedules control cycles so fast that no temperature variations are felt by persons in the heated space.

Not only is cold-weather heating a problem, so is cold-weather air conditioning. In hot weather, the temperature difference between a cooled room and the hot outdoors is used to make the air-conditioning system work. An expansion device responds to this difference and passes refrigerant liquid from the evaporator coil (which is outdoors) to the condenser coil (which is inside the cooled room).

In heavily populated rooms, or areas filled with heat-generating electronic equipment, air conditioning is often needed in winter, even with outside temperatures as low as zero. Since the outdoor temperature is lower than room temperature, the expansion device cannot properly control the system.

Carrier Corp. uses a solid-state control circuit to run a fan in its air conditioner. The fan cools the condenser coil and provides enough temperature difference to allow the system to function normally.

The circuit (Fig. 2) shows the fan motor in series with a full-wave bridge rectifier across the ac line. Motor speed is determined by current through the windings, which depends on the amount of SCR conduction. Since the SCR is across the bridge output, it receives dc.

The thermistor (a negative-coefficient type) is mounted on the condenser coil. R1, the thermistor, and R3 form a voltage divider across the bridge output.

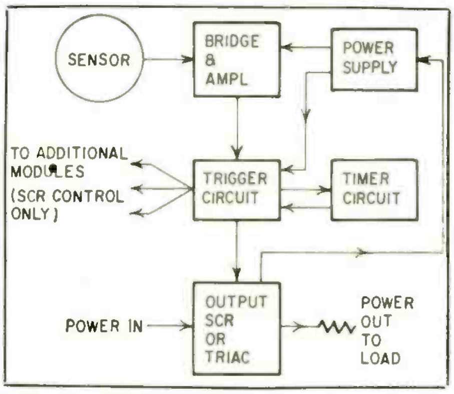


Fig. 1—Building heat is automatically controlled by a thermistor in this circuit.

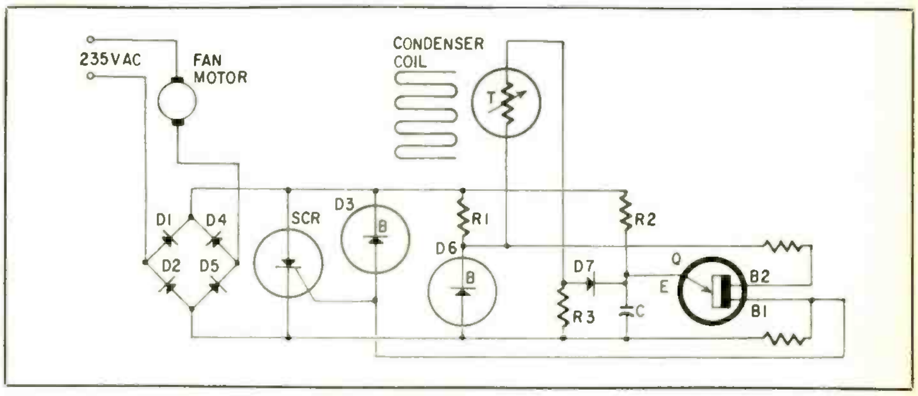


Fig. 2—An air conditioner that operates even on winter days uses a thermistor to cool the refrigeration unit when temperature outside the house is cooler than that inside.

SOLID STATE IN ELECTRIC APPLIANCES

As the temperature of the condenser coil increases, thermistor resistance decreases. This allows capacitor C to charge up to the bias point of Q, turning it on. Emitter-to-base-1 resistance becomes very low and C discharges through Q into the SCR gate, firing it.

Zener D6 stabilizes the voltage across Q, and Zener D3 does the same for the SCR. These diodes also provide transient protection.

Thus, the thermistor controls the air conditioner at low temperatures.

Moisture control

A clothes dryer can simply be set with a timer to run a specified length of time. But different loads require different drying times, and set times can be wasteful of both time and money. Several manufacturer's lines of dryers are automatic—they shut down when the clothes are dry.

The secret of operation is the fact that dry clothing is a poor conductor of electricity, while wet or damp clothing has more conductivity.

The control that performs this unique function was designed by Texas Instruments Inc. and is patented under US No. 3,266,167. It is manufactured and marketed by TI's plant in Versailles, Ky.

Fig. 3 is the dryer control-module schematic. The user puts the clothing in the tumble compartment and then adjusts R2, the ELECTRONIC DRYNESS control, to the degree of dryness desired. When the START switch (not shown) is pushed, 117 volts ac is applied to the module, at which time voltage builds up on the gate of the SCR and it's triggered. Thus the relay is pulled in. Contacts 4

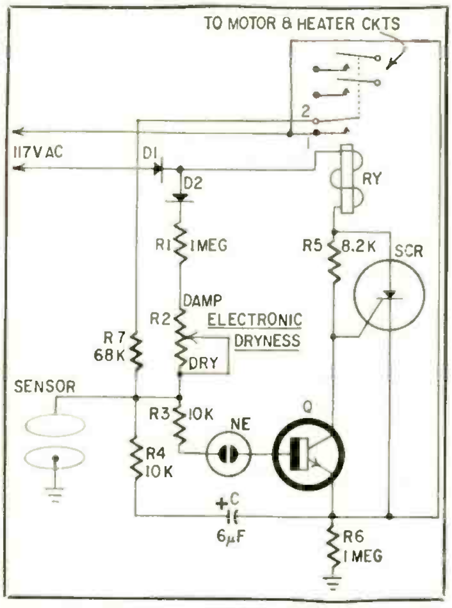


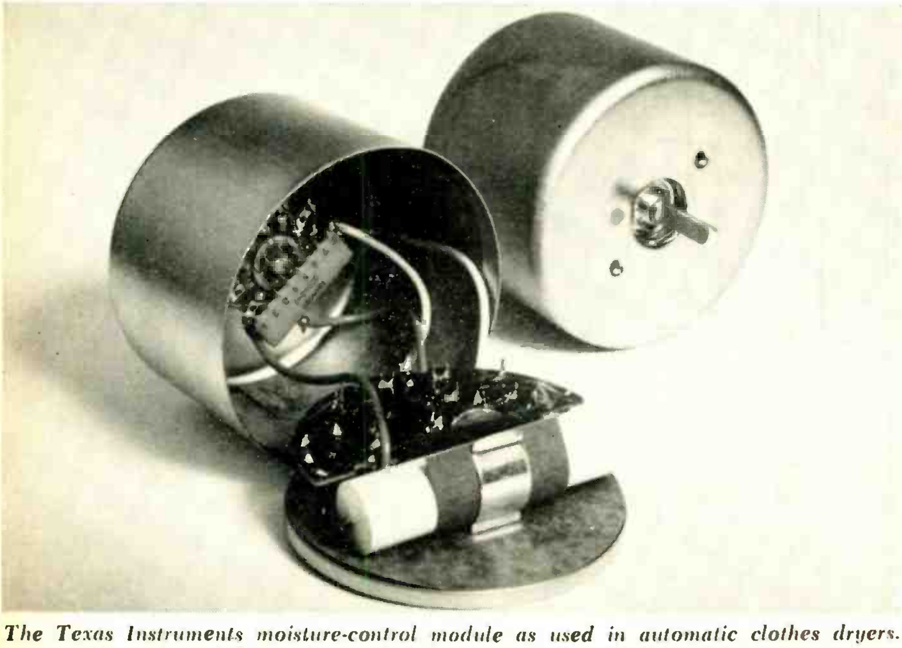
Fig. 3—Moisture control determines the timing cycle in automatic clothes dryer.

on R4 are closed (connection not shown) shorting out the start switch so the dryer will not shut off when the switch opens. Other contacts on the relay cause the motor and heating element to operate. The tumble chamber rotates, hot air is applied, and the clothing begins to dry.

Because the clothing is wet to begin with, the sensor is more or less shorted, preventing capacitor C from charging to the dc potential applied through the diodes and resistors R1, R2, and R4. As the clothes become less damp, their resistance increases, thus unshorting the sensor. This allows capacitor C to charge, and when it reaches about 70 volts, the neon lamp fires and discharges the capacitor through Q. When Q is triggered into conduction, it puts a virtual short across the gate-to-cathode circuit of the SCR, turning it off. Since the SCR cannot conduct, the relay drops out, and the motor and heating element are turned off. Thus the dryer stops when the clothes are dry.

Contacts 1 of RY close (connection not shown) allowing the capacitor to be drained of all residual charge.

Actually, a bimetallic thermostat control circuit (not shown) is used to cycle the heating element and maintain a preset temperature. After the control module relay drops out, the tumble motor continues to operate during a cool-down period, until the thermal cutout drops out.



The Texas Instruments moisture-control module as used in automatic clothes dryers.

Gas ignition

The usual gas range has one disadvantage—it needs a continuously running pilot flame to ignite the burners. Not only does the pilot waste fuel if it should be accidentally extinguished, but the buildup of gas may eventually present a serious hazard as it's poisonous and highly flammable.

Wilcolator Corp.'s EM-20 Electronic Match avoids this problem by making possible a "cold" oven which burns gas only when needed. Fig. 4 is the circuit.

When the range is turned on, 117 volts ac is applied to the input terminals. Storage capacitor C2 begins charging through diode D2 and R2. At the same time, C1 begins charging through R1. The time constant of R1 and C1 is 1 second. At the end of this period the voltage on C1 has reached the firing potential of NE1, causing it to break down and trigger the SCR.

When the SCR conducts, it discharges C2 through the primary of the transformer. Since T has a high turns ratio, discharging the 1,250 volts of C2 across the primary produces a secondary pulse of about 18 kV. This pulse is applied to a series of spark gaps, one for each burner, the broiler, and the oven. Each spark is sufficient to ignite the gas stream.

NE2 is panel-mounted on the

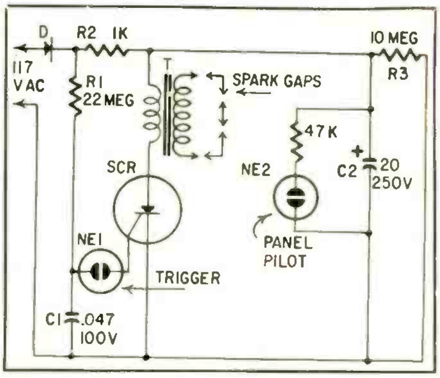
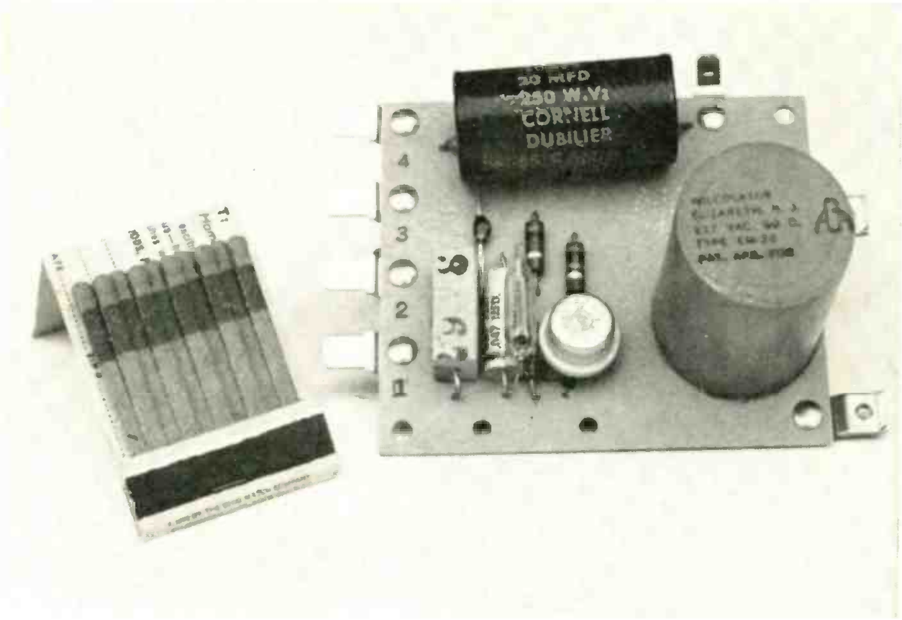


Fig. 4—Gas-range igniter functions like an automobile capacitor-discharge system.



There's no need for a matchbook if a gas range uses Wilcolator's Electronic Match.

range, to show that the circuit is functioning. It also acts as a voltage regulator for storage capacitor C2.

Semiconductor alarm clock

Women like cordless clocks because there's no ac line to clutter the wall. Windup clocks being a nuisance, tiny but efficient battery-operated dc motors were developed. The next step was the solid-state motor-control circuit. Now comes a transistor-controlled alarm clock—which is *not* a radio.

Fig. 5 shows the circuit of the TR-3 movement used by General Time Corp. in their Seth Thomas Auditron. S1 is the arming switch, and is shown in the ALARM position. Normally, with S2 as shown, the transistor drives the balance wheel (which is shaft-coupled to the clock hands) by passing current through the drive coil. This coil produces a magnetic field which interacts with the permanent magnet mounted on the rim of the balance wheel, thus keeping the wheel moving.

Alarm tripping is set to the desired time by adjusting the cam position. At the preset time, the cam throws S2 to the ALARM ON position. Then the base of Q is no longer connected to the positive battery supply through R, but through pickup coil L2. The rotating permanent magnet induces a pulse into L2, which is coupled through the speaker. This tone has a frequency of about 2,500 Hz and occurs in pulses of 300 per minute. The frequency was chosen because human hearing is more sensitive in that region; the pulse rate was chosen to simulate the average song of a cricket's chirp on a warm summer night—a pleasant sound to most people. The user shuts off the alarm by throwing S1—the only switch accessible to him.

Since current drain of the TR-3 circuit is low, battery life is long. An ordinary zinc-carbon C-cell will last 6 months; a mercury cell will last a year.

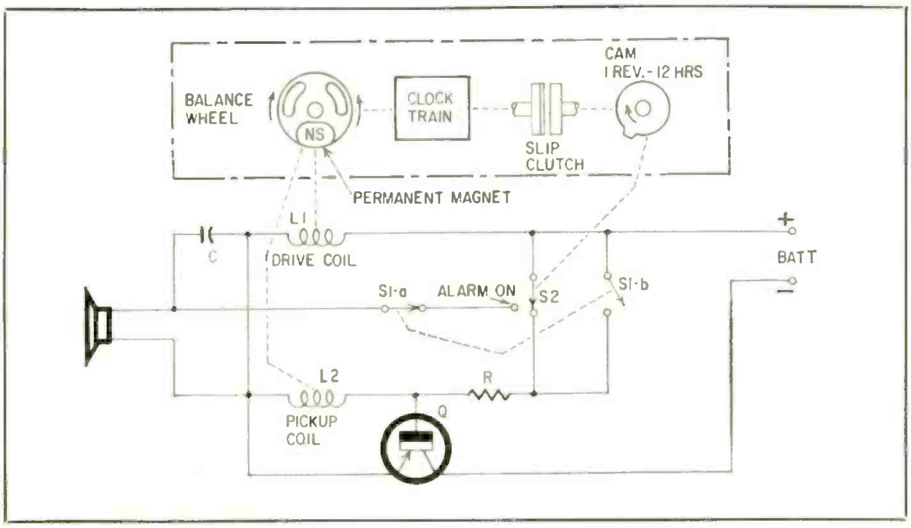


Fig. 5—This nonradio electronic alarm uses a single transistor to produce its chirp.

The immovable switch

Have you ever got on an elevator in one of those new buildings, pressed the floor-selector button, only to find it couldn't be depressed? I have. Funny, the thing *did* light up—and I reached the floor I wanted to. But why didn't the button move? How did the thing operate?

Fig. 6 shows how. Normally the SCR is cut off, and capacitor C2 cannot charge from the supply voltage. When someone touches pushbutton S (actually a small immovable metal plate or disc) body capacitance completes the circuit for C2. Because C2 is quite small, it rapidly charges to the firing point of NE, the neon fires and triggers the SCR on. The load—in the SCR anode circuit—can be a relay which stops the elevator at the desired floor. The "switch," by the way, is merely a metal plate to sense finger proximity.

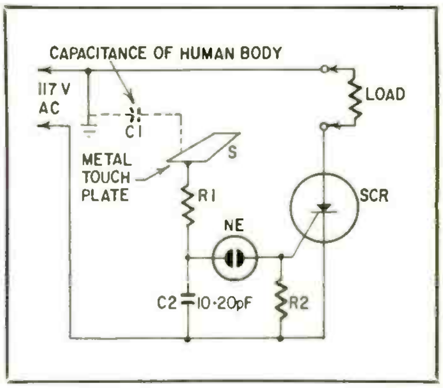


Fig. 6—Body capacitance touch switch.

Future applications

The solid-state revolution has conquered another beachhead in the appliance industry and is rapidly moving inland. Ahead are even more diverse uses—such as the all-electronic home, the SCR-controlled electric car, and . . . but who knows, really? All we know for sure is that semiconductors can be made cheaply and in large numbers. They can replace many more complicated and unstable circuits, and they promise much longer service. All these things point to greater solid-state use.

One item is pertinent: Ordinary electrical knowledge is not sufficient to repair these new electronic appliances. People who know how to troubleshoot SCR's, TRIAC's and transistors are going to be needed in ever-increasing numbers to handle service on everything from cordless toothbrushes to clothes dryers.

The future of solid-state appliances can be *your* future. END

Build An Audio Tone-Burst Generator

By RICHARD J. DE SA, Ph.D.

HIGH ON THE LIST OF "HOT" ELECTRONIC items are those amazing little devices known as integrated circuits. Now that their prices have dropped so dramatically, it's quite simple to incorporate a couple of them in a multipurpose test instrument. Here's a practical and useful project for audio testing.

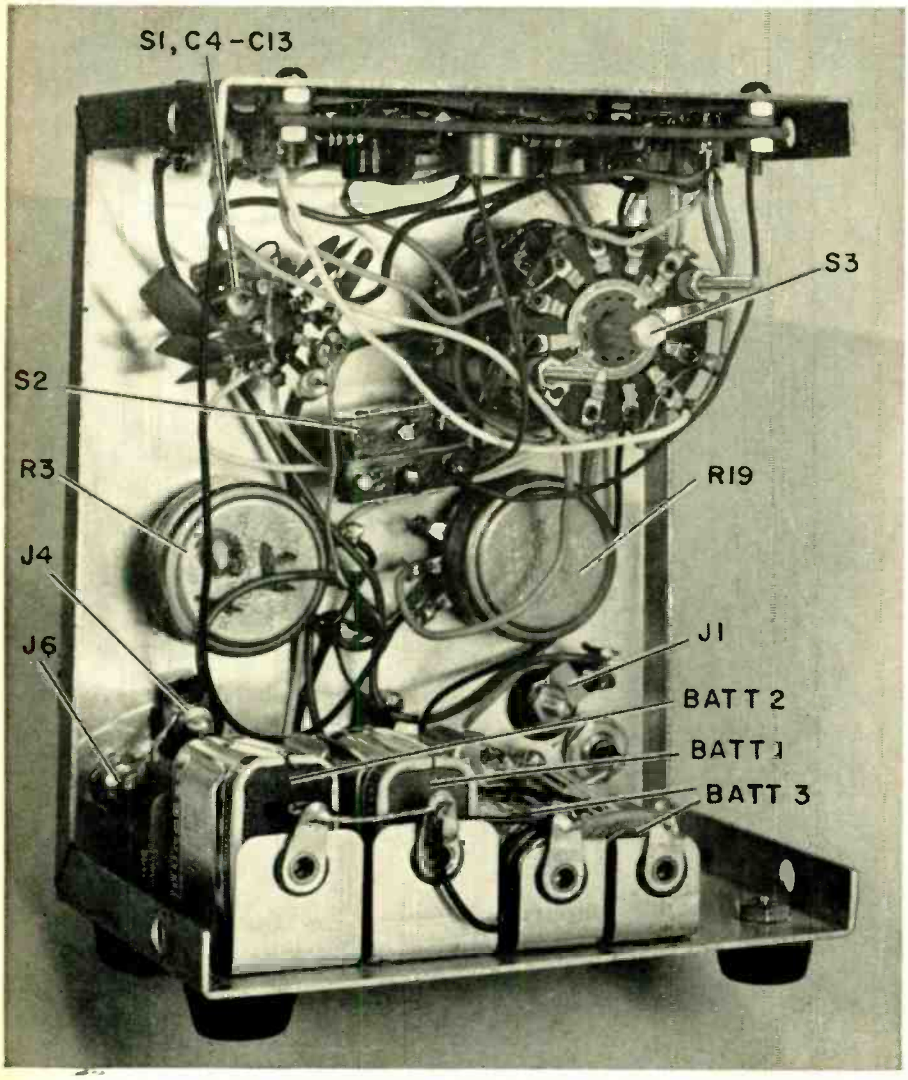
True to their acclaim, integrated circuits allow construction of the instrument with minimum fuss and few auxiliary components. At the same time, they provide versatility, small size and, most importantly, low cost.

When used alone, the instrument puts out a high-quality square wave (rise time under 450 nsec) at five switchable frequencies ranging from 20 Hz to 12 kHz. When the unit is used with an external sine-wave generator, variable-width pulses are produced. The square-wave and pulse outputs are both excellent signals for testing and trouble-shooting audio components.

Most important, however, is the instrument's ability to gate or switch an external signal to produce tone bursts. The external signal to be gated can be any waveform—sine or square waves, white noise, even music or speech. Cost runs under $20, and construction should take no more than two or three evenings.

The tone burst is excellent for testing transient response in speakers, amplifiers, tape recorders, crossover networks and other audio components. The gated or switched output provides a close simulation of the rapid attack-and-decay patterns of musical material. The tone-burst waveform is also useful in evaluating overload characteristics of power amplifiers.

Unfortunately, commercial tone-burst generators are complicated and expensive. To reduce complexity and cost, the instrument described in this article uses an extremely simple transistor-gating (chopping) circuit together with two inexpensive (under $1) Fairchild integrated circuits. It produces, as shown, excellent tone bursts. If you've thought of trying integrated circuits, here's a good chance to get your feet wet in them.



In the box specified, there is just enough room for batteries to fit behind panel jacks.

Fig. 1 shows the schematic of the generator. Fig. 2 is a simplified block diagram showing its essential features. The unit consists of four subunits. IC1 is connected as a variable-width pulse generator (Schmitt trigger). IC2 is a free-running multivibrator. Q1 and Q2 are the gate driver–amplifier and the gate, respectively. Q3 and Q4 form a compound emitter follower to provide a low-impedance output. A direct-coupled npn–pnp pair is used here so the output is at ground potential.

Sine waves introduced at input jack J1 (Figs. 1 and 2) are converted to fast-rise pulses at the input frequency by IC1. Pulse width is controlled by R3. Pulses, applied via C2–R5 to IC2, serve to lock in the square wave produced by free-running multivibrator IC2 (the gating waveform) with the incoming sine wave (the gated waveform). The tone burst will start at the point at which the sine wave crosses the zero axis. The input sine wave also is routed to gate Q2 by R9–R15, to be gated by the output of IC2.

The multivibrator (IC2) produces a clean square wave without the round-cornered characteristic of the usual multivibrator output. In addition, a signal from IC2 is presented at J3 to sync the scope.

The gate (Q2) is a circuit frequently used in analog computer systems. Extremely simple, it is relatively free from switching transients. It is also highly effective. Signal through the closed gate is down more than 65 dB! Note, however, that, with R15 switched into the circuit by S2, "leak" through the gate is increased so that the signal is down only 20 dB from the main tone burst. This feature is useful when you are interested in noting the behavior of the device under test after the main tone burst is switched off.

In addition to its function as gate driver, Q1 amplifies signals obtained from the integrated circuits. Waveforms up to 15 volts peak-to-peak are available at the output jack when the unit is operated as a square-wave or pulse generator.

Switch S3 selects the desired function (OFF, PULSE, SQUARE WAVE, NON-GATED, GATED). Each battery is switched into operation only when it is necessary for the selected function. The signal applied to R19 also is switched to pass the desired output signal through the GAIN control. For the gate-open or nongated function, R10 is connected between 15 volts and the base of Q1. The driver is thus turned on, disabling the gate.

Construction

The entire unit is built into a 5 x 4 x 3-inch aluminum box. Most of the circuitry is mounted on a perforated printed-circuit board. Capacitors C4 through C13 are mounted directly on switch S1. Fig. 3 shows the circuit pattern, and the photos show component placement. Letters A through O of Fig. 1 refer to the terminations shown on the circuit board. These points are connected to various positions on the switches, input/output jacks and pots.

The circuit pattern can be readily copied using standard printed-circuit etching techniques. Careful hand application of ordinary nail polish makes an ideal and inexpensive way to apply an etch-resistant coating to the copper-clad board. After etching in warm ferric-chloride solution, the nail polish is easily removed—with nailpolish remover, naturally!

The circuit board is fastened to the top of the box with 4–40 hardware and small spacers, and the batteries are installed in the bottom of the box. If you wire the lettered points on the board to the appropriate points, the unit can be wired quickly. Addition of rubber feet, knobs, etc., will then complete the assembly.

After the wiring is complete, install the batteries and connect output jacks J4 and J5 to the vertical input of your scope. Connect sync jack J3 to the scope's external-sync input and turn on the instrument. With function switch S3 in position 3, you should get a clean square wave. S1 varies the frequency of the output. Now inject a 1-kHz 8-volt sine wave at J1 and J2. Place the function switch in position 4 (nongate). You should get an unaltered sine wave at J4. In position 5, the sine wave will be switched on and off at the frequency chosen by S1, thus producing tone bursts.

Adjustment of R3 will allow the tone burst to begin at the zero-axis crossing of the sine wave (this is not necessary, but it results in a more attractive display). Similarly, the gate can be made to close at the zero-axis crossing by trimming the input frequency slightly. Throw S2 and note that the "leak" during the gate-closed period is increased to −20 dB.

