MASTER

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Radio-Electronics

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A GERNSBACK PUBLICATION