Operation of the pulse generator can be checked by setting switch S3 to position 2 and varying R3. Note that R3 can be adjusted to give a symmetrical square wave; thus the unit will pro-

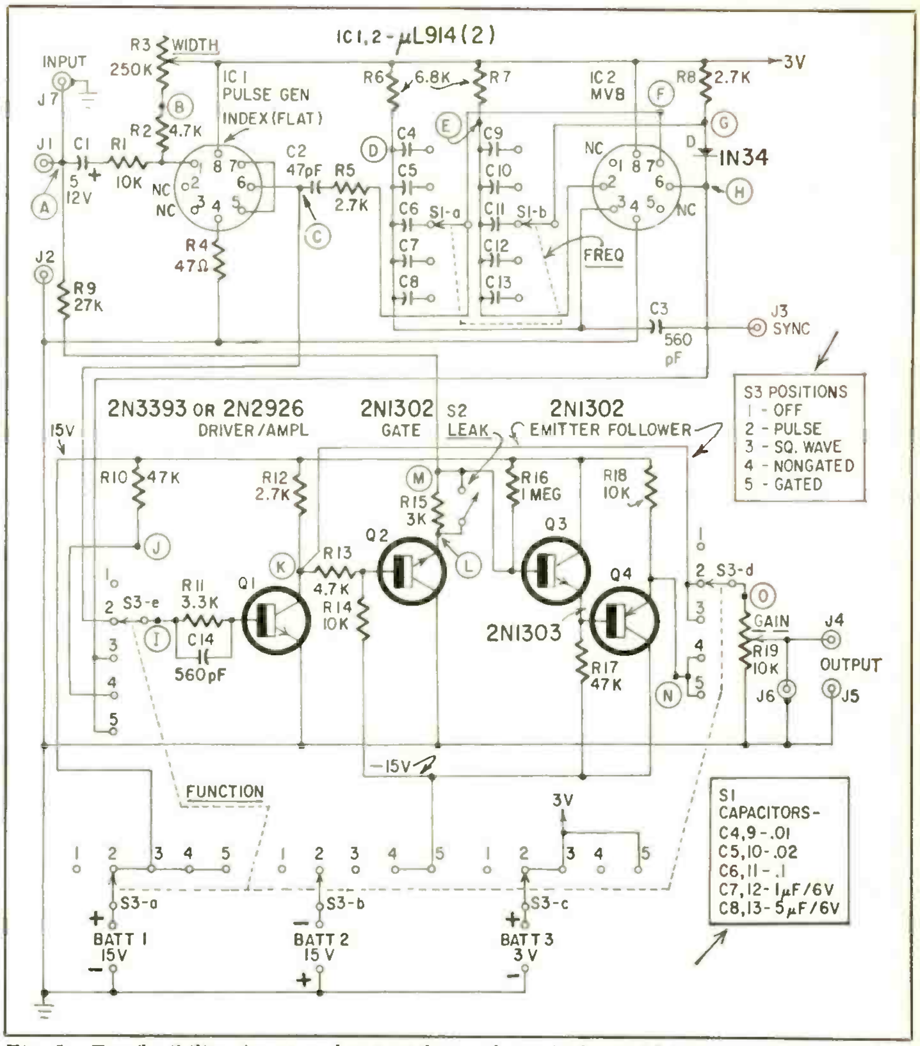


Fig. 1—For flexibility, input and output have phono jacks and binding posts in parallel.

SPECIFICATIONS

Input:

External signal generator—impedance approximately 7,000 ohms at 1 kHz. Requires 2 to 3 volts rms to drive pulse generator.

Output:

a. Output impedance approx. 5,000 ohms (affected by position of level control). Maximum output 15 volts peak to peak (5.2 volts rms). Square-wave and pulse outputs positive-going from zero.
b. External scope-sync output.

Performance:

a. Gating and square-wave frequencies 20, 100, 250, 5,000, 12,000 Hz nominal.
b. Pulse frequency—determined by external signal generator—usable to at least 500 kHz.
c. Frequency response in gated and nongated modes—flat from dc to approx. 50 kHz.

PARTS LIST

R1, R14, R18—10K
R2, R13—4,700 ohms
R3—pot, 250K
R4—47 ohms
R5, R8, R12—2,700 ohms
R6, R7—6,800 ohms
R9—27K, 5%
R10, R17—47K
R11—3,300 ohms
R15—3,000 ohms, 5%
R16—1 meg (see text)
R19—pot, 10K
All resistors ¼ watt 10%, except R3, R9, R15.
C1—5 μF, 15 volts, electrolytic
C2—47 pF, disc
C3, C14—560 pF disc
C4, C9—.01 μF, disc
C5, C10—.02 μF, disc
C6, C11—0.1 μF, disc
C7, C12—1 μF, 6 volts, electrolytic
C8, C13—5 μF, 6 volts, electrolytic
D—1N34
IC1, IC2—μL914 Fairchild integrated circuit. Available through Fairchild distributors
Q1—2N3393, 2N2926 (GE)
Q2, Q3—2N1302 (RCA, TI)
Q4—2N1303 (RCA, TI)
S1—2-pole 5-position rotary switch
S2—spst slide or toggle switch
S3—5-pole 5-position rotary switch
BATT 1, 2—15-volt battery (Burgess U10 or equivalent)
BATT 3—two 1.5V Z-batteries in series
Box—5 x 4 x 3-inch Minibox or equivalent (Bud CU-2105A)
J1 through J5—4-way binding posts
J6, J7—Miniature phono or coax connectors
Battery holders—2 for Burgess U10 (Keystone 166 or equivalent) 1 for 2 Z-batteries (Keystone 140 or equivalent)
Perforated copper-clad board (Lafayette 19C3601 or equivalent)
Screws, nuts, spacers, wire, solder, etc.

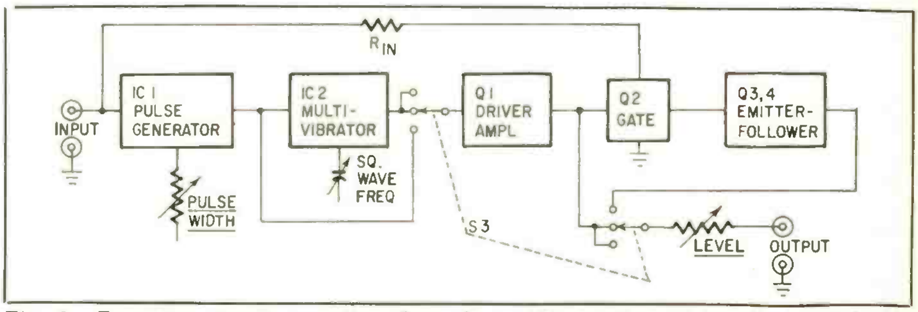
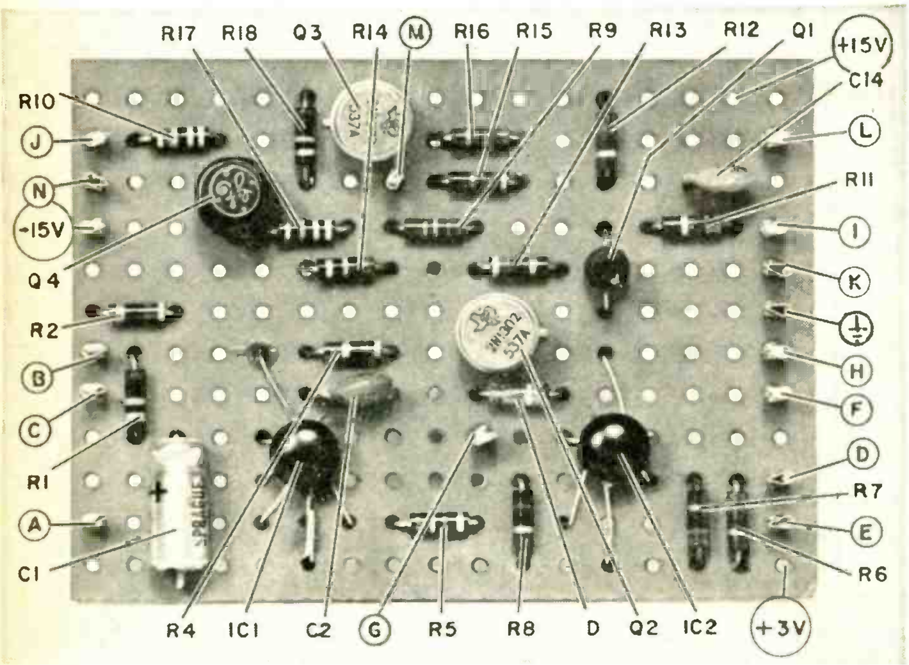


Fig. 2—Generator circuit operation depends on the position of function switch S3.

duce square waves at the frequency of the external sine-wave generator in addition to the five internally produced frequencies.

With the unit in the "gated" mode, but with input jack J1 shorted to J2, check the gate offset. (This offset effectively places the tone burst on a slight pedestal). It should be less than 0.1 volt.

This offset is caused by two effects. The first and less significant one is the leakage current through Q2 when it is cut off. Second, the positive and negative 15-volt supplies are not necessarily equal in magnitude. In fact, as the batteries age, the offset will vary, since battery voltages do not change at the same rate. One could overcome this problem by making R16 variable so the offset could be adjusted to zero occasionally as the batteries age. Such an adjustment was omitted, however, to reduce circuit complexity. In any event, the offset will not exceed about 0.1 to 0.2 volt through the useful life of the batteries. END



Front of the perforated board contains most components with some room to spare.

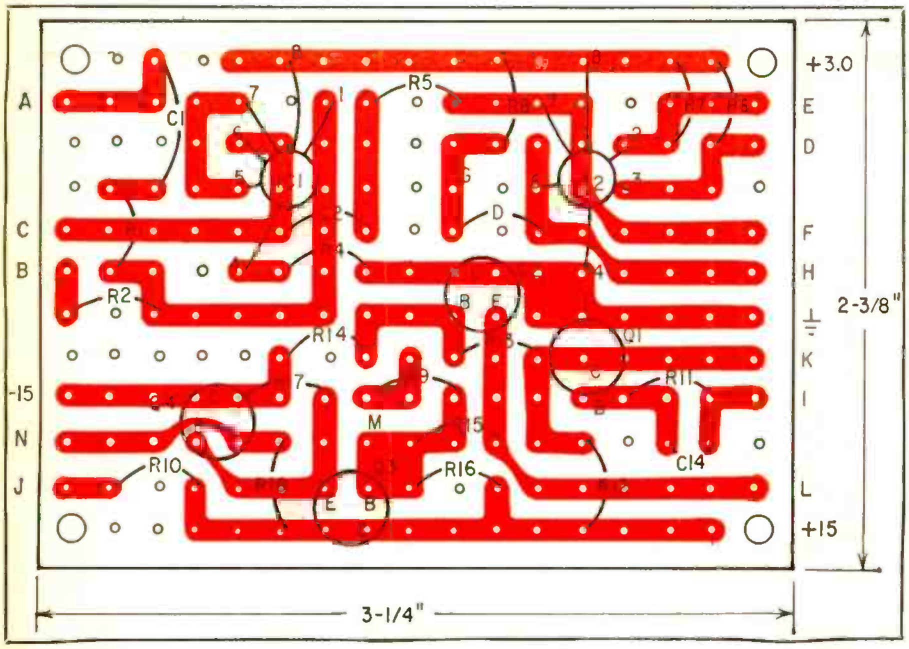
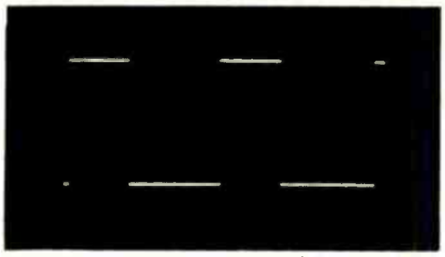
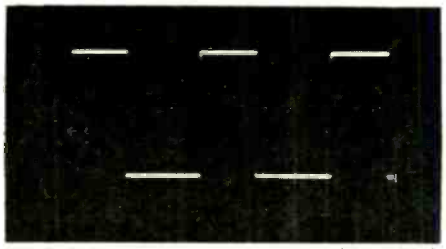


Fig. 3—Back of the board above, showing copper connecting paths to all elements.

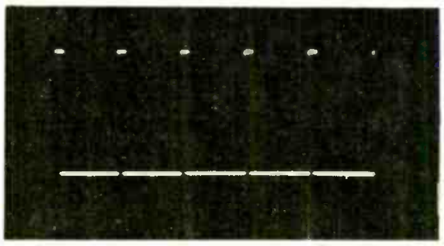
Fig. 4—Samples of generator waveforms:



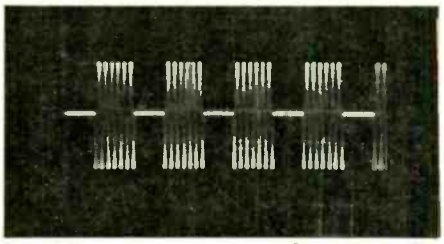
Low-frequency square wave (about 20 Hz).



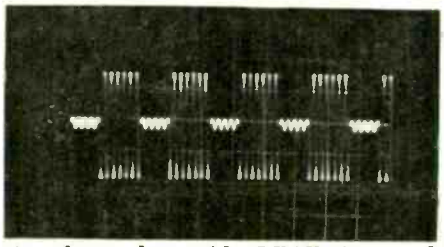
High-frequency square wave (12 kHz).



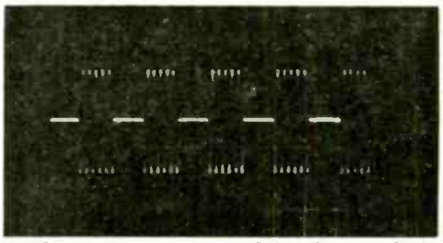
Pulse output at approximately 10 kHz.



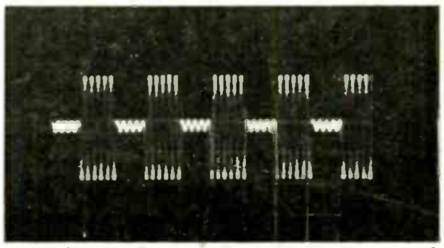
1,000-Hz sine wave, gated at 100 Hz.



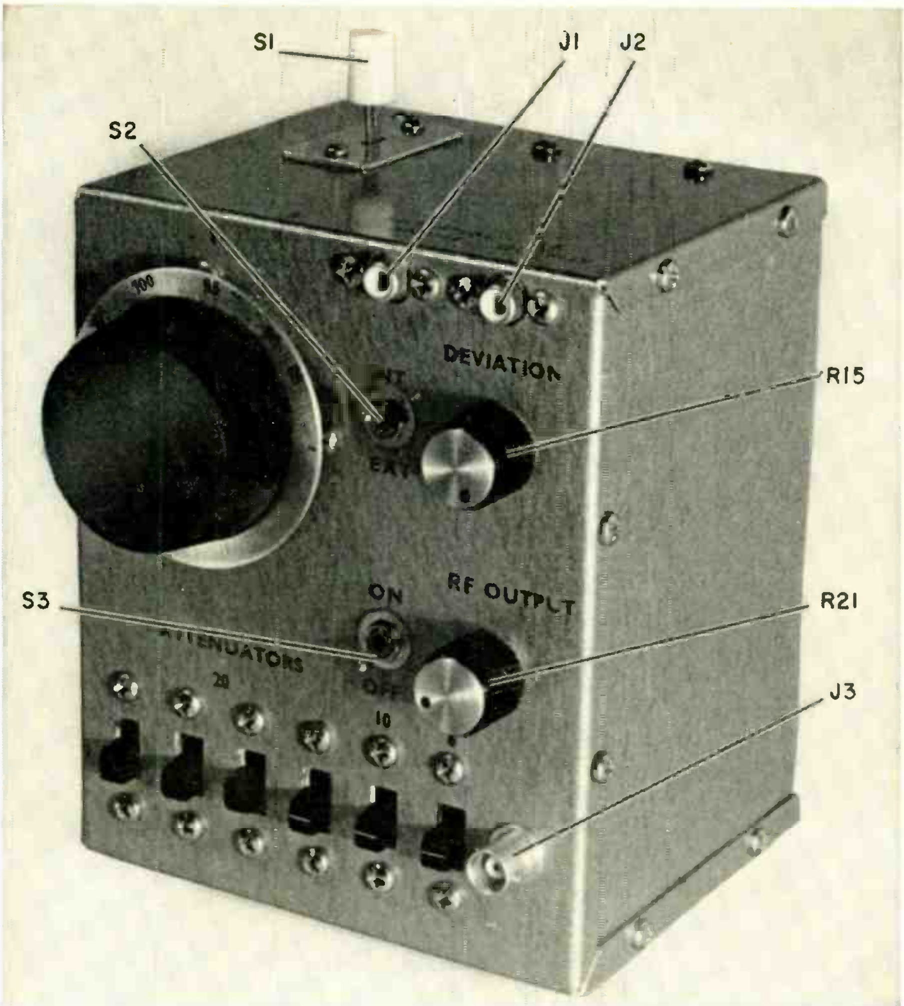
As above, but with LEAK increased.



50 kHz sine wave gated at about 5 kHz.



As above, but with LEAK increased.



FM at Your Fingertips

By KENNETH F. BUEGEL

FEW INSTRUMENTS ARE AS VALUABLE to the modern service shop as a good FM signal generator. The price is generally so high, however, that most shops use a combination FM–TV sweep generator for FM alignment. Many of them have such great leakage signals that the user can never be sure of his results, especially in a receiver front end.

The generator described here is an updated version of a unit first built over 4 years ago. Its stability is excellent. Output on either band is from a fundamental oscillator and few spurious signals are present. The deviation is true FM and is adjustable, remaining constant with tuning.

The wideband modulator will accommodate a multiplex signal input and the internal audio oscillator also has an adjustable front-panel output. The attenuator will reduce the rf output level low enough to permit alignment of even the most sensitive receivers. Cost of construction is about $35.

The circuit is shown in Fig. 1. Q1 operates as a grounded-base Colpitts oscillator. Bandswitch section S1-b selects tuned circuits either to cover the rf range of 88–108 MHz or set the i.f. of 10.7 MHz. S1-a adds additional feedback through C9 to insure oscillation at the lower frequency.

S1-c selects the modulator input voltage required for each band. As C7 is varied to tune through 88–108 MHz, the modulating voltage applied to D1 must also vary or the deviation will be greater at higher frequencies. A 72-tooth gear on the shaft on C7 drives a 48-tooth gear on the shaft of R18. As the capacitance of C7 is decreased, the wiper of R18 picks off a smaller portion of the modulating voltage. R17 and R19 are tracking adjustments to set modulation at the ends of the tuning range. R16 adjusts modulation for the 10.7-MHz output.

Q2 is a phase-shift oscillator operating at about 500 Hz. The output of emitter follower Q3 is a low-impedance signal applied to front-panel deviation control R15. The input to Q3 may be either the internal audio signal or an external signal between 10 and 100,000 Hz. About 2.8 volts p-p is required to provide 75 kHz of deviation from an external source, nominal 100% modulation of an FM signal. The output of Q2 can modulate the signal in excess of 100 kHz.

Construction

A bracket should be made for S1 which will hold its contacts about 1/4 inch above the foil surface of the circuit board. Another bracket holds R18 and C7. Use care in laying out this bracket so that the gears will mesh smoothly without binding.

C7 has been modified by removing all but six rotor plates and five stator plates. Because C7 has a 3/16-inch diameter shaft, a 1/4-inch spacer is drilled out on one end to fit snugly over this shaft. The gears listed (see parts list) must be drilled and tapped for a No. 8 setscrew.

Mount all parts on the PC board except C8, L1, L2, and L3: then mount the parts on brackets. The coils and trimmer are mounted last. The photo shows location of components and wiring between the board and front panel. The $-V_{cc}$ points shown on the schematic are connected by short lengths of hookup wire. Keep these leads close to the foil surface and route them as shown in the drawing.

The generator cabinet is a 4 x 5 x 6-inch chassis box. Extra holes are drilled in the cabinet so that each seam has two screws fastening the box together. Small aluminum angles are placed to provide tight connections between the seams which normally do not make contact. This is necessary—do not omit it as a bothersome detail. At 100 MHz the leakage from these seams can radiate to an extent that will render attenuator switching meaningless. Sand off any paint between mating surfaces of the box.

The attenuator section is constructed with large slide switches. Miniature types have too much capacitance between contacts and the attenuation will be less than desired. Each section is shielded as shown in Fig. 2, with only a small opening between sections for connections. In addition, each switch has a copper shield fitting between its contacts.

All switches should have 6–32 nuts soldered to the switch-mounting plate before being wired into the attenuator.

All pieces of the attenuator cover and shielding are thin copper. (This type of copper is available through hobby shops or heating suppliers.) The back cover of the attenuator is spot-soldered in place after the attenuator is

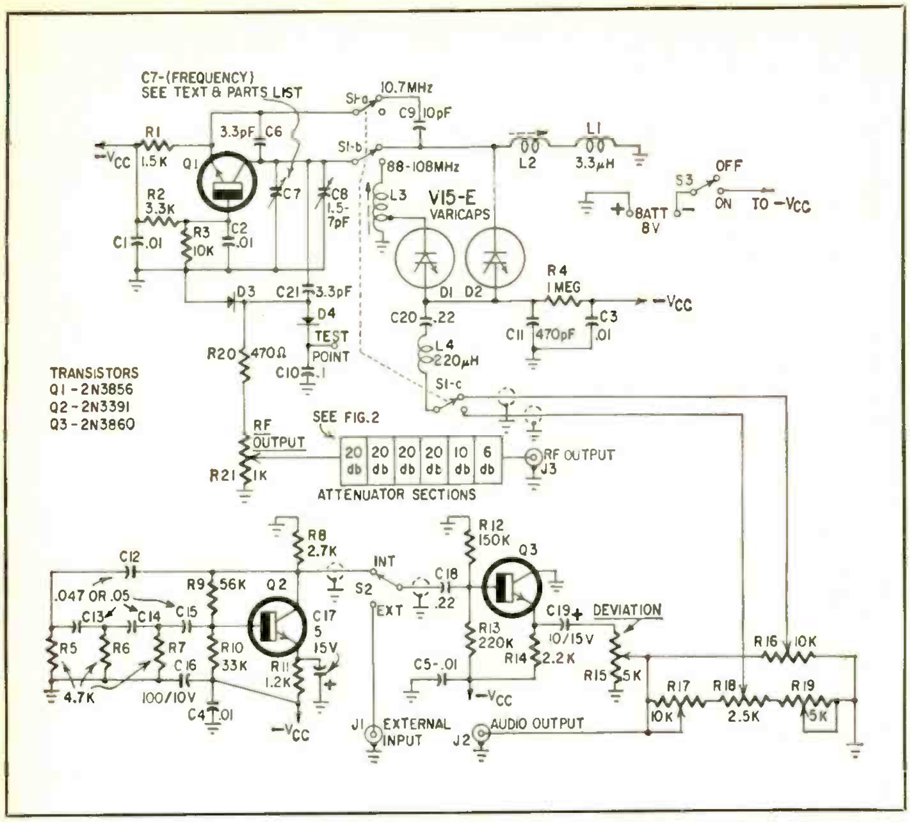
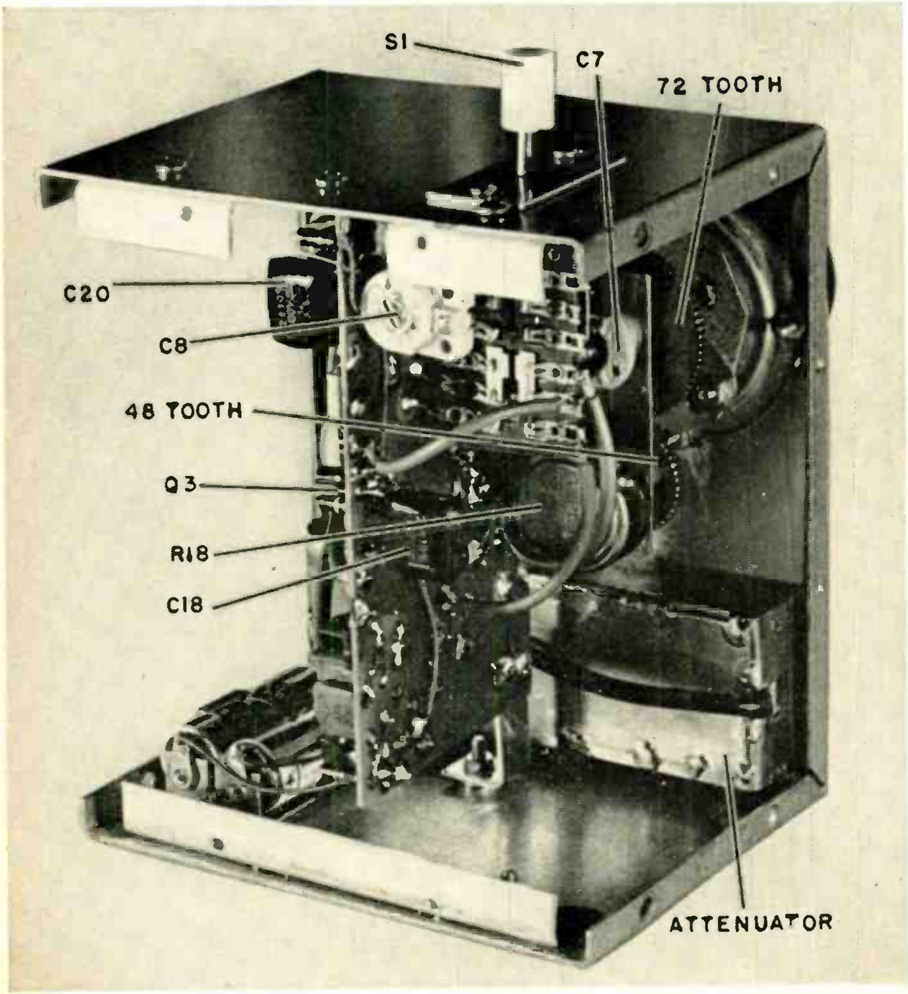


Fig. 1—The generator wiring is simple but should be point-to-point and closely spaced.

An invaluable feature of this generator is the well-shielded attenuator mounted at the bottom of the front panel. PC board in center of cabinet contains most components.



FM at Your Fingertips

mounted in the cabinet. The output lead is a short length of 300-ohm line. One side of the line is connected to the ground side of the output connector. (Insert blocking capacitors in series with the output test leads when servicing transformerless sets.)

The constructor is cautioned to measure very carefully when placing the circuit board in the cabinet. Although the board material is glass epoxy and extremely rugged, if any misalignment exists between the planetary dial and the shaft of C7, the output frequency will shift after you release the knob. The brackets which attach the circuit board to the cabinet should be made slightly shorter than required and the gap filled with washers after the dial is tightened to C7.

Alignment

Aligning the rf portion may be completed before mounting the circuit board in the cabinet. An FM receiver is used to set the dial points on the generator. Apply power to the circuit board and check at the collector of Q2 for a sine wave of 2–3 volts at about 500 Hz. Any clipping or distortion may be removed by changing the value of R9 slightly. Apply this signal to C18. The same signal should be at Q3 emitter.

Adjust R15 until about 200 mV rms is applied to C20 with R16 and R17 set for maximum signal. Throw S1 to the high band. Connect a clip lead from the junction of R20 and R21 to the receiver antenna terminals. Set C7 and C8 to midrange. A signal should now be found in the 88–108-MHz range. Adjust the slug in L3 until the output is at 88 MHz with C7 fully meshed. C8 sets and output to 108 MHz with C7 *almost* completely unmeshed.

Stability at the high end will be better if the plates are not completely open. Repeat the adjustments on L3 and C8 at opposite ends of the dial until tracking is accurate.

Intermediate dial calibration points may be determined with crystal marker harmonics or by comparison with known stations.

Bring the clip lead near the first i.f. stage and rotate S1 for 10.7-MHz output. Set C7 to midrange and adjust the slug in L2 until the output is on the correct frequency.

The circuit board should be mounted in the cabinet before calibrating deviation control R15. If an accurate generator is not available as a comparison source, the following technique will do the job with only slight inaccuracy. Using an oscilloscope, measure the peak audio output of several stations in your FM receiver. This peak output should be noted and used as a reference value.

Be sure to measure it following the de-emphasis network in the receiver.

Connect the generator to the first i.f. stage input and inject enough signal at 10.7 MHz to quiet the receiver completely. Set 15 at midrange and, using internal modulation, adjust R16 until the receiver output is at the reference level. Leave R15 at the same setting and switch to the high band. Inject the signal at the antenna terminals. Tune both receiver and generator to 88 MHz and adjust R17 for reference output. Tune to 108 MHz and adjust R19 for reference output. Repeat until the deviation is accurate at each end of the tuning range. The setting of R15 is now very close to 75-kHz deviation and should be marked for future use.

Since it is possible to deviate the output frequency linearly far more than 75 kHz, this unit may be used as a sweep generator with either internal or external modulation. Sweep width is controlled by the deviation control. The scope horizontal input should be connected to the generator audio output jack. The vertical input will be the detected signal. The modulator bandwidth will easily handle a multiplex signal.

The generator output may be monitored during alignment by connecting a 100-μA meter between the test point and ground.

Build carefully and you'll have a useful source of FM at your fingertips.

END

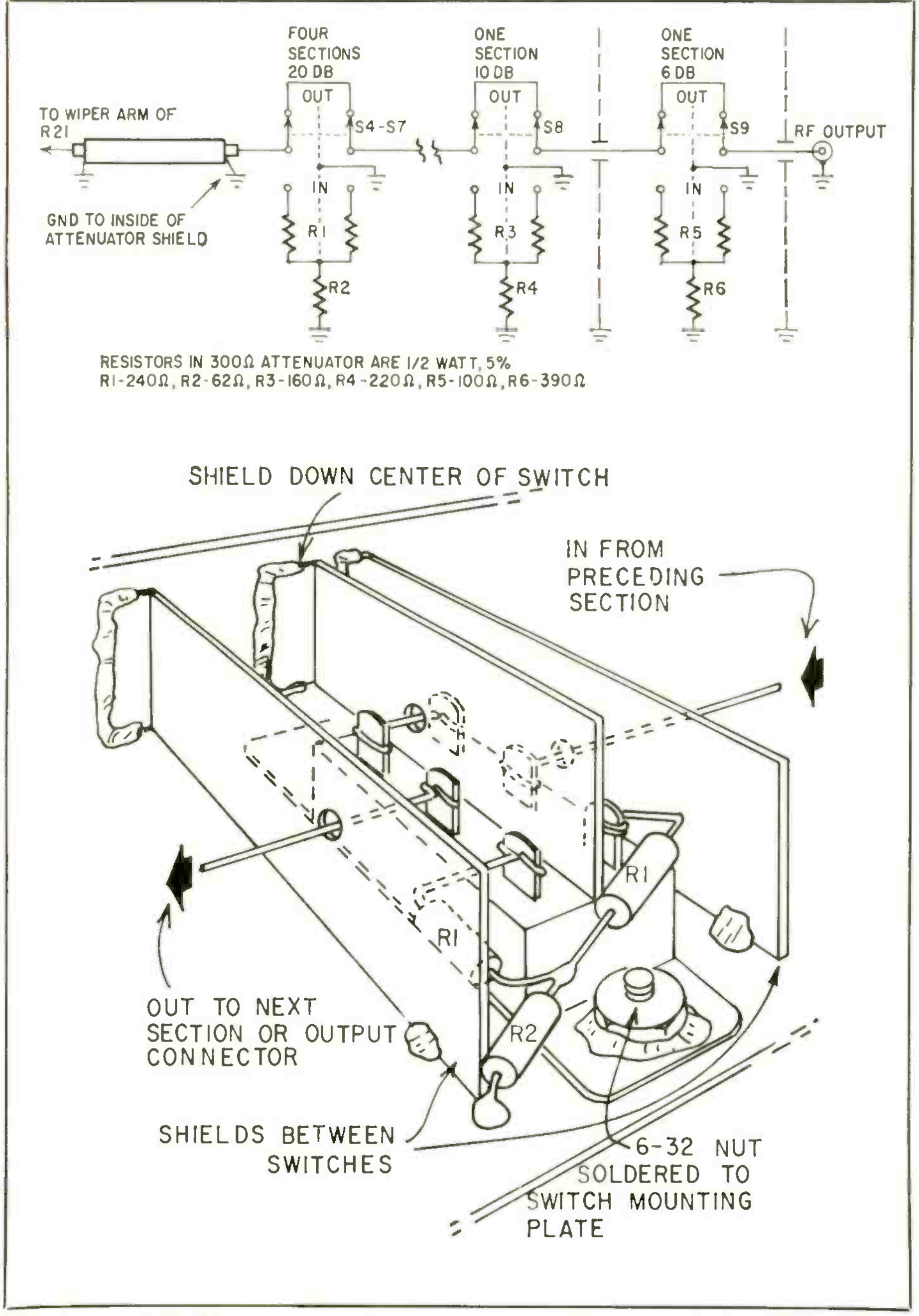


Fig. 2—Good shielding is essential to proper attenuator function. You should solder or braze the shield plates to the chassis for least signal leakage between sections.

PARTS LIST

R1—1,500 ohms
R2—3,300 ohms
R3—10K
R4—1 meg
R5, R6, R7—4,700 ohms
R8—2,700 ohms
R9—56K
R10—33K
R11—1,200 ohms
R12—150K
R13—220K
R14—2,200 ohms
R15—pot, linear taper, 5,000 ohms, 2 watts
R16, R17—pot, linear taper, 10K, ¼ watt, horizontal PC mount (Mallory MTC1414—Newark Electronics stock No. 60F2242, $0.39—or equivalent)
R18—pot, linear taper, 2,500 ohms, 2 watts
R19—pot, linear taper, 5,000 ohms, ¼ watt, horizontal PC mount (Mallory MTC53L4—Newark Electronics stock No. 60F2239, $0.39—or equivalent)
R20—470 ohms
Fixed resistors ½ watt, 10% unless otherwise specified
Resistors for attenuator (all ½ watt, 5%)
9—240 ohms
4—62 ohms
2—160 ohms
1—220 ohms
2—100 ohms
1—390 ohms
Q1—2N3856
Q2—2N3391
Q3—2N3860
D1, D2—variable-capacitance diode, 15 pF (TRW/PSI type V15E Varicap, Allied Electronics, 100 N. Western Ave., Chicago, Ill. 60680, $3.05)
D3, D4—1N295
C1, C2, C3, C4, C5—.01 μF, 50 volts, ceramic disc
C6, C21—3.3 pF, NPO ceramic
C7—2.7 to 19.6 pF, E.F. Johnson type 160-110, modified per text
C8—1.5 to 7 pF, ceramic trimmer
C9—10 pF, silver mica
C10—0.1 μF, 16 volts
C11—470 pF, ceramic disc
C12, C13, C14, C15—.047 μF, 16 volts
C16—100 μF, 10 volts, electrolytic
C17—5 μF, 12 volts, electrolytic
C18, C20—0.22 μF, 100 volts, Mylar
C19—10 μF, 15 volts, electrolytic
L1—rfc, 3.3 μH, 10%, miniature
L2—20 turns No. 24 enamel closewound on J. W. Miller 4300 form
L3—5 turns No. 20 tinned copper wire, evenly spaced to cover form. Tapped at one turn from ground end
L4—rfc, 220 μH, miniature
S1—4pdt locking switch. (The type shown in the photos is no longer available. You can substitute a miniature rotary or slide switch or a lever type such as the Mallory 6M2412.)
S2—spdt miniature toggle switch
S3—miniature spst toggle switch
S4 to S9—dpdt slide switch (see text)
J1, J2—phono jacks
J3—miniature coax connector
BATT—8 volts (two Mallory TR133R mercury cells or equivalent)
Case—2-piece 6 x 5 x 4-in. aluminum utility box (Bud CU-2107-A or equivalent)
Dial—National Co. type AM-1 or equivalent
Gears—Boston Gear 72-tooth type G-146 ($2.27) and 48-tooth type G-142 ($1.62) from distributors listed in classified directory under "Gears" or for $5 for the two (minimum order) from Boston Gear Works, 14 Hayward St., Quincy, Mass. 02171
Etched and drilled glass-epoxy circuit board No. FM112, $4.35 postpaid from Transitek Co., P. O. Box 205, Des Moines, Wash. 98016

WANTED: Test Instrument Info

Are you sore at a test instrument manufacturer because you feel he has not lived up to his promises, or his equipment has let you down? If so, you are not alone. In years of answering all sorts of mail from readers, I recall very few kind words in reference to test gear or manufacturers. Gripes and complaints? We've had plenty. They fall into four basic groups. We've looked into enough to know why some of them happen.

Group one: You are sore because you have not received a response to requests for service or information. Few manufacturers, if any, are set up to handle large volumes of mail from equipment owners but all are cooperative in rendering services established in their operating policies.

One difficulty is that you have been writing to the manufacturer at the rather incomplete address printed on the instrument panel or to an address that the company left when it moved years ago. Undeliverable mail cannot be returned to you if you failed to include your return address or if it is illegible. Correct addresses for most service-instrument makers will be found in the accompanying table. If you don't find the one you need, check ads in the various electronic publications.

Another reason for no response from manufacturers is that you consistently fail to put your complete address on the letter. The return address on the envelope is not enough when writing to a business firm. In most cases, incoming mail is opened at a central point, envelopes are discarded and the letters then routed to the appropriate departments. You can't expect a reply if you make a habit of putting your address only on the envelope.

Group two: By far the most numerous and vehement complaints are from those of you whose tube testers cannot handle the latest tube types. Well, if your tester is over 12 years old, you probably need a new one. The manufacturer *might* have an adapter that will enable you to test nuvistors, compactrons, and all the other base configurations that have been developed since your tester was built. The table will tell you if an adapter is available and will supply information on new tube setup charts.

If your job or hobby requires that you be able to test both vintage and modern tube types, then you need two testers. Better buy a new one to handle modern tubes and those to be developed in the years to come. Keep the old tester for the jobs that require it. Don't palm it off on some unsuspecting beginner who may need a modern instrument.

Group three: You want service or instruction manuals. The table lists manufacturers' policies on manuals. Generally, they are available for 5–10 years after a particular model has been discontinued. If you want a schematic and one is not available from the manufacturer, you might find it in your local library. Take a look through "Test Equipment Circuit Manual" (TEC-1) published by Howard W. Sams & Co., Inc. For scope schematics, try "Encyclopedia of Cathode-Ray Oscilloscopes and Their Uses" by Rider and Uslan.

Group four: The smallest group of complaints is from beginners and do-it-yourselfers who expect to receive what amounts to a complete course in radio–TV–electronics servicing along with the purchase of a vom or signal generator. Instruction manuals include a few basic uses for instruments but you need much more if you are a beginner. For detailed information on using various test instruments, we suggest such books as "The Oscilloscope", "Oscilloscope Techniques", "The VTVM" and "How to Get the Most Out of Your VOM" from the Gernsback Library series, and Robert Middleton's "101 Ways to Use Your . . ." series published by Sams.

Manufacturer	Instrument type	Model No.	Current (C) or discontinued (D)	Tube chart price	Instruction manual price	Accessories type and price	Additional Notes
Amphenol Distributor Div. 2875 25th Ave. Broadview, Ill.	CRT tester	855	C	NC	NC	None	2-3
	Color bar generator	860	C		NC	None	2-3
	F-S meter	840	C		NC	Uhf module $54.95, vhf module $69.95, balun $8.95, probe antenna $12.95	2-3
B & K Div., Dynascan Corp., 1801 W. Belle Plaine Ave., Chicago, Ill. 60613	Tube tester	600	D	$1.50 single $2.50 4/year	$1.00	Note 4	5
	Tube tester	606	C		$1.00		5
	Tube tester	625	D		$1.00		5
	Tube tester	650	D		$1.00		5
	Tube tester	700	D		$1.00		5
	Tube tester	707	C		$1.00	None	
	CRT tester	200	D	$1.00 2/year	$1.00	Note 4	
	CRT tester	350	D	$1.00 2/year	$.50 diag. only		5
	CRT tester	400	D	$1.00 2/year			5
	CRT tester	440	D	$1.00 2/year	$1.00		5
	CRT tester	445	D	$1.00 2/year	$1.00		5
	CRT tester Note 9	465	C	$1.50	$1.00		5

Manufacturer	Instrument type	Model No.	Current (C) or discontinued (D)	Tube chart price	Instruction manual price	Accessories type and price	Additional Notes
Conar Instrument Div., National Radio Institute, Washington, D. C. 20016	Tube tester	220	D				
	Tube tester	221	D	$3.00*	$2.00	3AD pix tube adapter cable $4.98, 5AD 110° adapter $4.77	6-11-12
	Tube tester	223	C	$4.50**			
EICO 131-01 39th Ave., Flushing, N. Y. 11354	Tube tester	625	D				
	Tube tester	628	C	$4.50**	Note 7	Note 4	8
	Tube tester	666	D				
	Tube tester	667	C				
	Note 9						
Electronic Measurements Corp., 625 Broadway, New York, N. Y. 10012	Tube tester	204	D				
	Tube tester	207	D				
	Tube tester	209	D				
	Tube tester	205-A	C	$1.50	NA		
	Tube tester	206-A	C				
	Tube tester	211	C				
	Tube tester	213	C				
	Vtvm	106	C		$0.75		
	Vtvm	107-A	C		$1.00		
	Appl tester	108	C		$0.75		
	Dwell/tach	100	C		$1.00		2-7
	Scope	600	C		$1.00		
	Scope	601	C		$1.00		
	Batt elim.	905	C		$0.75		
	Batt elim.	907	C		$0.75		
	Note 9						
Heath Company, Benton Harbor, Mich. 49022	Tube tester	TT-1A	C		$0.50	None	
	Tube tester	IT-21	C		$0.50	None	12-13
	Tube tester	TC-1	D				
	Note 9						
Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio 44108	Tube tester	533A	D				
	Tube tester	600A	D				
	Tube tester	605	D		$3.50–$4.50		
	Tube tester	800K	D				
	Tube tester	535	D				
	Tube tester	605A	D				
	Tube tester	800	D				
	Tube tester	800A	C				

1—Tube set-up charts available at least 3 years after instrument is discontinued.

2—Instruction manuals available for 5 years after instrument has been discontinued or until supply is exhausted—whichever is longer.

3—Charts and accessories available from any Amphenol distributor.

4—Write manufacturer for accessories price list.

5—Order charts and manuals from factory, accessories from local distributor.

6—Order charts, manuals and accessories from Coletronics Service, Inc., 1744 Rockaway Ave., Hewlett, L.I., N.Y. 11557

7—Write factory for information and prices on manuals.

8—Order accessories from factory or local distributor, tube charts from EICO, Tube Test Data Div., 1744 Rockaway Ave., Hewlett, L.I., N.Y. 11557.

9—Write factory for information on instruments not listed.

10—CRT adapters CRA ($4.50) and CRA-110 ($3.95) for models 625 and 666 and CRU ($9.95) for models 667 and 628. Model 610 adapter ($5.95 kit, $11.95 wired) for testing newer tube types in 625 and 666 testers. Model 615 adapter ($5.95 kit, $11.95 wired) for testing older tube types in 628 and 667 testers.

11—Tube setup charts available 10 years after instrument has been discontinued.

12—Tube setup charts available 7 years or more after instrument has been discontinued.

13—Instruction manuals available 7 years after instrument has been discontinued.

14—Tube setup charts available 20 years after instrument has been discontinued.

15—Instruction manuals available 10 years after instrument has been discontinued.

16—Instruction manuals available indefinitely at special cost.

17—Tube setup charts available one year after instrument has been discontinued.

18—Instruction manuals available indefinitely.

19—Instruction manuals available for 5–10 years after instrument has been discontinued.

20—Tube setup charts available 5 years after instrument has been discontinued.

*Single-copy price

**One-year subscription of three or four issues.

Manufacturer	Instrument type	Model No.	Current (C) or discontinued (D)	Tube chart price	Instruction manual price	Accessories type and price	Additional Notes
	Tube tester	580	D			Note 4	
	Tube tester	580A	C				
	Tube tester	750	D				
	Tube tester	539B	D	$4.50			11-16
	Tube tester	539C	C				
	Tube tester	6000	D				
	Tube tester	6000A	D				
	Tube tester	6005	C		$1.85		
	Tube tester	752A	C				
	Tube tester	799	C				
	Transistor tester	870	C	—		—	
	Transistor tester	1880	C	—		None	
	Transistor tester	850P	C	$1.80			
	Transistor tester	890	C	$4.20	—	—	—
	Note 9						
Jackson Electrical Instrument Co., Dept. D, 35 Windsor Ave., Mineola, N. Y. 11501	Tube tester	648-1	C	—	—	None	—
	Tube tester	648-A, -B, -C, -P	D			None	
	Tube Tester	648-R	D	$3.00*		648-1 SMK overlay panel $24.95	
	Tube tester	658-1	C	$5.00**	$1.00	None	14-15
	Tube tester	658	C				
	Tube tester	658-A	C			658-1 SMK overlay panel $24.95	
	CRT tester	825	C	—	—	None	—
	Note 9						
Knight and Knight-Kit (Allied Radio Corp., 100 N. Western Ave., Chicago, Ill. 60680)	Tube tester	400A	C		$0.30	None	—
	Tube tester	KG-600B	C	$1.75	$0.50	90° CRT harness $4.50, 110° adapters for above $3.50	
	Vtvm	KG-625	C		$0.75	Hf probe kit $4.95, HV probe kit $5.95	
	Scope	KG-635	C		$1.50	Direct probe $1.95, rf demod probe $4.25, low-C probe $3.95	
	Vom	KG-640	C		$0.75	None	17-18
	Vom	KG-645	C		$0.50	None	
	Rf sig gen	KG-650	C		$0.75	None	
	Rf sweep gen	KG-652	C		$0.75	None	
	Audio gen	KG-653	C		$0.75	None	
	Color bar/pattern gen	KG-685	C		$1.25	None	
	Sig tracer	KG-690	C		$0.50	None	
	Scope	KG-2100	C		$2.00	Wired low-C probe $22.00	—
Lectrotech, Inc., 1221 W. Devon Ave., Chicago, Ill. 60626	CRT tester	CRT-100	C	$1.50 2/year	$1.00	Adapter for Japanese b-w CRT's $5.95	2-11
	Color gen	V-6	D		$1.00	None	2
	Color gen	V-6B	C		$1.00	None	2
	Color gen	V-7	C		$1.00	None	2
Mercury Electronics Corp., Dept. TT, 315 Roslyn Rd., Mineola, N. Y. 11501	Tube tester	101	D	—		MH-3 CRT adapter $12.95, MA-20 decal adapter $3.75	—
	Tube tester	102	D	$2.50* $4.00**			
	Tube tester	103	D				
	Tube tester	MC-1	D	—		—	
	Tube tester	201	D	$3.00*		MA-20 decal adapter $3.75	
	Tube tester	202	C	—			
	Tube tester	203	C	$2.50*	$1.00	—	
	Tube tester	204	C	$4.00**		None	14-15
	Tube tester	300	C			—	
	Tube tester	301	C	— $3.00*			
	Tube tester	1000	C	$3.00* $5.00**	$1.00	MH-3 CRT adapter $12.95, MA-20 decal adapter $3.75	
	Tube tester	1100, -A	C	$2.50* $4.00**	$1.00	—	
	Tube tester	1101	C	—	$1.00	MH-3 CRT adapter $3.75	
	Tube tester	1200	C	$3.00* $5.00**	$1.00	MH-3 CRT adapter $12.95, MA-20 decal adapter $3.75	
	Tube tester	2000	C	—	$1.00	MH-3 CRT adapter $12.95	
	Tube tester	FC-1, -2	D	$2.50* $4.00**	NA	MH-3 CRT adapter $12.95, MA-20 decal adapter $3.75	—
Olson Electronics 260 S. Forge St., Akron, Ohio 44508	Notes 2, 7 and 9						

Manufacturer	Instrument type	Model No.	Current (C) or discontinued (D)	Tube chart price	Instruction manual price	Accessories type and price	Additional Notes
Precision Apparatus, Div. of Dynascan, 1801 W. Belle Plaine Ave., Chicago, Ill. 60613	Tube tester	T-60	D	$3.00* $4.50**	$1.00	Model G-140 Nuvistor and compactron socket adapter $12.95, A-20 decal adapter $3.75 Note 4	5
	Tube tester	T-62					
	Tube tester	612					
	Tube tester	614					
	Tube tester	620					
	Tube tester	640					
	Tube tester	650					
	Tube tester	654					
	Tube tester	660					
	Tube tester	910					
	Tube tester	912					
	Tube tester	914					
	Tube tester	915					
	Tube tester	920					
	Tube tester	922					
	Tube tester	954					
	Tube tester	1012					
	Tube tester	1015					
	Tube tester	1022					
	Tube tester	1024					
	Tube tester	1040					
	Tube tester Note 9	1060					
RCA, Electronic Components and Devices, Harrison, N. J. 07029	Tube tester Note 9	WT-110A	D	Note 7	Note 7		18
Radio Shack Corp. 730 Commonwealth Ave., Boston, Mass. 02215	Tube tester	TBC	C	Note 6	$2.00	Test leads, $0.49 pair	
	Vom	All models			Free		
	Sig gen	22-040	C		Free		
Seco Electronics, 1001 2nd St. So., Hopkins, Minn. 55343	Tube tester	78	D	$3.00	Free	None	12-19
	Tube tester	88	C	$3.00	Free	Decal adapter $3.00, CRT adapter $4.00	
	Tube tester	98	C	$3.00	Free	Plug-in socket panel $13.95, CRT adapter $4.00	
	Tube tester	101/107A	D	$3.00	Free	1071N nuvistor adapter $2.00, 1171A adapter for compactron, decal, magnoval and novar tubes $6.95	
	Tube tester	107B	C	$3.00	Free	Plug-in socket panel $14.50	
	Tube tester	107C	C	$3.00	Free	None	
	Tube tester	1000/3000	C	$2.00	Free, Modification bulletins 4 and 5, free	Model 1092 vibrator patch panel, $17.50	
Sencore, 426 S. Westgate Drive, Addison, Ill.	CRT tester	CR128A	C	$1.00	$0.75	None	
	CRT tester	CR133	C	$1.00	$0.75		
	Tube tester	MU140	C	$3.00	$1.00		
	Tube tester	TC130	D	$2.00	$0.75		
	Tube tester	TC131	C	$3.00	Free		
	Tube tester	TC136	D	$2.00	$0.75		
	Tube tester	TC142	C	$2.00			
	Transistor tester	TR139	C	Not needed	$0.75		
Simpson Electric Co., 932 E. Benton St., P.O. Box 808, Aurora, Ill. 60507	Vom	260	C (series 5)		$0.55	Note 4	15-20
	Sig gen	479	D		$0.55	None	
	Sig gen	480	D		$0.55	None	
	F-S meter	498A	D		$0.55	None	
	Tube tester Note 9	1000	D		$3.00	None	
Sylvania Electric Products, 1025 Westminster Dr., Williamsport, Pa. 17704	Tube tester	139/140	D	$3.00* $4.50**			14
	Tube tester	219/220	D	Note 6	Note 7	Model A-15 new-socket adapter $13.95, A-20 decal adapter $3.75	
	Tube tester Note 9	620	D				
The Triplett Electrical Instrument Co., 286 Harmon Rd., Bluffton, Ohio 45817	Tube tester	3414	C	$1.00	$0.75	Note 4	2-20
	Tube tester Note 9	3444	C	$1.00	$1.00	Note 4	

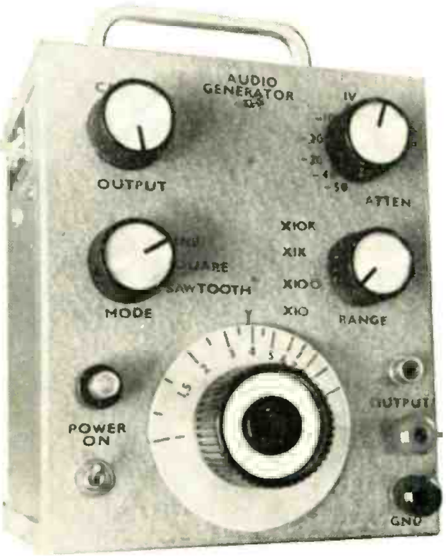
END

IC Sine-Square-Saw Generator

This instrument employs the latest semiconductor circuits, is compact and stable, with a clean output signal **By EARL T. HANSEN**

ALMOST ANY PHASE OF AUDIO TESTING OR general electronic servicing can benefit from a stable and accurately calibrated audio generator. The solid-state instrument described here provides output signals from 10 Hz to 100 kHz in four decade ranges. It also offers sawtooth signals at four fixed frequencies. Distortion is less than 0.1% for all sine-wave ranges. Cost of the ac version is about $60, while the battery-powered option runs about $10 less.

The thoroughly up-to-date circuit employs an FET, a unijunction transistor, an integrated-circuit package and other silicon semiconductors. Direct coupling is used throughout to assure good low-frequency characteristics.



Circuit description

The power supply, a straightforward bridge rectifier, is able to withstand large variations in line voltage. Generator output is unaffected at inputs ranging from 90 to 150 volts. A grounded center tap provides equal positive and negative output voltages.

Three RC sections for the 10-volt output and four for the +7/−6-volt source reduce the ripple virtually to zero. The 10-volt section is Zener-regulated; the +7/−6-volt section sees a fairly constant load and need not be regulated. C12, rated at 25 volts, operates at about 28. This procedure is acceptable, provided the temperature is kept down; this generator runs cold.

The sine-wave oscillator is a basic Wien bridge. It uses an FET at the input to establish a high-impedance load to the bridge network. The time-proven series lamp is used in one leg of the bridge for amplitude control. A bead thermistor also was tried, with the thermistor in place of R24 and R25 and the two resistors where the bulb is now. This arrangement provides good amplitude stability and slightly reduced distortion, especially at the very low frequencies. The lower distortion level is due to the thermistor's longer thermal time constant as compared with the tungsten-filament lamp.

The thermistor, however, had one serious drawback: the output amplitude was unstable with changes in room temperature. The generator required a well-calibrated output, so the lamp was chosen for the final design.

The FET (Q1) is operated as a source follower with unity gain. Effective value of resistor source load R20 is greatly increased by using bootstrap positive feedback through C3. Q2 acts mainly as a differential amplifier and inverter. Gain is low due to high feedback level from R24.

Q3 is a linear amplifier which drives push-pull emitter followers Q4 and Q5. Linearity of Q3 is improved by applying positive feedback to the collector load through C6. Emitter voltage is divided down (by R18 and R19) to supply gate bias for Q1, thus establishing the operating point of the Wien-bridge oscillator.

One side of the bridge—R25, R24, and R22 (the bulb)—provides the feedback path for all frequencies. The other side (R1, R2, C2, R3 and R4) provides positive feedback at one frequency, thus maintaining oscillation.

Frequency is determined by the total values of C and R in each leg: $f = \frac{1}{2\pi RC}$. C1, in parallel with one section of C2, compensates for the substantial capacitance existing between the frame of C2 and ground. This limits the minimum capacitance of each section to about 40 pF. Maximum value of each section is over 400 pF, allowing a frequency-adjustment range of 10:1.

To have each dial range cover a decade, resistance values are calculated as multiples of 40 (i.e., 40 meg). Multi-

SPECIFICATIONS

Range:	10 Hz to 100 kHz in four decade ranges, continuously variable, in both sine-wave and square-wave modes. Four fixed frequencies: 10, 100 Hz, 1 kHz and 10 kHz, in sawtooth mode.	Rise Time:	Less than 0.3 μsec for all square-wave frequencies. Approximately 2% of the slope length for the sawtooth frequencies.
		Tilt:	Less than 1% on any range, for square waves.
Distortion:	Less than 0.1% for all sine-wave ranges.	Linearity:	Less than 1% deviation from a straight line for all sawtooth frequencies.
Output level:	1 volt rms in sine-wave mode, 2.82 volts p-p in square-wave and sawtooth modes; all with the attenuator switch at 0 dB. Five steps of 10 dB each, and a continuously variable control in all modes.	Power Input:	117 volts 60-Hz, 1.2 watts, for ac operation. Two 10.5-volt batteries, 10 mA, for battery operation.
		Source Impedance:	Less than 150 ohms for all modes with attenuators adjusted for maximum output.

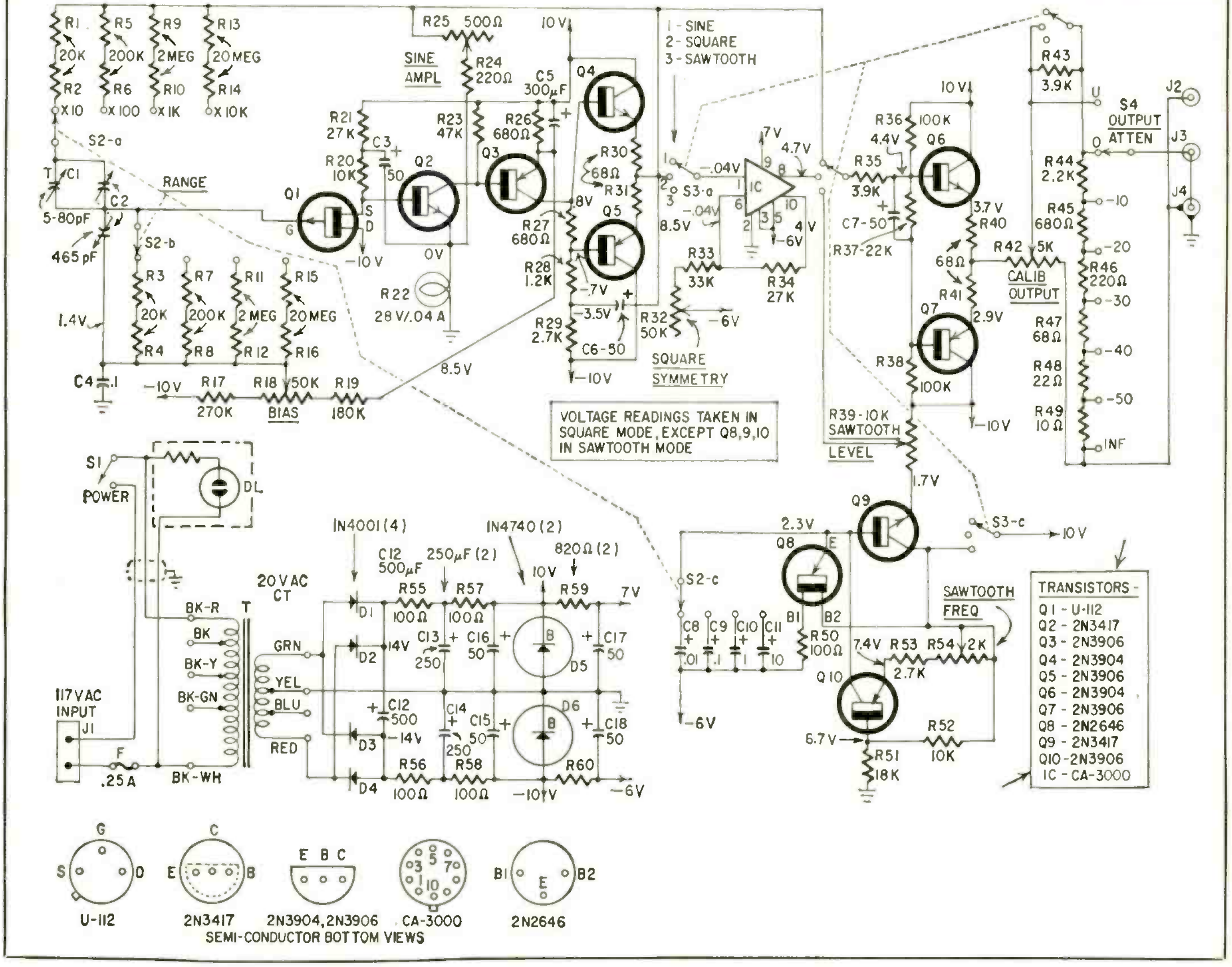


Fig. 1—As shown on this complete schematic, it's easier to shield the power-supply switch than the sensitive audio circuits.

PARTS LIST

R1, R2, R3, R4—20K, 5%, matched (see text)
R5, R6, R7, R8—200K, 5%, matched (see text)
R9, R10, R11, R12—2 meg, 5%, matched (see text)
R13, R14, R15, R16—20 meg, 5%, matched (see text)
R17—270K
R18, R32—pot, miniature, 50K (Mallory MTC-1 or equivalent)
R19—180K
R20, R52—10K
R21, R34—27K
R22—lamp, 28V .04A type 327.
R23—47K
R24—220 ohms
R25—pot, miniature trimmer, 500 ohms (Mallory MTC-1 or equivalent)
R26, R27, R45—680 ohms
R28—1,200 ohms
R29, R53—2,700 ohms
R30, R31, R40, R41—68 ohms
R33—33K
R35, R43—3,900 ohms
R36, R38—100K
R37—22K
R39—pot, miniature trimmer, 10K (Mallory MTC-1 or equivalent)
R42—pot, 5,000 ohms
R44—2,200 ohms, 5%
R46—220 ohms, 5%
R47—68 ohms, 5%
R48—22 ohms, 5%
R49—10 ohms, 5%
R50, R55, R56, R57, R58—100 ohms
R51—18K
R54—pot, miniature trimmer, 2,000 ohms (Mallory MTC-1 or equivalent)
R59, R60—820 ohms
All resistors ± 10%, ¼ watt or more, unless otherwise indicated
C1—5-80 pF, variable trimmer
C2—two-gang tuning capacitor, approximately 465 pF per section (Allied No. 45 A 3528)
C3, C15, C16—50 µF, 10 volts, electrolytic
C4—0.1 µF, 50 volts, any type
C5—300 µF, 3 volts, electrolytic
C6, C7, C17, C18—50 µF, 6 volts, electrolytic
C8—.01 µF, 50 volts, paper or Mylar
C9—0.1 µF, 50 volts, paper or Mylar
C10—1.0 µF, 20 volts, paper or tantalum
C11—10 µF, 20 volts, tantalum
C12—500 µF, 25 volts, electrolytic
C13, C14—250 µF, 15 volts, electrolytic
all capacitors ± 20%
S1—spst, toggle switch
S2—3-pole 4-position rotary switch, nonshorting (Centralab 1013 or equivalent)
S3—3-pole 3-position rotary switch, nonshorting (Centralab 1007 or equivalent)
S4—1-pole 8-position rotary switch, nonshorting (Centralab 1001 or equivalent)
S5—dpst toggle switch (battery operation only)
T—transformer, 20 Vac, c.t., 35 mA (Triad F094X, Allied 64 Z 731, or equivalent)
DL—panel indicator, neon (Dialco series 95 or equivalent)
J1—male TV interlock connector
J2, J3—5-way binding post
J4—coaxial audio jack
D1, D2, D3, D4—1N4001, or virtually any silicon power diode
D5, D6—1N4740 10-volt 1-watt Zener diode (Motorola Surmetic, or equivalent)
Q1—P-channel junction FET, (Siliconix U-112, or equivalent)
Q2, Q9—very-high-gain, high-frequency silicon transistor (G-E 2N3417 or equivalent)
Q3, Q5, Q7, Q10—high-gain, high-frequency silicon transistor (Motorola 2N3906 or equivalent)
Q4, Q6—npn silicon transistor, complement to Q3 (Motorola 2N3904 or equivalent)
Q8—2N2646 or similar unijunction transistor
IC—integrated circuit (RCA CA-3000 or equivalent)
BATT 1, BATT 2—10.5-volt battery (Burgess type 2X7, or equivalent)
F—fuse, ¼-A, solder-in type
Miscellaneous—metal box, 4 x 5 x 6 inches, aluminum (Bud CU-2107A or equivalent) wire, No. 24 stranded, assorted colors; knobs, dry-transfer decals; metal disc for frequency calibration knob; insulated flexible coupling and shaft and bushing; sheet insulation (1/16-in. Plexiglas or perforated board) for tuning capacitor mounting; perforated circuit board, (Vector type G, or equivalent); circuit-board terminals.

IC Sine-Square-Saw Generator

ples of the standard value of 39 would be close enough, except there is no combination of standard 5% resistor values that would total 39 meg. This is the reason for using two series values for each range—to arrive at exact multiples of 40. This approach also allows more precise matching and a balanced bridge.

In the sine-wave mode, the Wien-bridge output is fed through the second push-pull emitter follower (Q6 and Q7). The output attenuator provides coarse adjustment. With S4 set at the 0-dB position and with R42 fully clockwise, sine-wave output is 1 volt rms.

In the square-wave mode (S3 in position 2), the sine-wave signal is fed to a squaring circuit. This is an integrated-circuit package connected as a Schmitt trigger. The IC is a stabilized and compensated differential amplifier having high-impedance inputs and push-pull outputs. Fig. 2 shows the equivalent circuit. As used in the overall circuit, it works well as a stable and fast-acting squaring circuit. The 1-MHz bandwidth allows rise and fall times of 0.3 μsec or less. R32 varies the trigger level, thus varying the symmetry of the square wave. Tilt and low-frequency phase shift are minimized by using direct coupling.

The sawtooth oscillator has four fixed frequencies: 10 Hz, 100 Hz, 1kHz, and 10 kHz, selected by the range switch. It's basically a unijunction relaxation oscillator. The collector of Q10 acts as a constant-current source to charge the capacitor selected by S2-c. Because of a constant charging current, voltage across the capacitor changes linearly and forms the slope of the saw.

When the emitter of Q8 reaches its critical level, the capacitor discharges through R50 and the emitter–base-one junction, then the cycle repeats. Emitter follower Q9 couples the sawtooth voltage to the output-level control (R39) with negligible loading on the RC charging circuit.

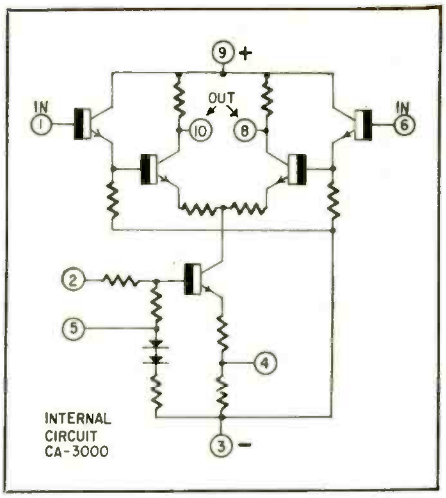


Fig. 2—What's inside the CA-3000 IC.

All signals are routed through push-pull emitter follower Q6–Q7. The follower gives good isolation as well as a low source impedance. R42 is the output-amplitude control, giving continuous adjustment to zero.

Output attenuator S4 has eight positions. Position U (uncalibrated) gives maximum output. With R42 turned fully clockwise, the 0-dB position provides a sine-wave output of 1 volt rms (2.82 volts p-p). The same switch setting gives an equivalent peak-to-peak output for the square-wave and sawtooth modes.

The −50-dB position provides an output adjustable from 0 to 31 mV, a range very useful for checking low-level amplifiers. The counterclockwise end of S4 gives most attenuation (zero output).

In laying out the components, there is one important consideration: The high input impedance of the FET is very sensitive to stray radiation, including that from the 60-Hz input power. Since the FET gate connects directly to the tuning capacitor, shielding is not easy. As a matter of fact, it is actually easier to shield the ac components than the signal components!

Leads used for the panel lamp and switch must be shielded wire. Copper foil or thin shim stock is easily fashioned into odd shapes to shield the ac-input connector, fuse, power switch, panel-lamp holder, and power transformer.

All power-supply components are mounted on the rear-cover half of the aluminum box. Interconnecting leads are left long enough to allow "open box" operation during calibration.

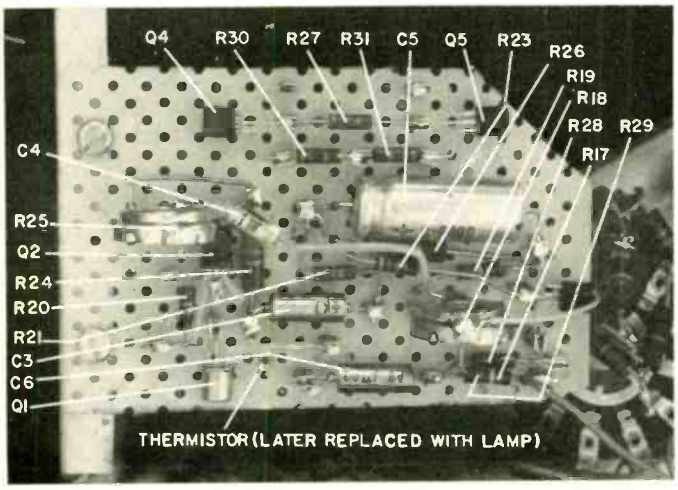
The tuning capacitor must be isolated from ground with a minimum of stray capacitance. An acrylic plastic base was used in the prototype. The base was then spaced away from the aluminum case using two additional strips of plastic. A better way might be to mount the capacitor on a piece of the perforated circuit board using spacers at the corners. The capacitor shaft is isolated with an insulated flexible coupling and brought through the panel using the shaft and bushing from an old volume control.

Small components should be mounted either on the rotary switches themselves or on perforated circuit board using push-in terminals.

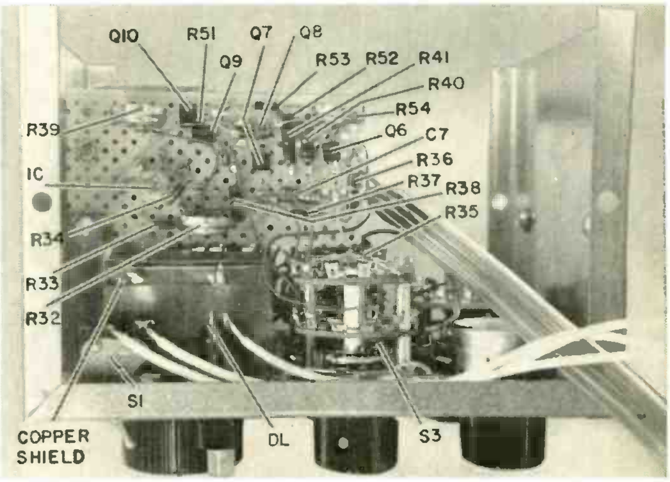
Resistors to be used in the bridge (R1–R16) should be carefully selected. Standard 5% resistors are specified, but closer matching is desirable. Good bridge balance is necessary to provide constant output amplitude across the tuning dial. R1 + R2 should exactly equal R3 + R4.

Furthermore, accurate decade relationships between range resistances will assure that dial calibration will be accurate between ranges. For example, R5 + R6 + R7 + R8 should exactly equal 10 times R1 + R2 + R3 + R4.

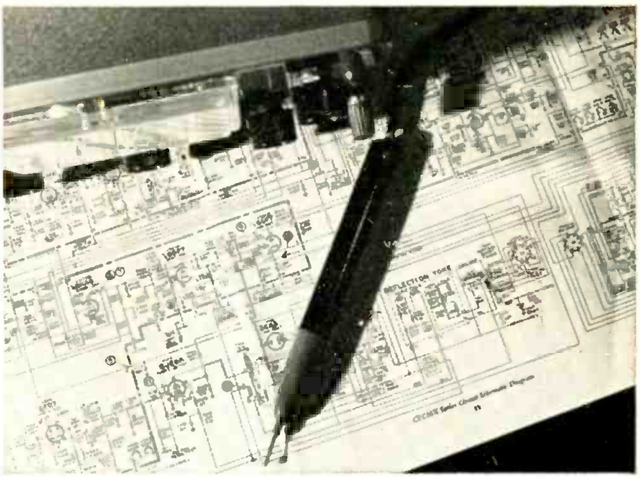
Signal grounding is important, too.



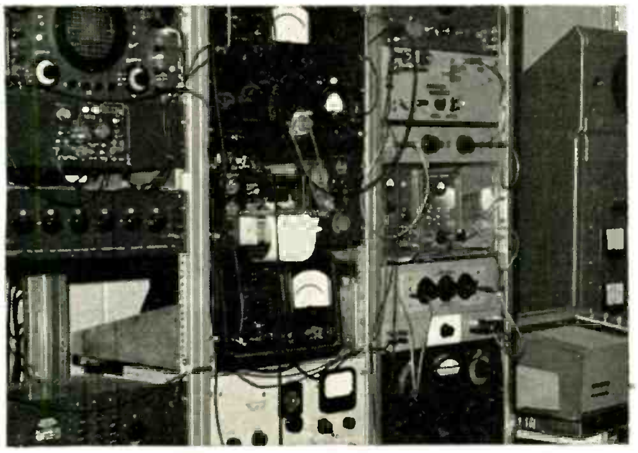
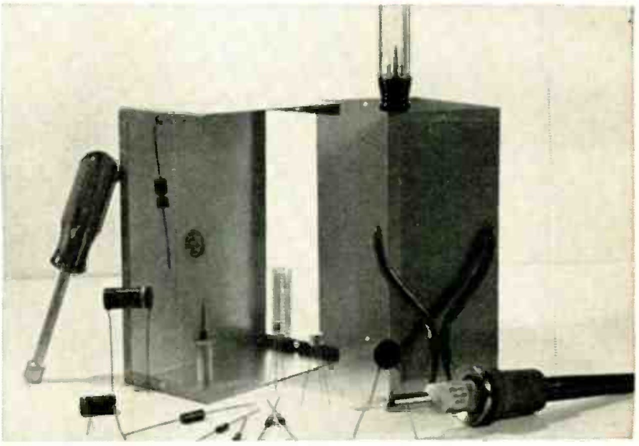
Top side of the Wien-bridge board with components in place.



The bridge board is mounted on one side of the cabinet.

Whatever your electronics interest,

here are 12 powerful reasons why you should subscribe to RADIO-ELECTRONICS.

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In 1966 more than 160,000 readers interested in every area of electronics learned from and profited by: January's Annual Color TV issue .... February, which highlighted practical construction projects ..... March, a Hi-Fi/Stereo/Tape issue ...... April, a career series feature ...... May, which contained a line-up of home video recorders and their workings ..... June, an annual issue on microcircuits and transistors .... July's special section on Stereo FM ...... August's Test Equipment issue, which delved into do-it-yourself instrumentation ..... September, with CB and communications content for "two-wayers" ...... October, full of the news in industrial electronics ...... November, which turned out to be a music issue featuring guitar amps, etc. ...... December, which featured electronic auto servicing ...... and its pros and cons. **You get all this ...** plus monthly features like Jack Darr's Service Clinic ... reports on test equipment and audio components ... new products ... technotes ... new literature and books and more.

Radio-Electronics

← X57-62-CAL. TST EQUIP

sign and people started dropping in off the turnpike."

"Never advertised?"

"Never. The first publicity we received as women in the business came about entirely by accident. Some man telephoned, doing an article on the repair-shop business. When he found there was no 'man of the shop,' he rushed out to get an interview with us."

[That was 4 years ago, and that man was one of R-E's writers. The article can be found in the August 1963 issue of RADIO-ELECTRONICS.—*Editor*]

As I went about snapping shots of the girls' shop and office, they revealed more details. Muriel, working on a color TV, brought out a little invention of her own, two convergence rods that enable her to reach the knobs of the convergence board from in front of the set while she maintains a straight line of vision.

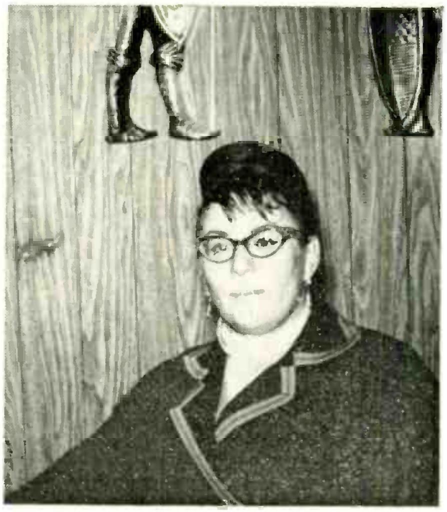
Seeing how interested I was in the ways she applies her electronic knowledge, Muriel dusted off a flat metal chassis that contained the rat maze and antenna. It turned out to be a homemade theremin. She declined a workshop display of her talent, but mentioned that she often accompanied her son when he played the organ or piano.

Strangely enough, neither Mrs. Burke nor Miss Kramer began her life with a silver transistor in her mouth: both came to electronics by roundabout ways. Kathi started as a bookkeeper. Muriel began as an artist; some exquisite pastels and an occasional oil adorn the walls of their white frame house in Woodbury, Long Island.

During the war Muriel's artistic ability was put to use drafting architectural plans for the Government. One day she visited the electronics section, and found her interest jumping to electronics drafting. She joined the department, and so it went until she drafted the sign outside her own shop: Burke's TV Service.

Another woman started her career in electronics and engineering purposefully. Cecilia Jacobs had a rough time of it in contrast to Mrs. Burke and Miss Kramer, who rather wandered into it from other fields. Despite years of part-time practical experience obtained while studying engineering and metallurgy at Brooklyn College, Miss Jacobs found it difficult for her "delicate, feminine and therefore-prone-to-fainting-or-hysterics" self to find a full-time position in either of those fields.

As it happened, at every job Miss Jacobs chose, men were preferred at that time. She stepped into each as the first woman. The struggle, ironically, wasn't only against an inhospitable men's world. When she landed a job as junior engineer with Vought-Sikorsky, her mother stepped into the picture with, "You're too young to go away to Connecticut alone."



Cecilia Jacobs has a varied background in engineering, accounting and management.

"Too young, too delicate, and probably dumb," went the refrain. Twenty or so years ago, women hadn't been "proved particularly suited to scientific and mathematical work . . ." as they now have, according to one representative of the National Aeronautics and Space Administration. Rather, a woman's touch on complicated machinery in those days was worse than dropping it.

By the time industry recognized that feminine intuition was good for more than discovering the presence of a man, Miss Jacobs had found another route to electronics.

"Put me in the accounting department, hmmm?" she might have said to herself. "We'll see; there's more than one way to skin a cat!"

So, Miss Jacobs set her womanly talents to working around and through those closed doors. She eventually joined an electronics company as financial consultant and shareholder, after years spent learning finance. Now she is seeking to enlarge her small communications electronics firm, J. H. Bunnell & Co., in Brooklyn, N. Y.

"You wouldn't know of a nice little electronics firm . . . lasers, maybe . . . that we might buy or merge with . . . ?" she twinkled at me. I had to shake my head.

Miss Jacobs took me on a tour of her factory, quite a treat. Tables of instruments filled a large warehouselike room. As we walked through, Miss Jacobs described some of J. H. Bunnell's products: switching racks for RCA; military intercoms; magnetic-tape winders; electronic tuning forks; the Cunningham tube, for which Bunnell at one time was sole distributor; also a facsimile machine for Western Union, and what seemed like hundreds of other items. Furthermore, Bunnell & Co. has designed a Telefax machine for Western Union, and once for a radio station.

Obviously at ease with her products, Miss Jacobs opened a brown metal cylinder to show me the delicate sensory equipment inside. Used in Vietnam, these cylinders are buried around a military camp to register and communicate the location and power of enemy guns booming "in the distance."

A danger nearer to home—burglary—finds a Bunnell device combating it, this time with a special "pen register." The pen register is an automatic burglar-alarm system that is wired to central police stations. An automatic dialing system checks each establishment to be watched, through a guard's call-ins at regular intervals. If a call-in is missed, immediate attention is directed to that location. One other use for this device is to record all numbers dialed from a particular phone. It thereby has detected many phone-cranks.

"Just checking this machine in the workshop takes two hours," Miss Jacobs commented, again showing her thorough knowledge of operations at Bunnell. She greeted the workmen by name and introduced me to those whose careful skills produce some of the most delicate equipment.

Bunnell & Co. was one of the first companies to enter data processing, Miss Jacobs told me, speaking enthusiastically about the communications industry as a whole.

"Soon, there's going to be no distinguishing between the computer fields and communications . . . everything done with a computer will have to be transmitted somewhere." She smiled, tapping out a quick Morse code on one of her telegraph keys, another company product.

Miss Jacobs added, "Computers and all other electronic equipment simply provide another medium through which man's creativity is expressed. In themselves, computers are not creative but repetitive; they mass-produce men's (and women's) ideas. . . ."

Certainly, with more machines to accept ideas, there's more room for a woman's creative contribution, and apparently computers aren't so discriminating against women.

A woman's intuition and intelligence in electronics can be as effective as a man's. The fourth woman-in-electronics proved it during the war, testing transmitters.

Mrs. George Labes gained entrance to that most forbidden lair, a man's workshop, when she allowed her husband-to-be to court her with electrical know-how.

"The more I learned, the prouder he became of me and the more interested I became in him," she told me, reminiscing. Mr. Labes took such pride in Vicki that he enrolled her at the ITT-Federal school in Harrison, N. J., while he went away to war. Her training was so thorough that she bypassed some classes and went to work for the principal of the school in his repair shop.

People came in to see if it was true that a girl could really repair radios and other such electrified items. The fire chief put her to the test when he brought in an old Philco "Cathedral" radio with all its condensers in one can. His laconic complaint was, "It's fading." Vicki discovered the faulty condenser and won the day and the fire chief's confidence.

When her husband returned from service, the two of them started the first of several repair shops. The present one is an audio-visual service shop in Ridgefield Park, N.J.

A glamorous facet of the Labes' audio-visual business is their penchant for movie-making. They make movies for themselves and for industrial advertising accounts. One technique of theirs is to tape-record the sound and then put the magnetic strip on the film. The result is fun and profit and a companionship in work that few couples share. Their films range from industrial shorts such as one about drop forging for Merrill Bros., a firm on Long Island, to advertisements used in home shows or industrial conventions.

Their favorite, however, was made during one of their creative moments. It is their first and best-loved film, a ghost story called "Never Again." Starting out to entertain the children and indulging the ham in themselves, Mr. and Mrs. Labes produced an honest-to-goodness modern ghost story. The film shows a wife going away and leaving her bottle-prone husband alone with a warning not to imbibe. He begins to sip, but feels so guilty that he begins to hallucinate. Glasses move through the air, his bottle escapes his grasp, and suddenly he sees a ghost. The "ghost" is actually his wife who has returned, but the cure works and the bottle no longer tempts him.

Said Vicki of the movie, "That's when I first realized my role around here—I'm the silent partner." But, partner she is, and likes it. "The best way to keep young is to keep busy, and I'd rather be busy here in the shop than cleaning house."

Though most of their business comes from schools (70%, in fact), the Labes' tackle any project. George teaches Vicki the newer equipment, and they intersperse their movies with other work. One movie, about a do-it-yourself father as he systematically blows himself up, might deter amateur tinkerers before they start.

Whether testing transmitters or servicing TV sets, Vicki Labes has the right touch.

One amateur tinkerer who went on to become a "pro"—a woman, of course—is Mrs. William Nolan. Confronted with a broken tape recorder and the prospect of a $40 tab for its repair, Mrs. Nolan took matters and the recorder into her own hands.

With no prior knowledge of electronics, Mrs. Nolan picked up a self-instruction book and dug into the tape recorder. When she was through, having found that "a chain pulley had come off in the drive mechanism," she kept on reading electronic books until she came to ac circuitry and ran into a block.

Out of curiosity that reached beyond ac circuitry, Mrs. Nolan left her job and took a course in electronics at RCA Institutes. She was surprised to find herself the only girl in the school at the time. Her first course led her to sign up for engineering electronics, a 2-year college-level course.

Upon her graduation, the amazing Mrs. Nolan went right into technical writing for the RCA Home-Study School. She soon gave this up to work as a free lance, and joined a professor at RCA Institutes in writing *Principles and Applications of Boolean Algebra*, published by Hayden.

Mrs. Nolan jumped into the writing field with no previous training, with no college degree, but—from the sounds coming over the phone during our interview—with a house full of children. She works at home "with my shoes off and my feet up," and sounds deliciously content!

We asked RCA Institutes if it had any other recent women graduates, and thus became acquainted with Miss Francis Brooks of General Precision Labs in Pleasantville, N. Y.

Miss Brooks found out about RCA Institutes when she decided that her factory job, TV assembly and testing, no longer suited her. She took the electronics technology course.

At the GPL plant, Miss Brooks works on the electrical layouts for closed-circuit cameras. As she explained it to me very patiently over the phone: "After the schematic has been drawn up by an engineer, it is put in the form of a printed-circuit board. From that, I fit the actual components into place on the plan, deciding the final placement of each part."

Miss Brooks' next goal is to earn her engineering degree in electronics. She is fortunate to work for a company that will reimburse a good part of her tuition.

Miss Brooks and Mrs. Nolan might be considered representative of women in a world where a knowledge of electronics is almost basic to feeling comfortable with the paraphernalia of their society—from tape recorders (which the youngest schoolchild listens to daily in language study) to automatically opening supermarket doors.

Even today's artists speak through an electronic medium, suggest its presence in their pictures of life. Balanchine's choreography spews human beings across a stage in the same precise formations in which a computer spews facts of human endeavor from its gaping steel and most *in*human jaw. The televisions and radios that the Mrs. Burkes and Miss Kramers repair interconnect all corners of the nation, informing the individual of the rest of humanity, allowing him to relate himself to his society.

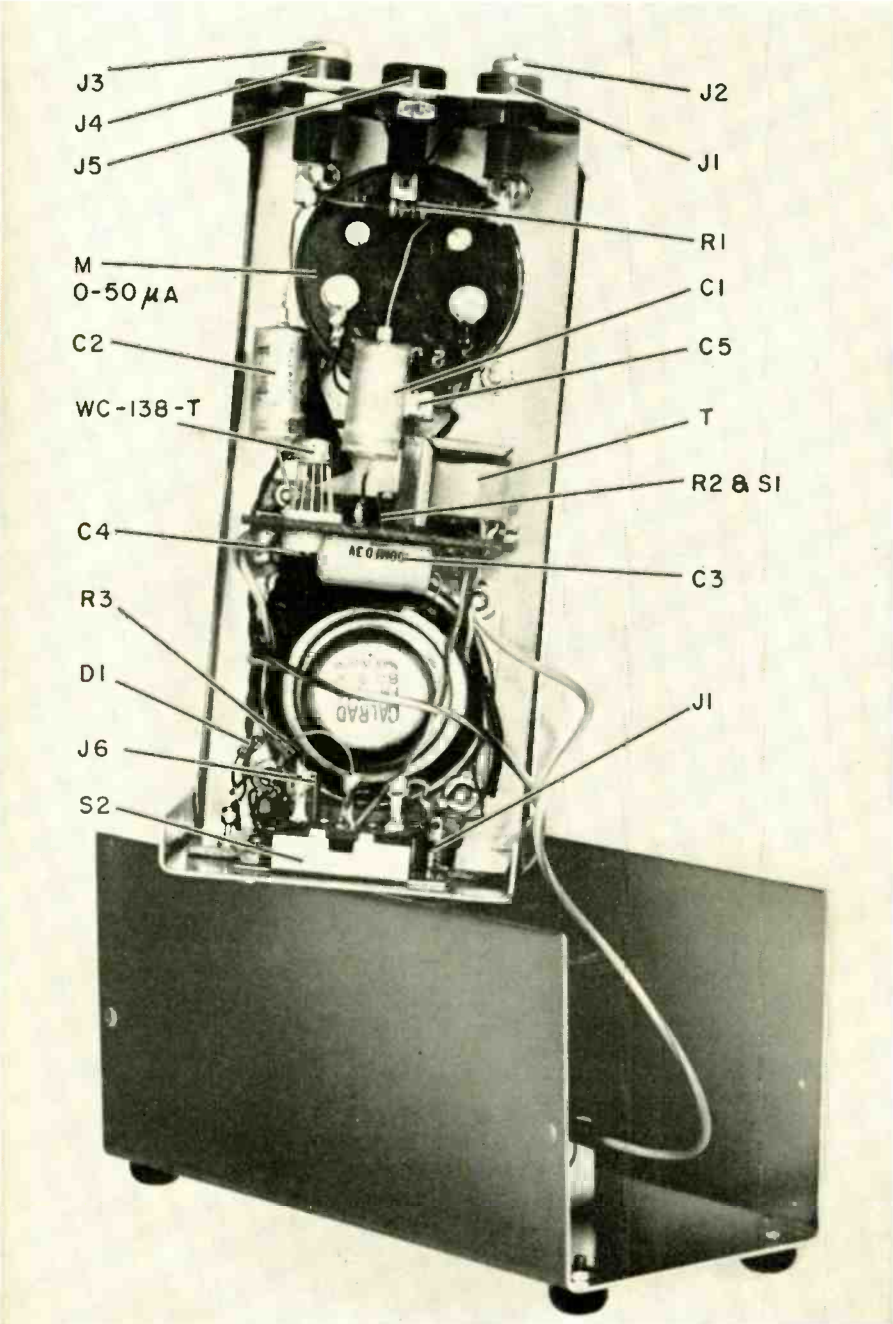
Testing instruments are similar across the country. They are highly objective, mathematically precise means for arriving at the truth, be it related to whether a man has been drinking while he is driving, or to what type of blood he has. Electronics suggests the more factual orientation of our society. Less is taken for granted. Men are judged by objective test scores; electronically compiled statistics dictate the nature of our conclusions.

Being a woman no longer automatically suggests weakness and lack of "that kind of interest." Thanks to computer-compiled "facts" there is less romanticizing about what ought to be and more dealing with what *is*. And there's one thing that is: Our society now has an electronic vitality, and if women want to enjoy a significant place in that society, their insight must extend to the electronics-of-it-all. END

Mr. IC – Tracer of Lost Signals

Here's a handy troubleshooting instrument, simple to build, which uses the newest solid-state device

By LYMAN E. GREENLEE



Parts placement isn't critical, but be sure that each component clears the chassis.

A GOOD AF/RF SIGNAL TRACER IS A REAL timesaver for troubleshooting rf and audio circuits. This one fits easily in your pocket. It can be used as a sound-level meter and as a simple preamplifier.

The instrument is built around an IC amplifier housed in a transistor-size (TO-5) case. The solid-state circuit consists of an eight-transistor amplifier with 90-dB gain and 50-mW power output when used with a 4.5-volt battery. No-signal battery drain is 3.5 mA. Volume is adequate for any signal-tracing application. It's also sufficient to drive the small speaker to the point of distortion.

The tracer has two input circuits (Fig. 1) because the WC-183-T employs a balanced circuit with internal dc feedback. An input signal can therefore be fed to pin 3 or to pin 10. It can also be fed to both pins simultaneously. Normal bias voltage between pin 3 or pin 10 and ground (pin 1) is slightly more than 0.6 volt, so input-decoupling capacitors C1 and C2 are required to avoid altering the bias level. The input circuit can handle a signal swing of ±6 volts, and signals as great as 2 volts dc can be applied to either input without damage. Maximum battery voltage is 9 volts dc. There is very little advantage, however, in supplying more than 4.5 volts.

A 47K carbon resistor (R1) couples the inputs. Without it, the amplifier may motorboat at some settings of gain-control pot R2. Variations in gain between various examples of the IC amplifier might require reducing the value of R1 or connecting a .005-μF capacitor across terminals 5 and 8 of T to insure complete stability.

The capacitor will alter the frequency response, of course, with cutoff at about 4.5 kHz. Without the capacitor, overall response of the tracer is good to 20 kHz and is limited primarily by the response of T.

The input voltage must be held to a low level. For signal tracing high-voltage equipment, the probe shown in Fig. 1 provides the required attenuation. R5 is a 2,500-ohm miniature potentiometer mounted on a small piece of Bakelite so it can be used as a fingertip volume control. R4 is in series with the input probe, mounted directly under the miniature potentiometer. This resistor limits the current through R5 to a safe level, even though the probe tip is used for circuits with plate voltages of 300 or more.

R2 is a gain control that will vary the over-all amplifier gain by about 30 dB. This is not enough to prevent overloading at high signal levels; hence the need for R5. The maximum signal input that can be tolerated without excessive distortion is about 50 mV.

The signal-tracing probe can be plugged into either J2 or J3, to provide input to either side of the balanced circuit. For measuring rf voltages, a capacitor/diode detector can be added to the audio probe. Fig. 2 shows a separate rf probe.

Almost any rf probe designed for use with a vtvm can also be used, provided the tracer is fed through a series resistor of at least 1.5 meg with a 2,500-ohm or smaller resistor going to ground. The added resistors insure that excessive voltages will not damage the IC amplifier. J1 and J4 are banana-type jacks in parallel with J2 and J3.

An impedance-matching input transformer may be connected across R1, using either pair of jacks. The correct value for the input impedance will be about 5,000 ohms. The amplifier can be matched to any input, including a speaker-type dynamic microphone, with the proper transformer. Common-

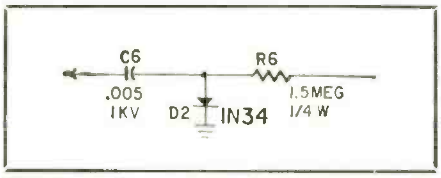


Fig. 2—To trace rf signals, build this probe.

Parts List

BATT—4.2-volt mercury battery (Mallory TR-133, or equivalent)
C1, C2—50 μF, 6 volts, electrolytic
C3, C4—100 μF, 3 volts, electrolytic
C5—10 μF, 3 volts, electrolytic
C6—.005 μF, 1,000 volts, ceramic
R1—47K, ¼ watt, carbon
R2—500 ohm transistor radio volume control, with spst switch
R3—33 ohms, ¼ watt, carbon
R4, R6—1.5 meg, ¼ watt, carbon
R5—subminiature pot, 2,500 ohms, No. 1 taper (Mallory No. MLC-252A, Newark Electronics Cat. No. 60F2166 or equivalent)
D1, D2—1N34A diode
IC—Westinghouse WC-183-T amplifier ($7.50 at Westinghouse distributors or Milgray Electronics, 160 Varick St., New York, N. Y. 10013)
J1, J4, J5—banana jacks (H. H. Smith No. 240 or equivalent)
J2, J3—phono jacks (Switchcraft No. 3501-FP or equivalent)
SPKR—1½-in. diam. speaker, 8-ohm voice coil
M—50-μA meter, 1⅝-in. diam.
S1—spst on R2
S2—spdt slide switch
T—output transformer (Lafayette 99-6132)
Miscellaneous—2¼ x 2¼ x 5-inch aluminum box (Gold anodized box, $1.50) Mobil Electronics, P. O. Box 1132, Anderson, Ind. 46015
12-pin TO-5 style IC socket (Augat No. 8058-1G28, Allied Radio Catalog No. 47D6087, $7.80 for pkg of 5 or equivalent)

The af probe contains an attenuator to limit input voltage to the IC at a safe value.

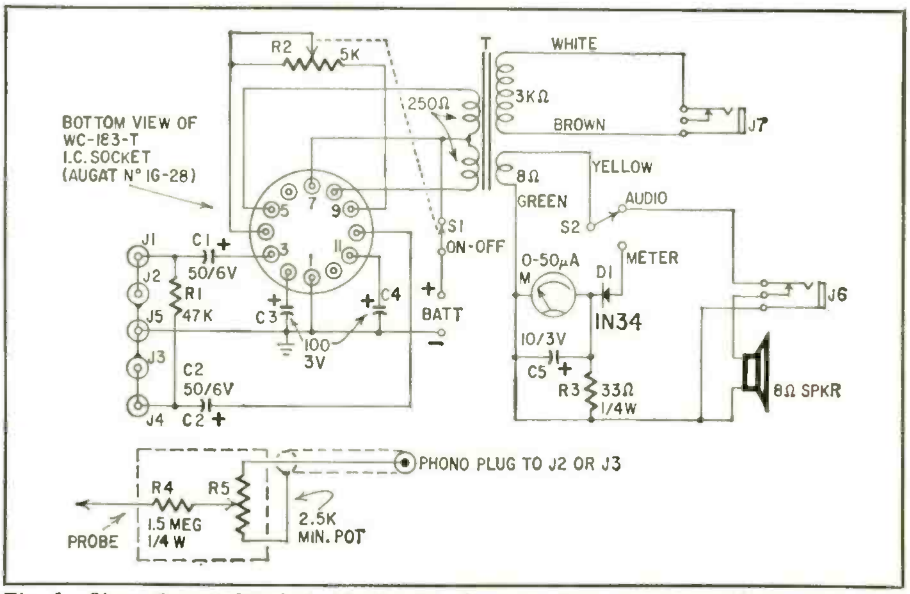
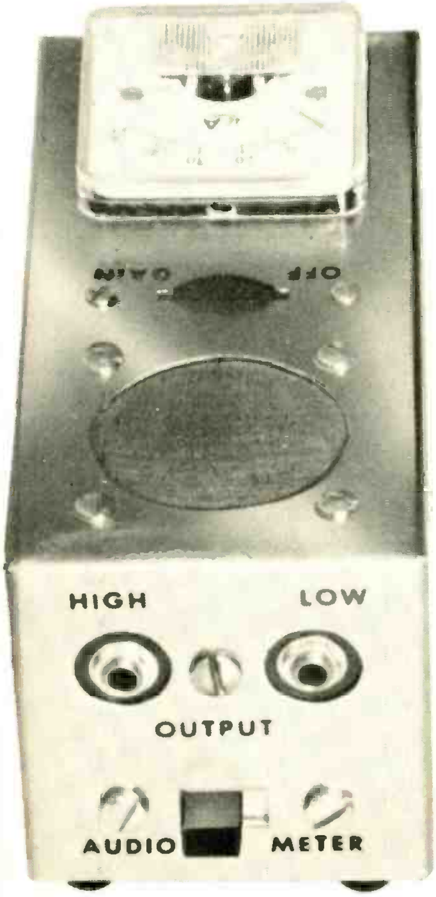


Fig. 1—Since the amplifier's inside the IC, there are few components for you to wire.



With straight-through wiring, inputs are at one end and outputs at the other.

ground jack J5 is connected to the chassis of the equipment being tested. Use test leads with a banana plug on one end and an alligator clip on the other.

The output transformer can be obtained from Lafayette Radio Electronics. The primary is 500 ohms center-tapped, and there are two secondary windings: 3,000 and 8 ohms. The 3,000-ohm winding connects directly to J7 to feed a pair of high-impedance headphones for signal tracing. The 8-ohm winding is coupled to closed-circuit jack J6 through S2.

When S2 is in AUDIO position, either the built-in speaker or a low-impedance earphone can be used. When S2 is in the METER position, the 50-μA meter is connected in the circuit.

C5 can range from 10 to 100 μF, depending on how much damping you want. The greater its capacitance, the slower the meter needle will move with signal changes. A 100-μA meter may be substituted with little loss of sensitivity.

Construction hints

Everything fits neatly into a stock 2¼ x 2¼ x 5-inch aluminum box. A 1⅜-inch chassis punch is used to make the hole for mounting the 1½-inch speaker. The speaker grille is a piece of brass screen about 80 mesh, such as that used in oil filters, etc. A 1½-inch punch is used to make the hole for the meter. The volume-control slot will have to be cut with a small flat file.

Input jacks are at the bottom end of the box; the output jacks and switch S2 mount on the top. To insure adequate circuit isolation, output jacks J6 and J7 are mounted on a piece of 1⅝ x 2¼ x 1/16 Bakelite.

Because output circuits are isolated from the common ground, shock hazard is reduced. When wearing a pair of headphones, you remain isolated from the chassis ground.

Use a 1⅜ x 1¾ x 1/16-inch of Bakelite to mount the transistor volume control and switch, the output transformer, the 12-contact Augat socket, and the two 100-μF bypass capacitors—C3 and C4. Cut a U-shape hole with a ⅝-inch chassis punch to mount the volume control/switch. Mount the control so that just enough of the control wheel protrudes through the panel to allow proper functioning.

You may find it difficult to solder connecting wires to the Augat socket pins. The pins are so very close together, and solder flows easily across adjacent pins. Slip a small piece of sleeving over adjacent pins before soldering, and you'll have no trouble with shorted connections.

Mount the IC amplifier board last. Just before mounting, insert the WC-183-T in its socket. Its pins must be fanned out slightly to fit the Augat socket. Do not cut the leads. Just fan them out to fit and carefully press the IC amplifier into the socket. Be sure all pins are started, then apply firm pressure. It takes considerable force to start all 12 pins at once. Note that there is a blue dot to indicate pin 1 on the Augat socket. *This dot must be indexed to the tab on the WC-183-T amplifier.*

The battery clip is on the bottom of the case. Be certain to get the polarity right when the battery is inserted in its holder. To avoid confusion it's a good idea to use red sleeving for the positive terminal. Before you insert the battery and turn on the amplifier, check *everything* for wiring errors.

Using the signal tracer

Plug in either probe and turn on the amplifier. Advance the gain control about a quarter turn. Set the probe volume control to minimum. Connect the chassis under test to the signal tracer with a ground lead to J5. Use the probe to find a signal, carefully advancing probe gain control R5 as you trace through the circuit.

Always keep R5 at the lowest level that will give a readable signal. You can use the built-in speaker or headphones to monitor the signal. Headphones are particularly useful when working in a high-noise area, or when there might be feedback into an open mike. After listening to the signal to check its presence and quality, you may switch in the meter to get a relative indication of gain per stage. Always listen first; you may otherwise be measuring noise rather than useful signal.

Use as a preamplifier

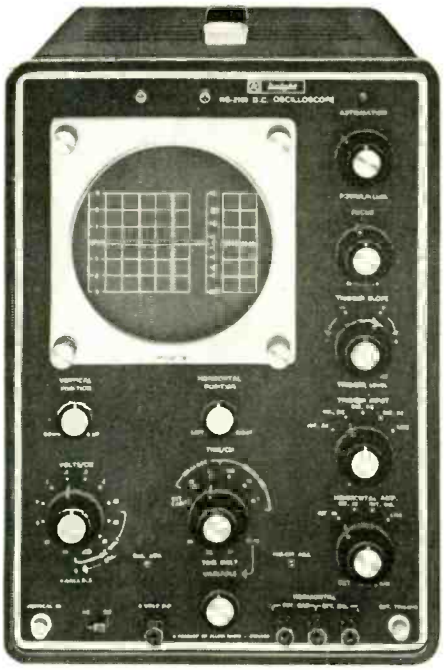
Connect the low-level device through a proper impedance-matching transformer. A transformer secondary of 2,000 to 5,000 ohms may be connected directly across R1 (J1 and J4), or you can ground one side of the transformer and connect the other side to either J1 or J4. This will feed a signal through one side of the dual amplifier. Small transistor-input transformers are useful for impedance matching. You will obtain an undistorted output of 30 mW at either 3,000 or 8 ohms, sufficient to drive almost any amplifier or power-output stage.

Useful frequency range with the components shown is from a low of about 20 Hz to above 20 kHz. For speech only, this broad range can be reduced to about 4.5 kHz by using a .005-μF capacitor across pins 5 and 8. END

EQUIPMENT REPORT

Knight-Kit KG-2100 Laboratory Oscilloscope

Circle 26 on reader's service card



THIS IS NO KIT FOR A BEGINNER—UNless he has lots of patience. For one thing, there are over 1,300 separate pieces to be assembled. For another, it took me about 4 hours just to check the parts against the parts list. But wait—don't give up—it's worth it. This is a *triggered* scope, with bandwidth from dc to 5 MHz, 3 dB down. You gets what you pays for, and in this case you gets plenty.

Many components in this kit are contained in plastic bags, very handy for keeping nuts, bolts and washers together. Even nicer, most resistors are mounted on cards with numbers alongside. When the manual says "R-161," you shuffle through the cards to R-161 and pluck it out. (I found no errors in the cards, but to be safe, read that color code and cross-check it with the assembly manual.)

It took me about 50 hours to construct this kit. Of course, I may not be typical, 'cause I like to take it slow and careful with a piece of test gear. After all, I intend to *depend* on this scope from now on. I spent a few more hours calibrating the instrument. (Actually, I went through the calibration once just for practice, so I'd know how it felt.)

Guess I've built a couple dozen kits, and I like to think I know my way around a chassis. But (I hate to admit it) I goofed a few times on this one. Be sure to check your wiring every now and then. If anything looks suspicious—cross-check it with the schematic. I didn't exactly hook up the heater line to B+, but I did have the VOLTS/CM–VARIABLE control wired backward. Kind of made it impossible to calibrate.

Well, you're wondering, how did it come out? After getting rid of my own bugs, pretty nice. Ever have a scope that floated and drifted? This one doesn't. Recurrent-sweep scopes often give you a pain from having to resync all the time. Not the KG-2100. Set the stability control once and you'll sync on any trace that you can comfortably read. All critical voltages are regulated, assuring immunity from line-voltage changes.

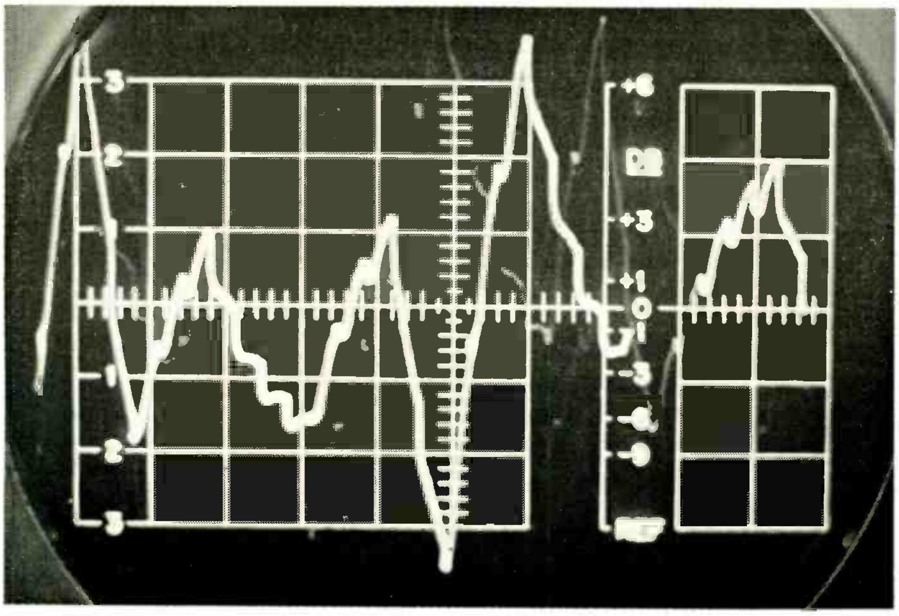
Why a triggered scope? Well, for one thing, it lets you observe nonrecurrent waveforms. I was fooling around with a neon-lamp ring counter and wondered what the waveform across a six-unit job would look like. The counter works on the principle that each lamp has a slightly different firing potential from the others. I coupled the KG-2100 across the circuit and got the trace shown in the photo. Notice the previous traces, slowly decaying on the phosphor; each one is different. There was no jitter and no hum, just clean sweeps.

The KG-2100 is well worth the price, time and effort. The CRT is a flat-face special and horizontal deflection is quite linear. The bezel (that metal gizmo in front of the CRT faceplate) has studs for camera mounting, so you can take scope photos for your family album. And the handle isn't one of those tight-hand-fitting jobs made only of plastic—it's a handful and has *steel* inside so you won't drop baby.

Oh, I almost forgot to mention the off-screen lamps. Seems that with a triggered scope you get not deflection until you probe a waveform. Okay—but what if you're not centered vertically? Well, there are these two little-bitty neons above the CRT. One has an arrow pointing down, the other up. You can guess the rest. Clever, clever.

Finally, I have a complaint. The ventilating fan makes noise. (It's needed to cool all those tubes.) And some of the panel knobs are loose. Oh well—what do you expect, perfection? Performance isn't affected.

—*Thomas R. Haskett*



MANUFACTURER'S SPECIFICATIONS

VERTICAL

Sensitivity: .05 volt p-p/cm (dc); .005 volt p-p/cm (ac)
Response: 3 dB down, dc to 5 MHz, .05 to 20 V/cm (dc); 3 dB down, 5 Hz to 1.5 MHz, .005 to .02 V/cm (ac); 3 dB down, 5 Hz to 5 MHz, .05 to 20 V/cm (ac)
Overshoot: Less than 2% on a 500-Hz square wave
Rise time: 85 nsec
Input Impedance: 1 megohm shunted by 40 pF
Attenuator: Frequency-compensated, calibrated, from .005 to 20 V/cm

HORIZONTAL

Sensitivity: .04 volts p-p/cm
Response: ±3 dB dc to 800 kHz
Expansion: 5 times
Input Impedance: 1 megohm
Inputs: Internal time base, 60 Hz and external
Time-base ranges: .05 sec/cm to 200 nsec/cm in 16 ranges
Triggering: Sensitivity, 200 mV external; ½ cm deflection internal. Inputs: line, external ac and dc, internal ac and dc
Calibration voltage: 0.1 volt p-p, regulated ±5%
Size: 14¼ x 10⅛ x 15½
Weight: 40 lb
Tubes: 22 including flat-face 5-in CRT
Power: 110–130 Vac, 50–60 Hz. 200 watts consumption; transformer primary tapped for adjustment to local line voltage
Price: $249.95 kit, $349.95 wired

END

RADIO-ELECTRONICS READER'S SERVICE

Here's how you can get manufacturers' literature fast:

1. Tear out the post card on the facing page. Clearly print or type your name and address.

   Include zip code! Manufacturers will not guarantee to fill your requests unless your zip code is on the reader service card!

2. Circle the number on the card that corresponds to the number appearing at the bottom of the **New Products, New Literature** or **Equipment Report** in which you are interested.
   For literature on products **advertised** in this issue, circle the number on the card that corresponds to the number appearing at the bottom of the advertisement in which you are interested. Use the convenient index below to locate quickly a particular advertisement.

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Advertisements in this issue offering free literature (see the advertisements for products being advertised):

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At the bottom of the Reader's Service Card, you'll find numbers from 1 through 6. Read the following questions and then circle your answers on the Reader's Service Card.

EQUIPMENT OWNED.

1 CB equipment
2 Tape Recorder
3 Component hi-fi system
4 Amateur Radio Station
5 Test equipment
6 Short-wave receiver

NEW PRODUCTS

More information on new products is available free from the manufacturers of items identified by a Reader's Service number. Turn to the Reader's Service Card facing page 70 and circle the numbers of the new products on which you would like further information. Detach and mail the postage-paid card.

TRANSISTOR PORTABLE PHONO, *model GD-16.* 4 speeds. Solid-state. 4 x 6-in. speakers, 2W output. Ceramic cartridge. 45-rpm adapter spindle. 117 Vac. 14 x 7¾ x 20½ in. $39.95.—Heath Co.

Circle 46 on reader's service card

NEW VOM, *Model 600.* Solid-state. Battery-operated. FET dc amplifier for high input impedance (11 megs). 3% ac-

curacy. Frequency range, 15 Hz to 2 MHz. 3³⁄₁₆ x 5⅜ x 6½ in. $78.—Triplett

Circle 47 on reader's service card

8-TRACK STEREO CARTRIDGE PLAYER, *model CTP-80 D.* Inputs for phonograph, AM–FM tuner or tape recorder. No warmup necessary. Automatically switches to next track at program finish. Pushbutton switch for manual change. Volume, tone and balance controls; channel-selector light and pilot light. Hand-rubbed walnut cabinet with matching speaker; 2 hi-fi extended-range speakers. Tape base measures 11 x 11 x 3½ in.; speakers, 10½ x 10⅝ x 7¾ in. $139.95.—**Tele-Tone Co., Inc.**

Circle 48 on reader's service card

SOLID-STATE PRIVATE TONE CALLER. *Priva-Com III,* No. 99-3117; *Priva-Com IV,* No. 99-3123; *Priva-Com*

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Circle 107 on reader's service card

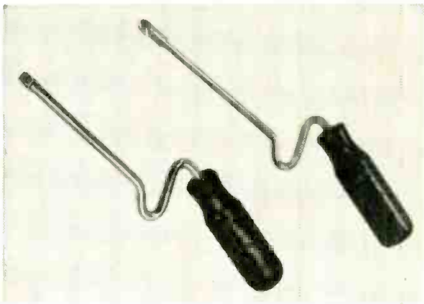
Circle 108 on reader's service card

V, No. 44-0149. Uses resonant and ceramic tuning forks. 9 transistors, 2 diodes. 1 7/16 x 4 x 5 3/4 in. $34.95—**Lafayette**

Circle 49 on reader's service card

SOLID-STATE POWER SUPPLY, *Knight-Kit KG-663.* 0–40 Vdc. 0–1.5A. Short-circuit protection. Input 110–130V, 50–60 Hz, 20W. Output regulation, less than 60 mV at full rated load. Line regulation, under 0.3V. Ripple, under 0.6 mV rms. 6 transistors, 11 diodes. Kit, $99.95; assembled, $149.—**Allied Radio Corp.**

Circle 50 on reader's service card



ECCEN TOOL. Based on principle of eccentric drive. One-hand operation. Available with 1/4-in. square drive or with high-speed tool-steel deburr and countersink heads. Sockets for square drive available.—**Techni-Tool, Inc.**

Circle 51 on reader's service card

CRT ANALYZER/REJUVENATOR, *model CR-35.* Continuously variable heater voltage, 0–13 Vac at 2A. Continuously variable control and screen grid voltage, +0–300 Vdc, −0–100 Vdc, 2% accuracy. 1 unijunction transistor, 3 silicon diodes, one SCR. 10 3/4 x 10 1/2 x 5 3/4 in., 9 lb. $99.95.—**Hickok**

Circle 52 on reader's service card

CB TRANSCEIVER AND COMMUNICATION RECEIVER, *HQ-205.* 6 CB channels, 5W. Receives 540 kHz to 30 MHz. Electrical bandspread for ham bands. Variable bfo for CW or SSB reception. Variable-bandwidth Q multiplier. Calibrated S-meter. $259.50.—**Hammarlund**

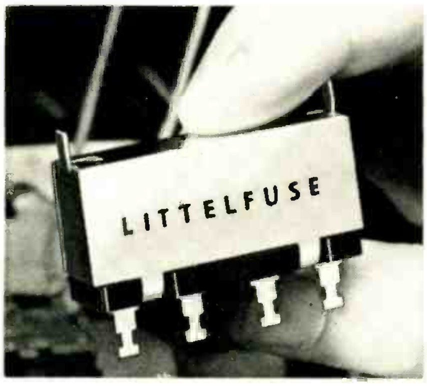
Circle 53 on reader's service card

CAR-DOOR SPEAKER, *C5FC.* 5.5-oz barium ferrite magnet. Moisture-resistant cone. Less than 2 in. deep. Impedance, 8 ohms. Handles 10W of program material.—**Utah Electronics**

Circle 54 on reader's service card

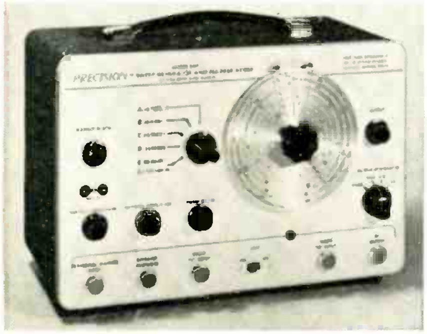
CIRCUIT-BREAKER KIT. For TV sets. Exact replacements. Tab-mounted. Noncycling reset action. Cross-referenced. $9.95.—**Mallory**

Circle 55 on reader's service card



DEGAUSSING SWITCH. Automatic. 1¾ x ¾ x ½ in. Phenolic base. 4 cadmium-plated terminals.—Littelfuse

Circle 56 on reader's service card



SWEEP GENERATOR AND MARKER ADDER, *model E-410C.* 5 bands, 3–216 MHz on fundamentals; 400–1,080 MHz on 5th harmonic. Continuously variable sweep width. Internal blanking and agc. 13 x 8½ x 7 in. $169.95.—Precision Apparatus Div., Dynascan

Circle 57 on reader's service card

SOLDERING–DESOLDERING IRON, *Uniline Mark VII.* 3-conductor cord, NEMA plug. Pneumatic suction for desoldering. 20, 30, 40, 50W sizes; 33 tip configurations. $39.50.—Vanguard Electronic Tools, Inc.

Circle 58 on reader's service card

VTVM, *model 235. Ac/dc Uni-Probe.* 6-in. meter. Frequency response, 30 Hz–3 MHz. 11-meg input. 1% multipliers, 3%

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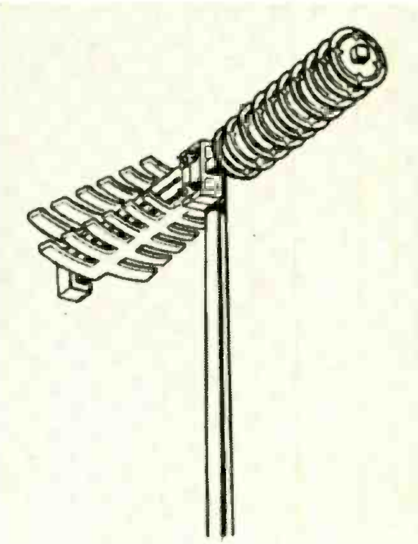
accuracy. 8 dc ranges, 7 ac peak-to-peak ranges. One zero-center adjustment for all functions and ranges. Transformer power supply. Ceramic switches. 8½ x 7½ x 5 in., 9 lb.—**EICO Electronic Instrument Co., Inc.**

Circle 59 on reader's service card

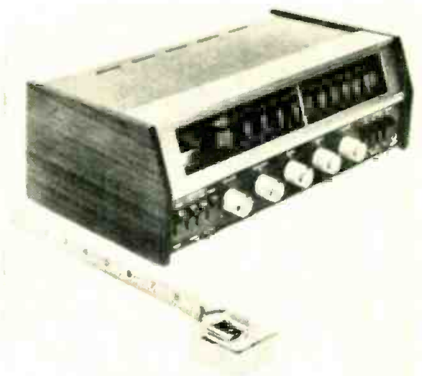


UHF ANTENNAS, *Color Laser series LPV-UCL*. Omnipolarized disc-on-rod director system. Zoned trapezoid director. —**JFD Electronics Co.**

Circle 60 on reader's service card

CB TRANSCEIVER, *Regency Ranger*. Specially protected for boating use. 11 channels. All-transistor. Epoxy-glass circuit board. Includes Collins mechanical filter. 12 Vdc. 120V 60-Hz supply available for base operation. 2⅞ x 6⅞ x 7$^{13}/_{16}$ in. $175.—**Regency Electronics, Inc.**

Circle 61 on reader's service card

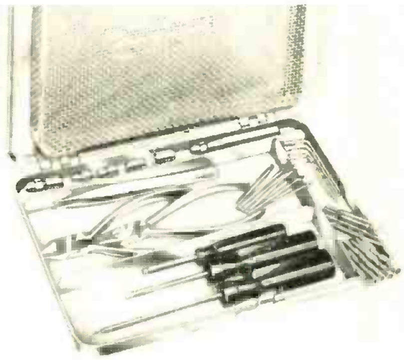


FM STEREO RECEIVER, *model ADC-606*. Solid-state. 45W per channel. Separation, 35 dB at 400 Hz. Input sensitivity, 2 mV. 9 x 17 x 5 in.—~~**Singer Products Co., Inc.**~~ AUDIO DYNAMICS ERROR

Circle 62 on reader's service card

VIDEO CAMERA, *model CC-6007*. Solid-state. 1-in.vidicon tube. Includes 25-mm f/1.9 lens. $399.95.—**Ampex**

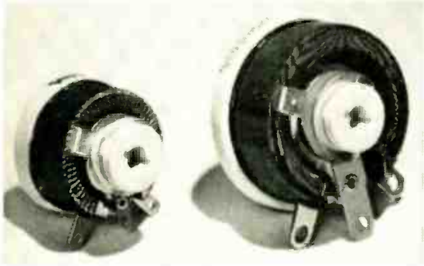
Circle 63 on reader's service card



MINIATURE TOOL KIT. Standard and deep sockets, [illegible] to [illegible] in., single hex. Clean-room kit nickel-plated with Delrin handles, includes stainless-steel tool-holding screen.—**Snap-on Tools Corp.**

Circle 64 on reader's service card

POWER RHEOSTAT POTENTIOMETERS, *style MP*, for industrial electronic applications. All ceramic construction; vitreous enamel bonded; self-lubricating shoe. Compact design and high resolution action. Resistance values to 5,000 and 10,000 ohms for 25- and 50-W

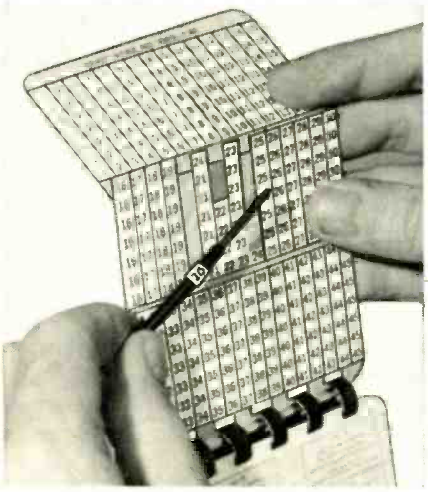


sizes, respectively. Directly interchangeable with those of major manufacturers. Standard tolerance is ±10%; functional output is linear.—**Ward Leonard Electric Co.**

Circle 65 on reader's service card

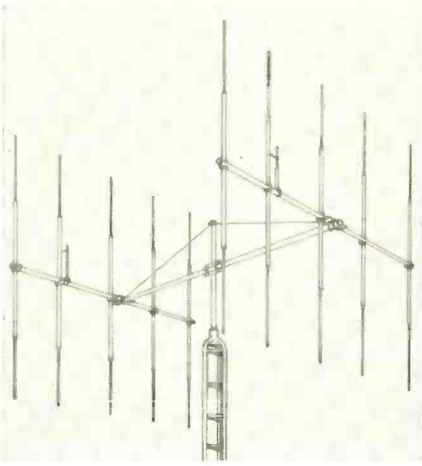
CASSETTE TAPE RECORDER, *model TC-100. Sonymatic* automatic volume control for recording. Uses 4 C-cells. Built-in ac converter. Includes cardioid microphone, leather case, 60-min tape cassette.—**Superscope, Inc.**

Circle 66 on reader's service card



WIRE MARKING KIT, *Porta-Pack.* 10 cards per kit, 45 markers per card. Provision for marking wire under 3/16-in. OD. Conforms to IPCEA-NEMA identification standards. $2.50.—**W. H. Brady Co.**

Circle 67 on reader's service card



CB BEAM KITS, *models SKT-3, SKT-4, SKT-5.* Each includes 2 beams, stacking harness, guy rope, boom, hardware, assembly instructions.—**Mosley Electronics, Inc.**

Circle 68 on reader's service card

CB TRANSCEIVER/PA SYSTEM, *model CG-21.* Solid-state, 5W, 17-transistor, 8-channel transceiver. Concentric volume, squelch controls. Illuminated channel selector. Dual-conversion receiver, image rejection 36 dB. $2\frac{3}{16}$ x 6 x 8 in., about 5½ lb. $139.95.—**Hallicrafters**

Circle 69 on reader's service card

CARTRIDGE TAPE RECORDER, *model M8300.* Solid-state. Snap-in loading. Portable. Includes jacks for earphone, microphone, ac power, foot-pedal switch. 2¾-in. speaker. 1⅞ x 4⅞ x 2¾ in. Weight without batteries, 3½ lb. $69.95.—**General Electric** END

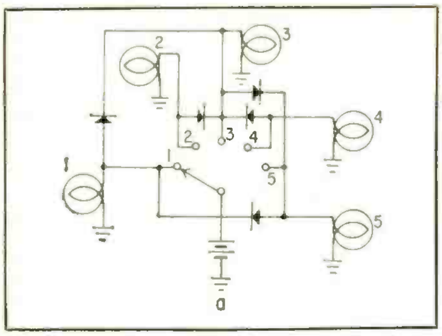
Circle 70 on reader's service card

WHAT'S YOUR EQ?

Conducted by E. D. Clark

Lamp Switching

I wanted a circuit using lamps, diodes and a single-pole 5-position switch to turn on various combinations of 5 lamps as follows (1) lamps 1 and 3, (2)



lamps 2 and 3, (3) lamps 3 and 5, (4) lamps 3 and 4, (5) lamps 5 and 1.

I built the circuit shown, but when I turned it on, strange things happened. What happened and what must be done to correct the circuit?—*Herschel P. Hall*

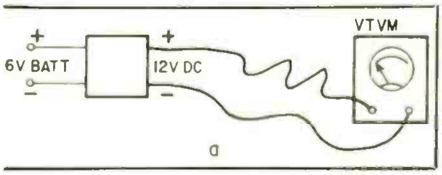
Two puzzlers for the student, theoretician and practical man. Simple? Double-check your answers before you say you've solved them. If you have an interesting or unusual puzzle (with an answer) send it to us. We will pay $10 for each one accepted. We're especially interested in service stinkers or engineering stumpers on actual electronic equipment. We get so many letters we can't answer individual ones, but we'll print the more interesting solutions—ones the original authors never thought of.

Write EQ Editor, Radio-Electronics, 154 West 14th Street, New York, N. Y. 10011.

Answers to this month's puzzles are on page 89.

Black-Box Voltage Doubler

What can be the simplest circuit inside the box to double the voltage as



shown? The box does not contain a battery, coil or moving part.
—*C. S. S. Shenoi*

A Mixer-Amplifier is useful in PA, recording, and broadcast remote jobs. A solid-state model you can build easily is featured in the August issue of RADIO-ELECTRONICS

NEW LITERATURE

All booklets, catalogs, charts, data sheets and other literature listed here are free for the asking with a Reader's Service number. Turn to the Reader's Service Card facing page 70 and circle the numbers of the items you want. Then detach and mail the card. No postage required!

TEST INSTRUMENT BROCHURE, Bulletin *No. 338*, 4 pages. Describes and illustrates 6 test instruments: the *CG10* and *CG138 Lo-Boy* standard color-bar generators, the *MX11 Channelizer* FM-stereo multiplex generator, the *TR139* in-circuit transistor tester, the *SM112B Service Master* vtvm/vom, and the *MU140 Continental* mutual-conductance tube tester.—**Sencore, Inc.**

Circle 71 on reader's service card

1967 KIT CATALOG. Illustrated, 36 pp. Includes test instruments, hi-fi, CB, lab equipment.—**EICO**

Circle 72 on reader's service card

PLASTIC POWER TRANSISTOR DATA. Engineering data sheet *B-5000*, 7-page pamphlet. Schematics. Includes mounting techniques, performance specs, applications.—**Bendix Semiconductor Div.**

Circle 73 on reader's service card

SOLDERING GUN CATALOG. Illustrated, 4 pp. Includes description of kit models *222 K-5* and *450 K-4*.—**Wen**

Circle 74 on reader's service card

SEMICONDUCTOR CATALOG, condensed. Specs, references on transistors, diodes, audio amplifier assemblies, integrated circuits, heat sinks, audio kits.—**Amperex**

Circle 75 on reader's service card

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

INDUSTRIAL AND POWER TUBE GUIDE. *B-9234*. 32 pp. Contains specs, base diagrams, electrical characteristics and interchangeability listing for 740 tube types in 19 categories. $.50—**Westinghouse Electric Corp., Gateway 3, 19N, Pittsburgh, Pa.**

END

"If it gives you any more trouble: Don't call me; I'll call you."

Down With Knob Twisting

By FRANK HADRICK AND CARL MICHELOTTI*

ZENITH 1967 COLOR-TV RECEIVERS USE an automatic fine-tuning system. The picture and sound remain tuned in correctly in spite of signal drift or fine-tuning misadjustment.

The two basic units in the automatic frequency-correction system are the *error sensor* and the *control device*.

The error sensor is a transistor discriminator (Fig. 1). The 45.75-MHz picture-i.f. signal is coupled from the plate of the third i.f. stage through a 1-meg ¼-watt resistor to discriminator input coil L. This coil is tuned slightly higher than 45.75-MHz (approximately 46.1 MHz) to compensate for the slope in i.f. response.

Thus, frequency deviations applied to the base of the transistor are approximately constant in amplitude. The picture-i.f. carrier is coupled through capacitive divider network C1–C2 to provide the proper operating signal level.

The transistor (a silicon planar epitaxial device) operates common-emitter, and provides more than 20 dB of power gain (voltage gain of 10). The transistor collector is then coupled through a tap to the primary winding of the discriminator transformer.

The transformer primary and secondary are coupled by both inductive (physical spacing between two coils) and capacitive (two 10-pF capacitors) means. These two coupling methods provide the in-phase and out-of-phase components generally associated with discriminator design. The matched diodes and their load resistors are appropriately coupled to the secondary; filtered dc control voltage is then available at point A in Fig. 1. The 1-μF electrolytic provides low-frequency decoupling, removing video information from the picture carrier. It also provides a sufficiently long time constant to prevent accidental lock-in.

The diode detector employs an unusual dc biasing method. Referring to Fig. 1, note the following: (1) Diodes D1 and D2 are reverse- and forward-biased respectively (in no-signal operation). (2) Approximately 3 volts is developed at the test point. This voltage (1 to 8 volts) is used to supply reverse bias for the varactors in the vhf and uhf tuners, and depends on frequency error and channel used. It should never be negative.

*Zenith Radio Corp.

The biasing of D1 and D2 provides the frequency characteristic shown in Fig. 2. Normally, a typical discriminator curve would follow the dotted line. However, this can be undesirable since it would produce a push-pull effect between the sound i.f. (41.25 MHz) or color i.f. (42.17 MHz) and the picture i.f. (45.75 MHz) if the oscillator is detuned to a higher frequency. The sound i.f. would move up the curve, tending to produce a more positive correction voltage; the picture i.f. would move down the curve, tending to produce a less positive correction voltage and resulting in poor operation.

However, with the small negative response, and under the same detuned condition, both carriers will ride down in amplitude and will aid, as in push-push action, in developing the necessary lower correction voltage. Thus, the dc biasing method discussed earlier provides: (1) A dc operating point for the varactor, about which the control voltage is developed, and (2) a means of preventing accidental lock-in on the sound or color i.f. carrier.

The range of correction voltage is from approximately 1 to 8 volts with a varactor capacitance change from 15 to 6 pF, respectively. (The frequency-control varactors are shown in Fig. 3.) The frequency pull-in range (to within 50 kHz) is approximately 150 kHz for channels 2 through 6, 300 kHz for channels 7 through 13, and 400–500 kHz for channels 14 through 83. The hold-in range is considerably greater.

Complete alignment instructions are provided in Zenith Service Manual CM-110.

Essentially, the discriminator transformer primary winding is adjusted for maximum response at 45.0 MHz, and the secondary winding for correct location of the 45.75-MHz signal (crossover point on the 3-volt bias line). The input coil is adjusted for maximum response at approximately 46.1 MHz. END

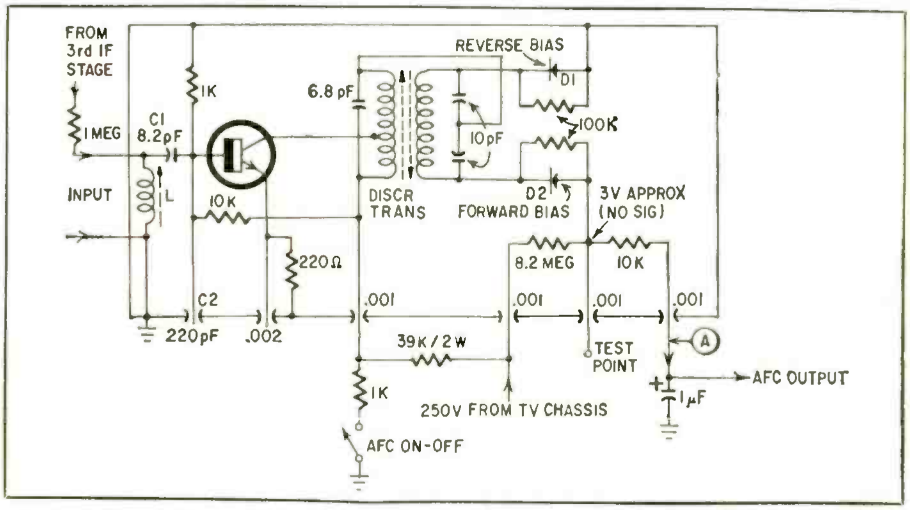


Fig. 1—This solid-state discriminator uses both forward and reverse bias on the diodes.

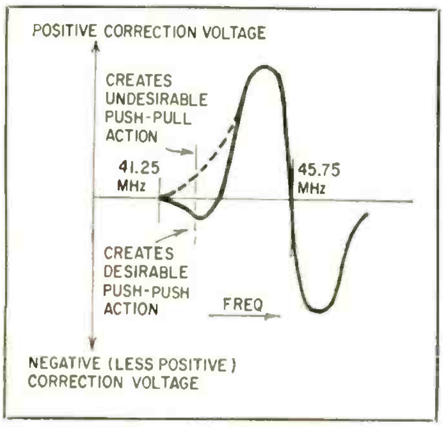


Fig. 2—Discriminator response curves.

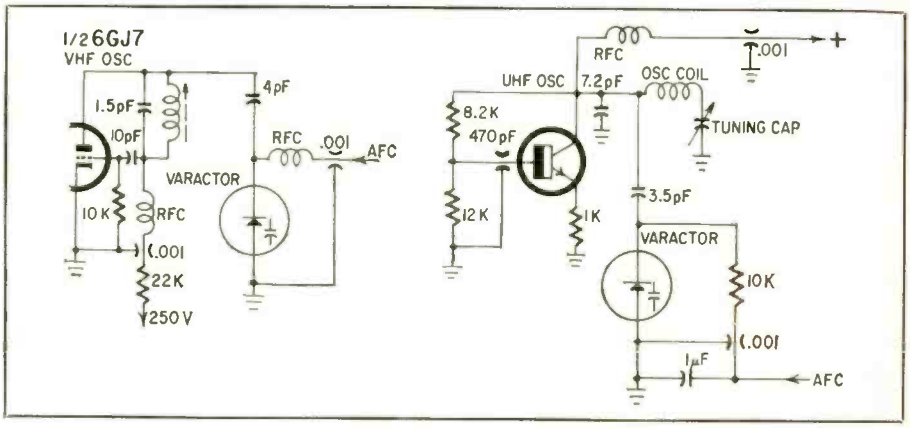


Fig. 3—Each local oscillator has a variable-capacitance diode across its tank circuit.

Verifying Amplifier Performance

A rundown of what to measure, equipment to use, and how to perform the tests

By PETER E. SUTHEIM

YOU CAN HEAR SOMETHING WRONG with an amplifier. It's fuzzy, maybe, or cymbal crashes don't have that clean crescendo they should. You can't quite tell what's wrong, but the amplifier just doesn't *sound* right. How do you determine what's happening? By measuring what the amplifier does to clean test signals. (In deference to audio engineers, who are often graying by 30, I have to say that measurements can't always be correlated with what we hear.)

What are the most important things to find out about an amplifier? First, a check of distortion at maximum power at various frequencies may tell you all you need to know about an amplifier for a specific purpose. A mere frequency-response check at a low power level indicates nothing that can't be learned better from a high-power measurement.

You may also want to know something about noise—specifically, hiss and hum. Stability is important, too. Does the amplifier have any tendency to ring or oscillate with certain kinds of loads? Does the cone of the speaker it's connected to seem to "breathe" or pulsate now and then—regularly, or for no apparent reason, or after a heavy transient?

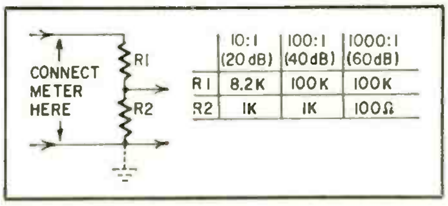
Gain measurements as such are usually important only in voltage amplifiers, such as preamps, mixers or control centers. In a power amplifier or an integrated amplifier (amp/preamp combination), power output is usually most important. If you get the expected power, you can then measure the input voltage to see if amplifier sensitivity is normal.

In a stereo or other multichannel amplifier you may want to check separation, and also determine if the amplifier still meets its specs when both channels are driven to full power simultaneously.

What equipment?

The three almost indispensable items are (1) a variable-frequency audio oscillator (or generator) with reasonably low distortion, hum and other noise; (2) a load resistor that matches one of the nominal output impedances of the amplifier, and (3) an ac voltmeter. Nearly as important as those three instruments is some sort of oscilloscope.

The generator should cover 20 to 20,000 Hz, at least. Frequency calibration is not too important. 10% accuracy is good enough, 5% excellent. What is more important is the *distortion* content of the signal. It should be 1% or less (total noise, hum and harmonics) for general audio work, and well under 0.5% for critical work with high-quality amplifiers.



	10:1 (20 dB)	100:1 (40dB)	1000:1 (60dB)
R1	8.2K	100K	100K
R2	1K	1K	100Ω

Fig. 1—If the lowest range on your ac meter is 1 or 1.5 volts, you can use a fixed voltage divider at the generator output. Ordinary 10% resistors will do—the error will be in the vicinity of only 1 dB. For higher accuracy, choose 1% resistors in ratios of 9:1, 99:1 and 999:1. The dividers should be enclosed in grounded shield cans to avoid stray hum and noise pickup.

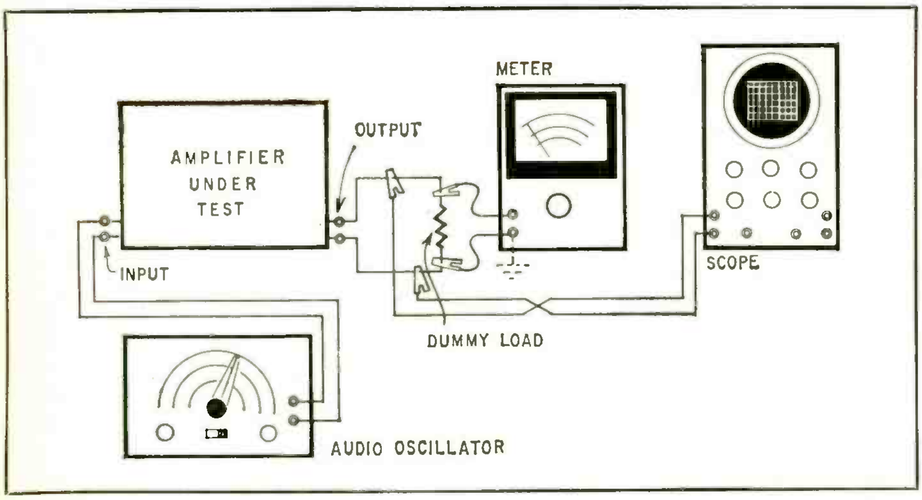


Fig. 2—For power amplifiers, load resistor must be capable of dissipating full power. For voltage amplifiers, load can be a ½-watt resistor of 100K, with .001 μF in parallel.

Another characteristic the generator should have is *flatness*, which means the output should be constant over the audio-frequency range. Here, 1 dB is good enough, but for more critical work it should be nearer 0.1 dB.

If the generator's output is nonuniform, you will have to monitor its output with a reasonably flat meter. Many generators have output meters. By the way, audio purists call the instrument an *oscillator* unless it includes an output voltmeter, in which case it's known as a *generator*.

Finally, the output impedance should be low enough not to be seriously loaded by the input impedance of the circuits you expect to test. Usually, an output impedance of 10,000 ohms or less is satisfactory unless you plan to work with professional equipment that has 600-ohm balanced inputs. In that case it may be worth your while to acquire a high-grade audio generator, which, in addition to its other attributes, will work into 600-ohm balanced inputs. Another solution is to put together a matching assembly to convert the 10,000-ohm unbalanced output to 600 ohms balanced. You can buy a high-quality well-shielded matching transformer for about $10–15.

You hear a lot about noninductive load resistors for audio work. Forget it. The inductance of an 8-ohm 50-watt wirewound resistor is around 10 μH, which amounts to a reactance of about 1 ohm at 15,000 Hz. The total impedance across the amplifier's output terminals is then about 8.06 ohms instead of 8. That's less than a 1% increase.

Since almost every amplifier has an 8-ohm output tap, 8 ohms is the best choice for a load resistor. The only hitch is that 8 ohms is not a standard value in many lines of power resistors. But 4 ohms is. The resistor should be rated at 50 watts, but 100 is better. For occasional work you can lay it on the bench (on a small piece of asbestos or fiberglass, or aluminum) and connect to it with clip leads. If you measure amplifiers often, you will want to mount the thing on a board or a little aluminum chassis.

For 600-ohm outputs, you will of course want a 600-ohm resistor. Usually, power levels at that impedance are small, so a 10-watt rating should do. The tolerance of many conventional wire-wound power resistors is 5%—fine for this application.

Your indicating device should be some kind of vtvm. A *good* vom is okay for measuring substantial powers at low impedances, but its impedance is too low on its lower ranges to be useful. It may load down the circuit under test and give misleading readings. The typical shop vom, for instance, is rated at 5,000 ohms/volt on ac. On the 1.5-volt (0 dBm) range, input impedance is therefore 7,500 ohms. Such a meter won't give an accurate reading on a circuit with more than about 750 ohms impedance. Cheap vom's often have inaccurate or highly un-flat ac voltage ranges. They are reliable only for measuring at 60 Hz, the frequency at which they are calibrated.

Your ordinary bench vtvm can do a good job, since its frequency response is usually flat throughout the audio band, and its input impedance is usually 1 meg on the ac ranges. The principal difficulty is that its lowest ac range is usually 1.5 volts rms full scale, which means that readings below 0.5 or 1 volt are dubious. Whether this is a serious objection depends on what kind of work you will do.

If you expect to have to measure preamplifier gain and frequency response, you may find the "blindness" of not having a sensitive enough instrument a real handicap. (Fig. 1 shows a way around the problem which may not always be convenient.)

Certainly the best instrument for general audio measurement is the ac vtvm, sometimes called the audio millivoltmeter or amplifier-rectifier meter. The cheapest of these, more than satisfactory for this work, can be bought as kits for around $50. For about the same cost, you can build the excellent all-transistor unit described in the March 1966 RADIO-ELECTRONICS. That one is battery-powered, so there are fewer problems with hum and ac leakage currents.

Most meters of this kind (including the R-E instrument) have a low range of 10 or even 3 mV full scale, and thus can read the output of many microphones and pickups directly. They are also indispensable for accurate noise measurements. Most recent models have an input impedance of 10 megs with very little shunt capacitance, and so have very little loading effect on almost any sort of circuit you're likely to run across.

Still another advantage: Scales are calibrated directly in dB as well as in volts, and the ranges are set up as steps of 10 dB. That greatly simplifies relative and comparative measurements like gain or noise. When used across a 600-ohm line, such voltmeters read directly in dBm (decibels relative to 1 mW).

You should have a scope. It need not be a fancy one. Response from dc to 5 MHz is nice but not necessary. A $50 or $60 kit scope with a 3-inch CRT and response from 20 to 200,000 Hz within 3 dB is fine for general audio checking. If you're already in the servicing business, the scope you have is sure to do reasonably well.

Now let's measure something.

Power and distortion

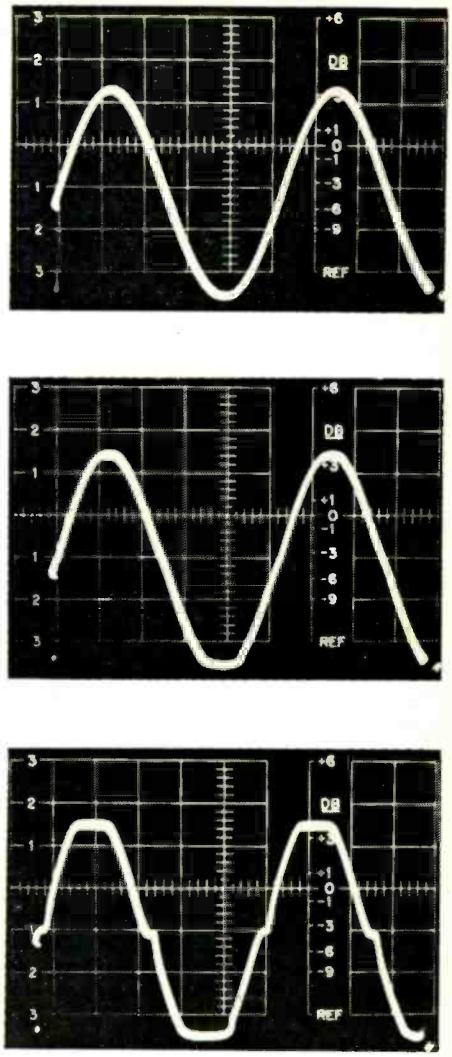
Hook up your equipment to the amplifier under test as shown in Fig. 2. Note that the amplifier is a "black box" in the drawing—it can be any kind of power amplifier or amp/preamp combination. Set the audio oscillator to produce 1 kHz at a level that is adjustable around the nominal input value for full ampifier output. If you are using an "auxiliary" or other high-level input, that figure will usually be in the range of 0.2 to 1 volt. If the amplifier has a volume or level control, turn it fully on and use the generator control to adjust input voltage. Set the vtvm to a range that includes the expected full-power output voltage. You can estimate that by taking the square root of the product of rated power and load resistance (8 ohms, or whatever you're using). For example, the maximum rms output voltage of a 10-watt amplifier on an 8-ohm load is around 9 volts.

Turn the input signal up far enough to get a lockable waveform on the scope; set the sweep for two or three cycles of signal. At this point—assuming you're still well below the maximum output power of the amplifier—you should have a perfect sine wave.

Slowly advance the generator level control and watch the scope for signs of distortion in the waveform: clipping at either peak or both, asymmetrical curvature, "fuzz," jogs or anything other than pure sine. Adjust the scope's sensitivity as needed to keep the trace visible.

In all modern push-pull amplifiers you should be able to reach full rated output at 1 kHz before you see any distortion. What usually happens then is that both peaks of the sine wave begin to flatten rather suddenly and about equally. As you increase the input voltage further, the waveshape becomes definitely angular. At the same time, there may be a distinct jog around the zero axis of the waveform. The output of the amplifier may continue to increase if you crank the input up further, but this is no longer *useful* output; it is very badly distorted.

If you have no distortion-measuring equipment, or if no distortion figures are specified, take the output at the point where flattening just begins as the nominal output of the amplifier. Read the output voltage, square the figure, and divide by the load resistance in ohms.



From top to bottom, the first trace shows clean sine-wave output. The next illustrates the clipping point; since bottom of the wave is clipped but top is not, the amplifier is slightly asymmetrical. The last trace clearly indicates severe amplifier overload; both halves of wave are clipped.

The result is the output power of the amplifier in watts rms.

Any substantial asymmetry in the clipping or flattening in a push-pull amplifier indicates an unbalanced output stage or phase inverter. If the amplifier has one or more balancing adjustments (*not* the channel-balance control in stereo amplifiers!), set them according to the manufacturer's instructions. If not, interchange the output tubes or transistors or try a new pair, preferably matched. If clipping is still asymmetrical, there may be trouble in the phase inverter or driver or in an earlier stage.

The most valid indicator of proper balance in a push-pull amplifier is minimum distortion at maximum output. If you have an IM or harmonic-distortion meter, adjust the balance settings for a minimum distortion reading at rated amplifier output power. Otherwise, try to get symmetrical clipping at "overload" output. This indicates that each half of the push-pull output stage is doing its fair share of the job.

If the amplifier under test is to be used for high-quality reproduction, you will want to repeat the distortion test at 50 and 10,000 Hz. A really topnotch amplifier should be able to produce full power at rated distortion at any frequency from 30 to 15,000 Hz, or even 20 to 20,000. Don't expect anything like that from low-priced amplifiers or the usual public-address equipment.

Remember one thing, though. Half power means a drop of 3 dB, which represents a barely audible change in loudness on program material. To sweat for hours to get 5 more watts from a 50-watt amplifier is pure masochism.

A final point before we go on to another kind of measurement: Single-ended amplifiers, the kind you find in cheap radio and phonographs and in "minimum" PA systems, produce asymmetrical clipping even when working right. Incipient overload in those circuits usually looks like a gradual skewing of the waveform, often well before distinct clipping sets in. Don't waste much time with them. If they produce their rated output without any terribly serious aberrations in the waveform, let well enough alone.

Noise and hum

One thing you must be sure about in making hum and noise measurements—that your test setup doesn't introduce hum and noise in amounts that approximate the quantities you're trying to measure.

Before you begin, try this. Short the input terminals of your ac millivoltmeter with an inch or two of wire and switch to the lowest range. Any reading on the meter is being generated by the meter amplifier or picked up internally from the ac wiring. It should be very small—not more than one or two divisions at the extreme left end of the scale. If it's more than this, try reversing the ac power plug or grounding the meter cabinet to a good waterpipe ground. If that doesn't help, something's wrong in your meter—bad wiring, a ground loop, heater–cathode leakage, a noisy tube or resistor, an open filter capacitor, etc.

Now, to check the amplifier, use the test setup of Fig. 2 again. All shields, bottom covers and suchlike that came with the amplifier should be in place and fastened. Short the amplifier input with a bit of wire and switch the meter to a low range, where you get a noticeable reading. Try various combinations of reversing line plugs on all the equipment that's interconnected, including the amplifier, and/or grounding the chassis of one or more instruments, until the reading is as low as it will go.

Now remove the short and run the amplifier up to full output at 1 kHz—to whatever figure you settled on after the power-output check—and note the figure. Disconnect the generator and again short the input terminals of the amplifier with a bit of wire. Increase the sensitivity of the meter range by range until you again get a readable reading. Note that figure.

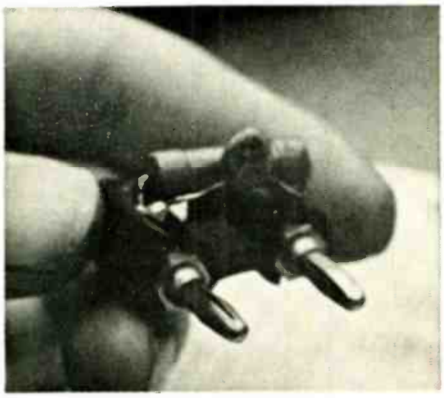
Ten times the common logarithm of the ratio of the full-output reading to the no-signal reading gives you the signal-to-noise figure in dB. (On an audio millivoltmeter, you can read off the figure directly in dB.) Noise should be at least 50 dB below full output, and preferably 70 or 80 dB.

The noise figure will probably change with various settings of volume and tone controls; the reading you choose is up to you.

For a really precise determination of signal-to-noise ratio, the input should be bridged by a resistance equal to the typical value of source resistance the amplifier is designed to work from. Such a resistor might be 1,000 ohms for low-level mike or phono inputs and 10,000 for high-level inputs.

Note that you cannot separate *hum* (60 Hz and harmonic multiples of it) from *noise* (random stuff produced by resistors, tubes, transistors, etc.) in this test. What you measure on your meter is an average of all the output produced by the amplifier in the absence of a deliberate input signal. To measure hum and noise independently requires the use of filters, a wave analyzer, or a calibrated scope.

You'll find it's a good idea to leave your scope (calibrated or not) connected throughout all tests on an amplifier. It provides a window through which you can see what's going on. For example, in the noise test, it's convenient to know what part of the total noise is raw 60-Hz ac, 120-Hz ripple, random noise, etc.



A standard dummy load for preamp outputs is a testing convenience. Put 100K of R and .001 μF of C in parallel across a dual banana plug (E. F. Johnson 108, General Radio 274MB, or H. H. Smith 210). Such a plug will fit the binding posts of most modern audio test equipment.

Gain, frequency response and sensitivity

Stated most simply, gain is the ratio of output voltage to input voltage. Gain in dB is 20 times the common log of that ratio. We're not going to talk here about power gain, which is usually not of interest in this kind of work and introduces messy complications about impedance. Just voltage gain.

When you measure gain, it will usually be the gain of a preamplifier, or some other device whose main purpose is to deliver an output *voltage* with negligible power. Such devices normally work into relatively high impedances. A good standard dummy load to put across the output of such an amplifier is 100,000 ohms in parallel with .001 μF. The capacitor simulates the capacitance of the connecting cable and the following stage.

Suppose you want to know whether a preamp on your bench has sufficient gain to produce 1 volt rms output when driven by a microphone whose maximum output is 5 mV. You can either set the output to 1 volt and measure the input voltage being applied to produce that output, or set the input to 5 mV and measure the resulting output. Dividing the output by the input gives you the gain figure.

Watch out for one thing, though. Too great sensitivity can be just as troublesome as not enough. Suppose the preamp produced 1 volt from an input of 1 mV—its gain is actually 1,000, which is 60 dB. It is possible that the 5 mV output of the microphone you intend to use will overload the preamp and cause distortion, even if there is a level control after that point to cut the input to the *main* amplifier back to what it should be. For that reason, it is wise to check not only gain and sensitivity but also the maximum input a preamp can tolerate before clipping the signal or introducing too much distortion. You will then be on safe ground.

In a well-designed preamp, the output stage should go into distortion before any earlier stage is overloaded. A top-quality mike or phone preamp should be able to handle inputs of up to 50 or 100 mV before it starts distorting seriously.

Measuring frequency response is just a matter of repeating the gain measurement at different frequencies. On a flat preamp, all you have to do is make sure the input level is the same at each frequency. This means either trusting the flatness of your generator or monitoring its output with a meter or scope. If the output of the preamp is also the same at every frequency, the preamp is flat. Variations of up to 3 dB are to be expected in PA equipment over the range of 50 to 15,000 Hz; better equipment should show variations of only 1 dB or less and often over a much wider range—perhaps 10 to 100,000 Hz.

If the preamp has tone controls, you will have to be sure they are set for flat response. This, unfortunately, is seldom just a matter of turning the controls to the dots marked FLAT. You may find remarkable humps and dips in the response curve unless you carefully set the controls for true flat response. This usually takes some tinkering. Learning by how much the true flat setting differs from the indicated flat setting is usually instructive.

In equalized amplifiers, like phono preamps, the problem is much more interesting. The best approach for occasional work is to measure the preamp's gain as described before at 1 kHz, which is your reference frequency, using a signal sufficiently small so that when you measure at 50 Hz, where the gain is supposed to be 17 dB (70 times) higher, you don't overload the preamp. Use a constant input for each frequency. Call the 1-kHz output zero dB. Then measure the gain at several at least of the other frequencies given in the table.

The outputs relative to the 1-kHz reference output, translated to dB, should approximate the numbers in the table. Equalization within 1 dB is excellent; within 3 dB, usually acceptable for low-priced equipment. Expect relatively greater deviations from correct equalization at the top and bottom ends of the curve. Note that the levels in the table are for the RIAA equalization curve only.

Stability

This check is about as empirical as anything in audio. It consists mainly in watching the scope screen as you do various things to the amplifier. Any thickening of parts of the signal trace, "fuzz" anywhere on the trace, or a periodic jumping, is a sign that the amplifier is either oscillating or darn near.

To be truly valid, this test ought to be conducted with the load the amplifier will actually see when it is in service. Since this is usually a loudspeaker, or maybe several, a real road test is usually impractical.

Bear in mind that a speaker almost never looks like a pure resistance. At high frequencies it gets more and more inductive, and at low frequencies—below the main bass resonance—it acts like a capacitor. Multiple speakers may have impedances that vary all over the map as you go from one end of the audio range to the other. The varying phase shift introduced into the amplifier's feedback loop by this varying reactive load can easily make negative feedback positive, or at least less negative, at some frequencies. Depending on the gain of the amplifier at the frequencies where the feedback becomes regenerative, the amplifier may actually take off and oscillate, or it may ring, or it may be triggered into short bursts of oscillation on certain kinds of signal.

Some amplifiers are unstable with signal and no load, some with load and no signal, or with no signal and no load, and so forth. A capacitance of .001 or .005 μF across the load can (but shouldn't) affect stability. Sometimes volume and tone controls influence stability as their settings are varied. You should check out all these combinations, especially if this is an amplifier of questionable quality or one you've built. If you plan to sell or rent out the amplifier, remember that you will have no control over what kind of speakers or lines the user connects it to. The power developed by a runaway regenerative amplifier can ruin speakers or transistors in seconds.

Stereo checks

A very enlightening test to run on a stereo power amplifier or combination is to connect its outputs to separate load resistors, feed the inputs in parallel with the same signal, and measure maximum output before clipping as described earlier. The sum of the measured outputs will be less (often very much less) than twice the figure you get by driving only one channel at a time, because the load on the power supply is approximately doubled and its output voltage has been dragged down. The better the amplifier, the more nearly the sum of the outputs of both channels driven simultaneously will approach the sum of the individual power outputs.

This test is not at all unrealistic; it represents the condition under which a stereo amplifier is most often used. Running this check will give you an idea of what to expect from the amplifier in actual service. It will also open your eyes to manufacturers' claims of "25 watts per channel—50 watts stereo!"

Stereo separation of an amplifier is the dB figure by which the signal in one channel (not being driven) is below the signal in the driven channel. The higher this figure, the better the separation.

To quick-check it, set one channel up as in Fig. 2. Set the other up the same way, with a load but without instruments. Run the first channel to full output. Then, without removing the input signal, switch the vtvm and scope across the load resistor of the other channel. The reading now should be some 50 dB lower at 1 kHz. Try the same test at 50 Hz and 10 kHz; the result will almost certainly be poorer.

At high frequencies, separation is reduced by stray-capacitive coupling between channels; at low frequencies, by common-impedance coupling through the power-supply filter.

Note that the input of the undriven channel should not be shorted. To short it might produce an unrealistically good separation figure, since it normally isn't shorted. If the scope shows that much of what you're reading as breakthrough between channels is actually hum picked up on the open-circuited input, then you will have to short that input or, better still, terminate it with a shielded 10,000-ohm resistor.

Try (just for fun) reversing the channels—driving the formerly undriven channel and measuring on the other. The figures you get may very well be different.

You may also want to check the two channels for gain. They should be within 3 dB or less of each other. Small differences can usually be compensated by turning the channel-balance control to favor the weak channel, but serious differences are a nuisance and indicate something wrong in the amplifier.

Especially in lower-priced amplifiers, the setting of the volume control can have a profound effect on the relative gain of the two channels. You will want to check relative gain around the setting at which the volume control will most often be put.

There are, of course, many more checks and tests you can make on an amplifier. Manufacturers go through a great many measurement procedures. Some involve very sophisticated equipment and take hours or days to complete. But the procedures described here will give you some idea of the quality of an amplifier and its suitability for some particular job. And you've gained an insight into the fascinating field of audio measurements. END

Frequency	Response	Frequency	Response
15 kHz	−17.2	3 kHz	− 4.8
14	−16.6	• 2	− 2.6
13	−15.9	• 1 reference	0
12	−15.3	700 Hz	1.2
11	−14.6	• 400	3.8
• 10	−13.8	300	5.5
9	−12.9	• 200	8.2
8	−11.9	• 100	13.1
7	−10.9	70	15.3
6	− 9.6	• 50	17.0
• 5	− 8.2	30	18.6
4	− 6.6		

Table of relative response for the standard RIAA disc playback curve. Dots to left of certain frequencies indicate checkpoints for rapid check of equalization. Start with 1 kHz and use that level as your 0-dB reference. Then work up or down. Readings are shown in dB's.

TECHNOTES

SENCORE CR-133 CRT TESTER

My Sencore CR-133 CRT tester-rejuvenator stopped working in the REJUVENATE 1 and REJUVENATE 2 modes. All other functions were normal. At first, I thought that the last few tubes that I rejuvenated were simply too far gone for the first two rejuvenate positions to have an effect. But when the same thing happened on several tubes that still had a fair amount of brightness left, I suddenly remembered that I had not noticed (in modes 1 and 2) the usual blue flash in the neck of the CRT.

The tube heater brightened progressively as the function switch was advanced from REJUVENATE 1 to 3. This showed that the voltage-boost part of the circuit was okay. The schematic showed that the only component not common to the three rejuvenate circuits is a 10-ohm 5-watt surge-limiting resistor, which is in the circuit in positions 1 and 2 but is bypassed in position 3. An ohmmeter check showed it to be open. Replacement with a 10-watt resistor restored the tester to perfect operation.—*Klaus Halm*

DESOLDERING? BLOW, DON'T SUCK

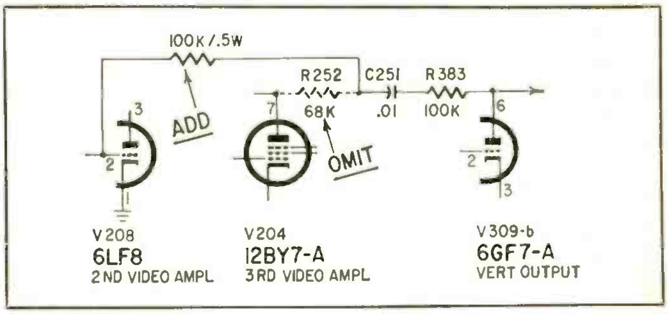
In our shop, we use an air compressor and storage tank with about 40 pounds of regulated air pressure to clean chassis and cabinets. I've also found it unsurpassed as a desoldering aid when removing components from printed-circuit boards.

Use wide masking tape to cover adjacent parts, then heat the terminals of the part being removed until the solder is molten. A short blast of air blows away the solder. This method of removing solder is far more efficient than the two suction devices I've tried. Even if the blown solder strikes a component or another joint, it won't stick because the air cools it instantly.

If you don't have an air compressor in your shop, you can use a small refillable air tank. You won't have to fill it often because the amount of air used for this purpose is negligible.—*Wayland Dunning*

DUMONT COLOR SETS

Improved vertical retrace blanking in chassis 120814 coded with triangle F or higher letter; 120822 and 120835 with triangle E or higher letter; 120844, 120858, 120859 and 120868 coded triangle B or higher.

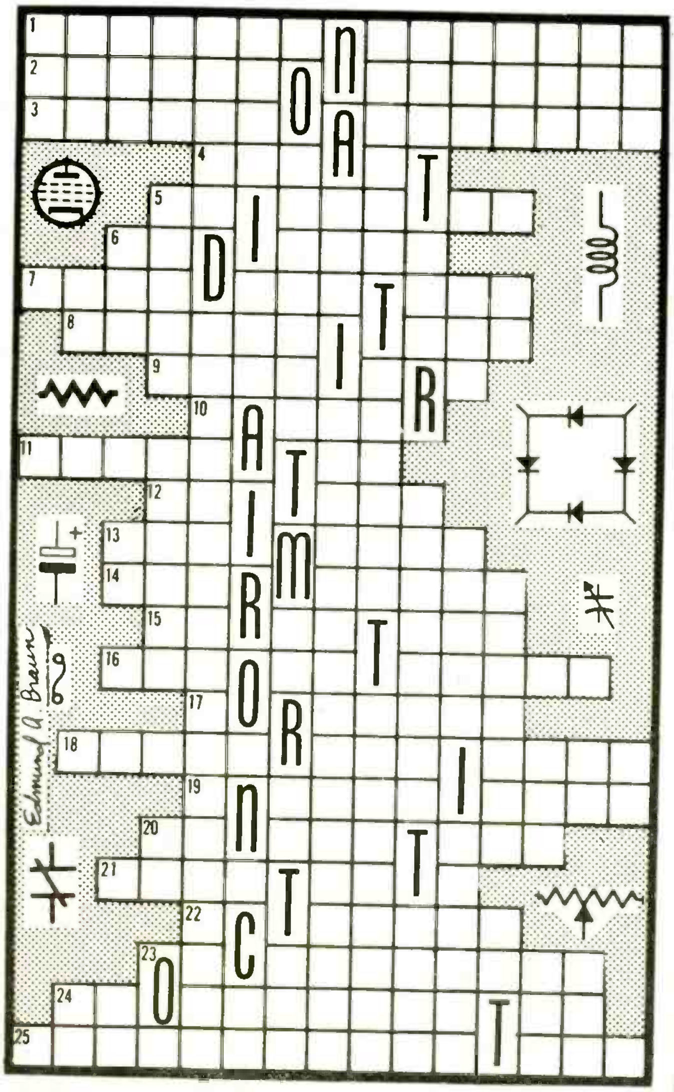


Remove 68K ½-watt resistor R252 from the circuit and add a 100K ½-watt resistor between pin 2 of V208, the 6LF8 second video amplifier, and C251 as in the diagram. Mount the resistor on the etched side of PC-2, the video and sound board. Insulate the leads to prevent possible shorts.
—*DuMont Field Service Bulletin* END

R-E PUZZLER

Try solving this puzzle based on electronic terminology. It shouldn't prove difficult except perhaps to someone who believes "heptode" is a bullfrog who's been around, or that "transformers" are worn under blouses! Each word is connected to the one above and below by a single letter. Get a pencil, make yourself comfortable, and begin!

1 Transformer combining primary and secondary as a single coil.
2 Material in which current flow is changed by light.
3 Involving both electrical and sound pressures.
4 Impurity added to a semiconductor to improve conductivity.
5 Three-terminal silicon semiconductor device.
6 Electrostatically focused, beam-switching tube.
7 Signal detection.
8 Equipment that produces and modulates rf current and delivers to antenna.
9 The third order or rank, as a coil winding.
10 Small capacitor inserted in series with a main capacitor.
11 Type of spring clip with two meshing jaws.
12 Oriented intergrowth between two crystals.
13 Instrument that measures radiation.
14 Pertaining to emission of electrons by heat.
15 Early form of detector that works like a thermistor.
16 Quality, degree, state, or measure of color.
17 Doughnut or ring-shaped.
18 Flowing only in one way.
19 Fluctuation or irregularity in performance.
20 Having a common center, such as a circle within another circle.
21 In microelectronics, the physical material on which circuit is fabricated.
22 Its atomic number is 89; its atomic weight is 227.
23 Pertaining to af or rf generation.
24 Varistor in which current–voltage relation may be modified by light.
25 Variation of components of a complex wave by each other.



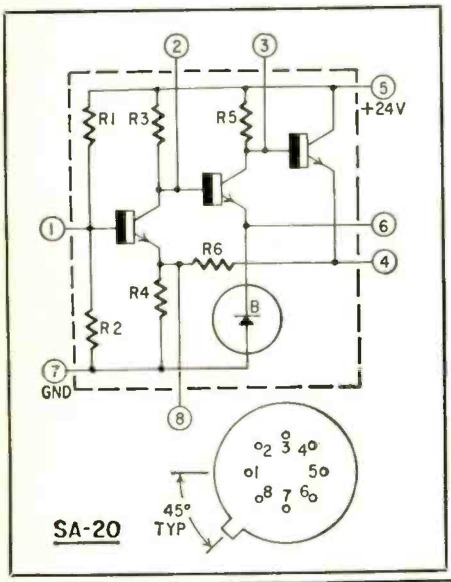
Solution next month

65

NEW SEMICONDUCTORS, MICROCIRCUITS & TUBES

WIDE-BAND LINEAR IC AMPLIFIER

The Sylvania SA-20 is a 3-transistor IC voltage amplifier having a typical gain of 11 set by two resistors (R4 and R6 in the diagram) in a feedback net-



work. An external resistor can be connected between pins 4 and 7 for precise gain adjustments.

The −3-dB frequency response is determined largely by the value of an external feedback capacitor connected between pins 2 and 3. With 10-pF feedback capacitance, gain begins to droop at about 3.5 MHz and is down 3 dB at about 12 MHz. With a 3-pF capacitor, rolloff begins at 20 MHz and reaches the −3-dB point at 80 MHz.

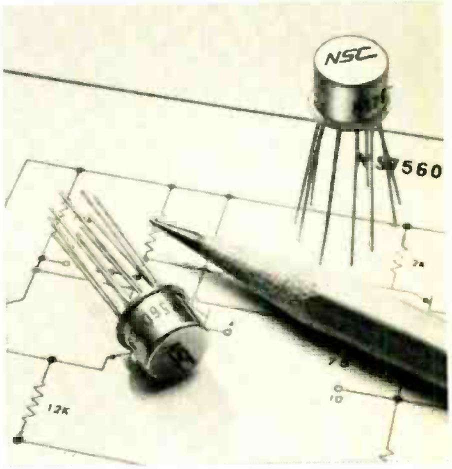
Input impedance is 1,200 ohms; output impedance is 2 ohms. Maximum output signal is 14V p-p. Power supply 24V at 15 mA. Temperature range −55 to 125°C. Packaged in 8-lead low-silhouette TO-5 case.

HIGH-VOLTAGE POWER TRANSISTORS

The B-176000–B-176015 and B-176024–B-176029 form a series of npn silicon power transistors for high-voltage applications. Maximum collector current is 5 amps. The series includes units with V_{CEX} and V_{CBO} ratings of 250, 400, 550 and 700 h_{FE} ratings ranging from 10 to 25. Additional information on these transistors can be obtained from Bendix Semiconductor Division, Holmdel, N. J.

HYBRID OP AMPS

The NS7560 and NS7560A are two hybrid operational amplifiers offering input-current, input-offset-voltage and output-current characteristics superior to



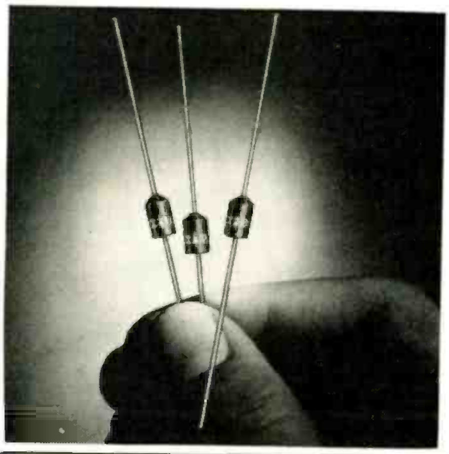
their monolithic counterparts in the −55° to +125°C operating range. They provide wide output voltage swing and high output current with minimum input current and low standby power requirements. END

Circle 117 on reader's service card

Typical input offset voltage at 25°C with V_s at ±12V is 5 mV for the NS7560 and 1 mV for the NS7560A. Typical input bias currents for these National Semiconductor units are 40 nA and 10 nA, respectively. The output is a complementary emitter follower supplying up to ±50 mA into a 100-ohm load. Unity gain point is about 10 MHz with no external rolloff. When adjusted for a gain of 10, response is flat within 1 dB to over 1 MHz. Standby current is 3 mA with supply voltages of ±12V.

NEW 1-WATT ZENER REGULATORS

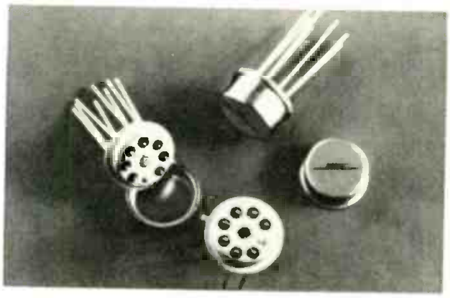
A new line of Zener diodes from International Rectifier is the 1ZM series.



Voltage ratings of these 1-watt units are from 3.3 to 15V with maximum current ratings from 300 to 60 mA. The series is described in *Bulletin C-102* available from International Rectifier, 233 Kansas Street, El Segundo, Calif. 90245.

MONOLITHIC VOLTAGE REGULATOR

The LM-100 voltage regulator is adjustable over a 2–32-volt output range and handles output currents up to 10

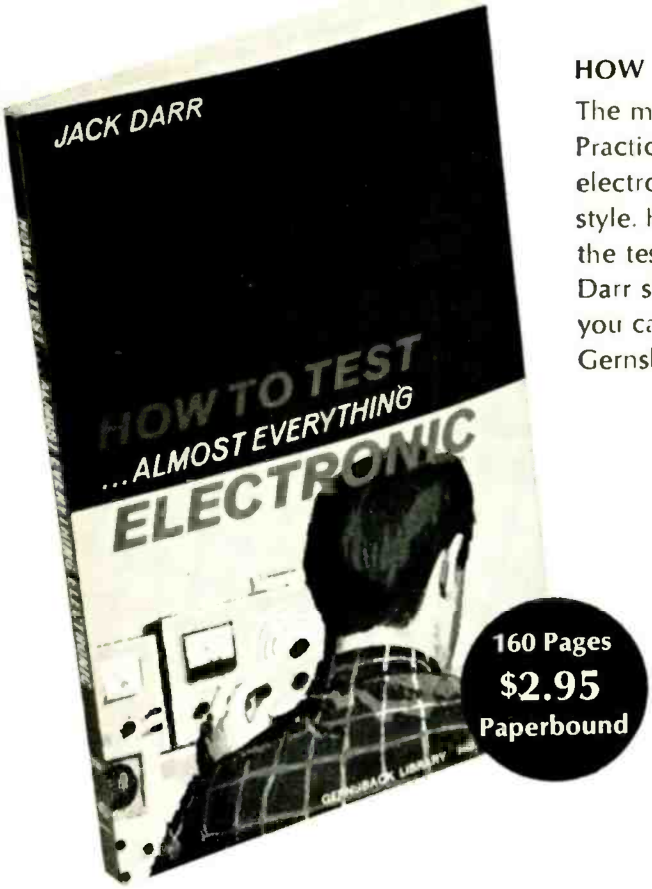


mA. The addition of a single transistor increases the current range to 200 mA. A second transistor will raise the output to 5A. The output voltage level is set by an external voltage divider. The LM-100 is packaged in an 8-lead TO-5 header. Specifications and applications notes can be obtained from National Semiconductor Corp., Microcircuits Div., 2950 San Ysidro Way, Santa Clara, Calif. 95051.

END

Circle 118 on reader's service card

Now...learn how to test and service electronics— read the new Darr Twins.



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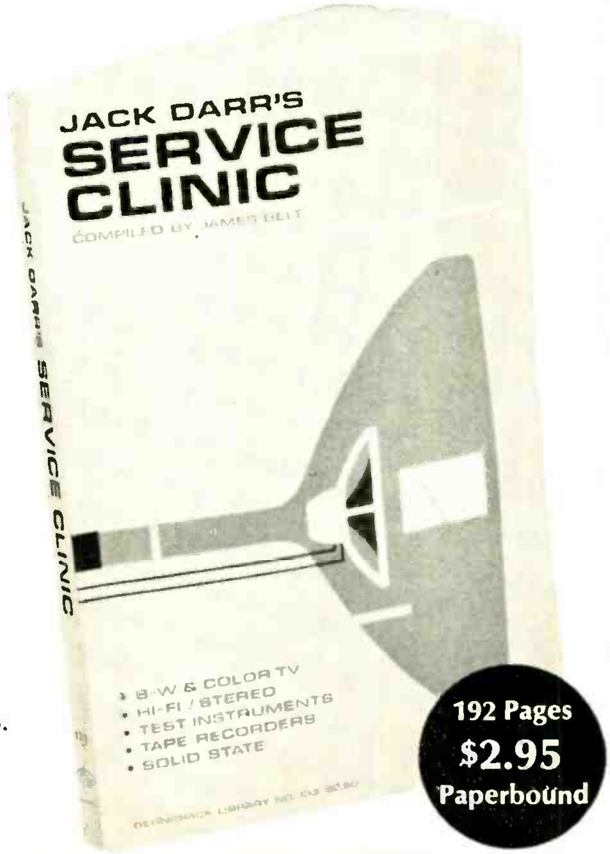

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Compiled by James Belt. The most helpful material from RADIO-ELECTRONICS Service Editor Jack Darr's monthly "Service Clinic." Every chapter contains distillations of concise and witty instruction about testing and trouble-shooting, followed by actual reader questions and answers. Hundreds of questions selected for lasting usefulness and grouped under convenient categories for easy reference. Gernsback Library #133.

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Pearl Radio & Electronics
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Seattle

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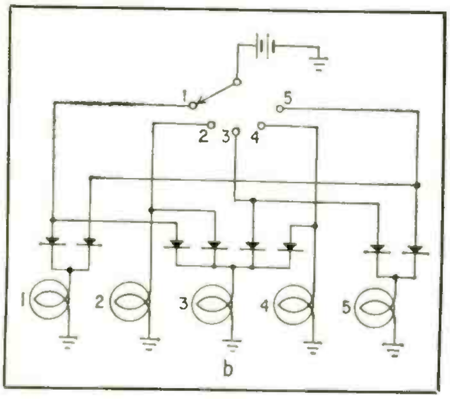
Seattle

WHAT'S YOUR EQ?

These are the answers.
Puzzles are on page 78.

Lamp Switching

As shown, the circuit will fire the desired lamps—but also some others. They come on as follows: (1) 1, 3, 5;

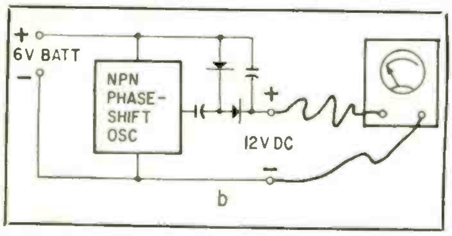


(2) 1, 2, 3, 5; (3) 1, 3, 5; (4) 1, 3, 4, 5; (5) 1 3 5.

The circuit operates correctly when connected as shown above.

Black-Box Voltage Doubler

The box contains an RC phase-shift



oscillator and a voltage-doubler rectifier, as shown. END

50 Years Ago

In Gernsback Publications
From July, 1917
Electrical Experimenter

Wireless on the American Submarine Chasers

How Radio Brought the News to the Farm

Lightning—How to Protect Yourself From It

The U. S. Signal Corps Wants You!

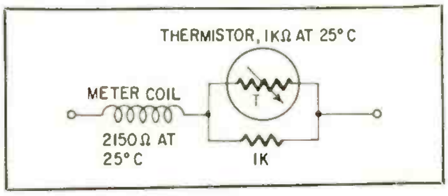
CB FREQUENCY Checks are required by the FCC and must be made with highly accurate equipment. But you can buy a surplus BC-221 frequency meter and build an inexpensive converter that will get the job done properly. Here's a source of additional income—an easy-to-build converter for CB work—in the August issue of RADIO-ELECTRONICS

NOTEWORTHY CIRCUITS

METER TEMPERATURE COMPENSATION

The resistance of a meter coil changes with temperature. Where meters are used over a wide range of temperatures, such as outdoors or in some factories, this can be important.

As an example: A meter movement that has a resistance of 2,150 ohms at 25°C (about 77°F) will drop to 1,800 ohms at −20°C (−4°F) and rise to 2,358 ohms at 50°C (122°F). Thus a meter that is accurate at 25° may be high 16% at −20° and low 10% at 50°.



By compensating that variation with a high negative-temperature-coefficient thermistor, the meter can be used over a wide temperature range with minimal error. I use meters so compensated in a foundry in Wisconsin, where temperature variations exceed those quoted above.

Using a YSI precision 1,000-ohm thermistor in parallel with a 1,000-ohm resistor (see diagram), the meter resistance at 25° is 2,150 ohms and the thermistor–resistor combination is 500, a total of 2,650 ohms. At −20°C the thermistor resistance rises to 7,325 ohms and the thermistor–resistor combination is 880 ohms. This, in series with the meter's 1,800 ohms, amounts to 2,680 ohms. The difference of 30 ohms amounts to ±1.13% instead of 16%. At 50°C the thermistor resistance is 468 ohms and the parallel combination with the resistor 319 ohms. Thus system resistance, with the 2,358 ohms of the meter, is 2,677 ohms, a difference of only 1.02% from the "standard" 2,650.

Adding the extra resistance of the compensation system will decrease the meter sensitivity. In many instances, however, the original circuit uses a resistance in series with the meter. Reducing that resistance by 500 ohms leaves the total resistance unchanged. —*Howard T. Bailey*

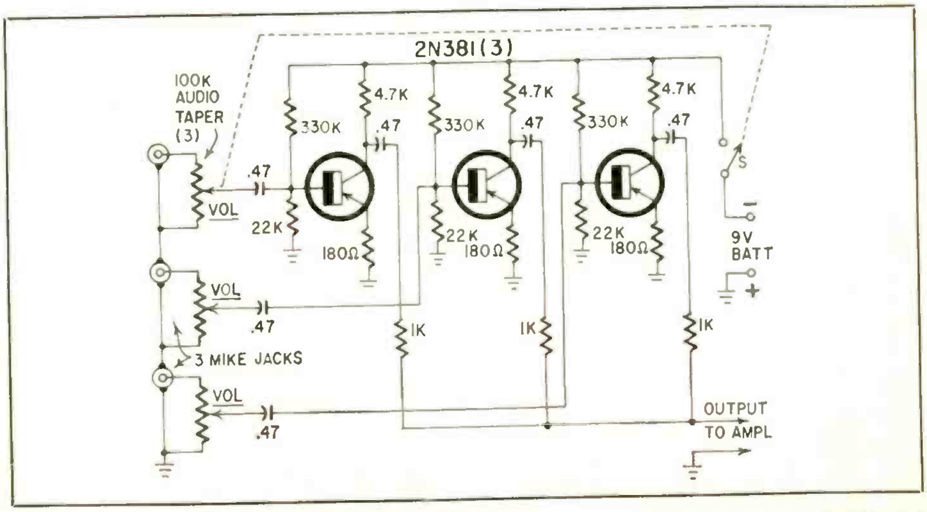
3-CHANNEL MIKE MIXER

Here is a compact transistor mixer for any combination of three ceramic or magnetic microphones or pickups. Humfree, this unit has very good battery life. Drain is less than 4 mA from a 9-volt battery. The mixer provides good input isolation and separate volume controls for each of the three inputs. The overall voltage gain of this circuit is approximately 22 dB, depending on transistor gain.

Construction is simple, and only normal precautions need be taken. The unit can easily be mounted in an enclosure 5 x 2 x 2 in. All parts are standard and readily available from any electronic parts outlet. The coupling capacitors, 0.47-μF 12-V units, are miniature disc ceramics. The cost of the completed unit is about $10.—*Wm. R. Shippee*

[Bass response rolls off quite rapidly, resulting in a speech-only type characteristic good for communications or PA applications. For music, connect a series resistor between each input terminal and the top end of the associated volume control. Adjust the value of resistance to give adequate bass response with acceptable losses.—*Editor*]

END



Solution to R-E Puzzler for June 1967

1 microfaradmeter	13 aquadag
2 metrechon	14 squegger
3 aperiodic	15 neutrodyne
4 quadrupole	16 octode
5 static	17 yellow
6 cesium	18 wavemeter
7 beam	19 compensator
8 module	20 corrosive
9 antihunt	21 parameter
10 constants	22 asympote
11 autodyne	23 graph
12 wattage	24 orthicon
25 microelectronic	

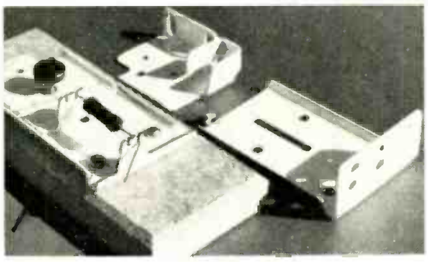
Your rating:

60-64 Well-l-l 76-84 Smart!
68-72 Pretty good. 88-96 Brilliant!
100 Genius!

Tell the truth, did you sneak a peek?

By Edmund A. Braun

TRY THIS ONE



LEAD-BENDING JIG

Precise bending of resistor and capacitor leads to fit circuit boards is no problem with this simple bending jig made from a discarded adjustable drapery-rod bracket. The photo shows a jig and the bracket from which it was made.

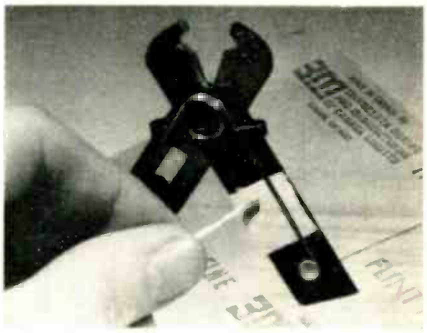
The two parts were modified by sawing off unnecessary parts and by replacing the self-tapping screw with a nut and thumbscrew through the long slot.

Use a ruler or pair of dividers to set the notches in the jig the same distance apart as the holes in the board. To use, center the component in the jig and simultaneously bend both leads.

—Edward A. Bollinger

STRIPPING ENAMELED WIRE

A small square of sandpaper cemented to a wire-stripper handle will insure a quick and convenient way of removing enamel insulation from wire. Enameled wires aren't used often, but when they are it's difficult to strip them.



Use rubber cement to attach the sandpaper so you can remove it when worn out. Leave part of the sandpaper unglued, so it can be folded over to scrape both sides of the wire.

—Robert E. Kelland. END

NEW BOOKS

QUANTUM ELECTRONICS, by John R. Pierce. *Anchor Books, Doubleday & Co., Inc., Garden City, N. Y. 4 x 7 in., 140 pp. Paper, $1.25*

A scientific approach to the fundamentals of transistors and lasers, with not too much mathematics. The treatment isn't really high-brow, although the reading gets a little dull at times. There's a lot of good information here, and it is worth getting through.

CATV SYSTEM MANAGEMENT AND OPERATION, by Robert B. Cooper, Jr. *Tab Books, Drawer D, 18 Frederick Rd., Thurmont, Maryland 21788. 5½ x 8½ in., 256 pp. Plastic mechanical, $12.95*

Could be more aptly titled "How To Plan and Build a CATV System." Covers the history and future of CATV as an industry, plus everything from site surveys and antenna systems through pole agreements through securing financing and choosing equipment. One chapter is devoted to opening and promoting the new system, and another to starting and maintaining public relations. Otherwise, the book is entirely on how to set up a new CATV system.

RADIO ASTRONOMY, by John D. Kraus. *McGraw-Hill Book Co., 330 W. 42 St., New York, N. Y. 10036. 6 x 9 in., 496 pp. Cloth, $13.75*

Informative and easy to read. Plenty of math if you need it, but also well enough written that even the nonmathematical reader can understand what it's all about. Covers the fundamentals of astronomy, then progresses to radio astronomy. Talks about radiotelescope receivers and antennas. The entire last third of the book is taken up by discussions of various radio sources in astronomy. Hundreds of references for further reading. END

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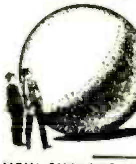

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60,633EH	3	3.75	3.60
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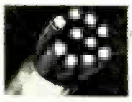

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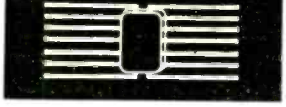

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400	.25	.80	2.00	12.00
600	.35	1.20	2.50	20.00
800	.45	1.50	3.00	
1000	.65		3.50	35.00

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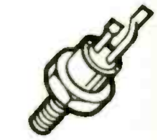
100	.12
200	.15
400	.20
600	.25
800	.35
1000	.50

Top Hat & Epoxy

PRV	AMP
100	.07
200	.09
400	.12
600	.20
800	.25
1000	.50
1200	.65
1400	.85
1600	1.00
1800	1.20

Silicon Control Rectifiers



TO-66 pack | Studs

PRV	3A	7A	20A
50	.35	.50	.80
100	.50	.70	1.35
200	.75	1.05	1.90
300	1.25	1.60	2.45
400	1.50	2.10	2.85
500	1.75	2.80	3.50
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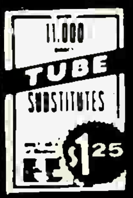

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1L4	6AU5	6CM7	6SA7	7B6	12C5
1T4	6AU6	6CZ5	6SH7	7C5	12CA5
1U4	6AV6	6D6	6SJ7	7N7	12SN7
1X2	6AW8	6DA4	6SK7	7Y4	12SQ7
3BZ6	6AX4	6DE6	6SL7	12AD6	25L6
3DG4	6BA6	6DQ6	6SN7	12AE6	25Z6
5U4	6BC5	6EA7	6SQ7	12AF6	35W4
5U8	6BD6	6EM5	6SR7	12AT7	35Z3
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5Y3	6BJ6	6GH8	6U8	12AX7	24
6A6	6BL7	6H6	6V6	12BA6	27
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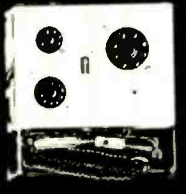

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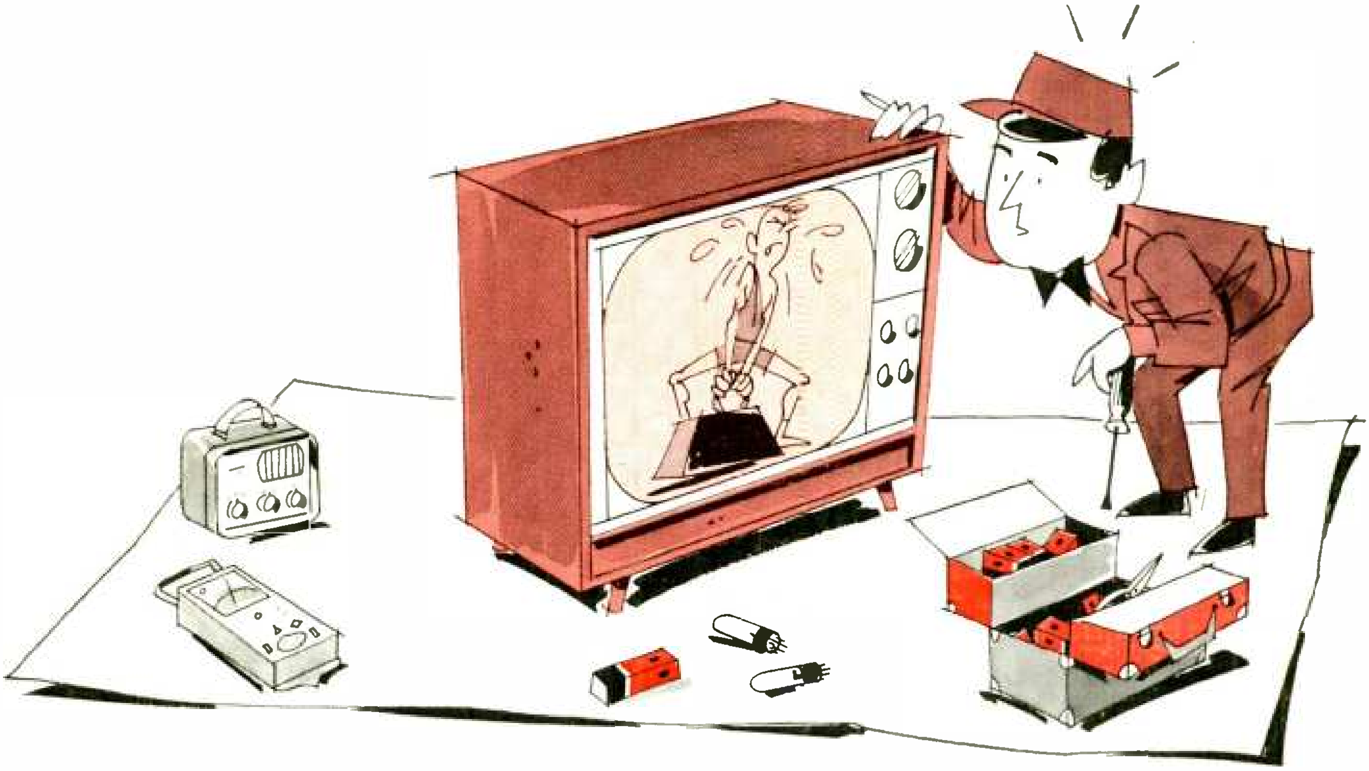
RCA's COLOR TV FASTCHECK #7

WEAK COLOR?



Follow these steps to isolate the trouble area...

If colors lack full saturation, make sure that fine-tuning, brightness and color controls are set correctly. Then determine the receiver section in which signal is attenuated as follows:

1. Apply an rf color-bar signal at the antenna terminals.
2. Connect a scope at the video detector. Check amplitude of the color-bar pulses and sync pulses. They should be approximately the same. If color-bar pulses are attenuated, check for trouble, including poor bandpass, between the antenna terminals and the video detector.
3. If amplitudes are correct, look for trouble in the chroma section, as follows:

   a. Check bar-pulse amplitude at input and output of bandpass amplifier.

   b. Check bar signal at input and output of demodulators and color amplifiers. Note: Trouble in only one of these stages will produce a *shift* in colors, which will show up in the color-bar pattern. Loss of color saturation in the demodulators or color amplifiers, therefore, indicates trouble in a circuit common to the demodulators or color amplifiers.
4. Once the defective stage or section has been found, use voltage or resistance measurements to pinpoint the circuit defect.

This is another in RCA's continuing series of color TV service hints, to help make your job easier. Your RCA tube distributor can also make your job easier, because he's your best source for quality RCA receiving tubes for color TV, as well as for black-and-white TV, radio and hi-fi. You enjoy more customer confidence and satisfaction when you replace with RCA receiving tubes,

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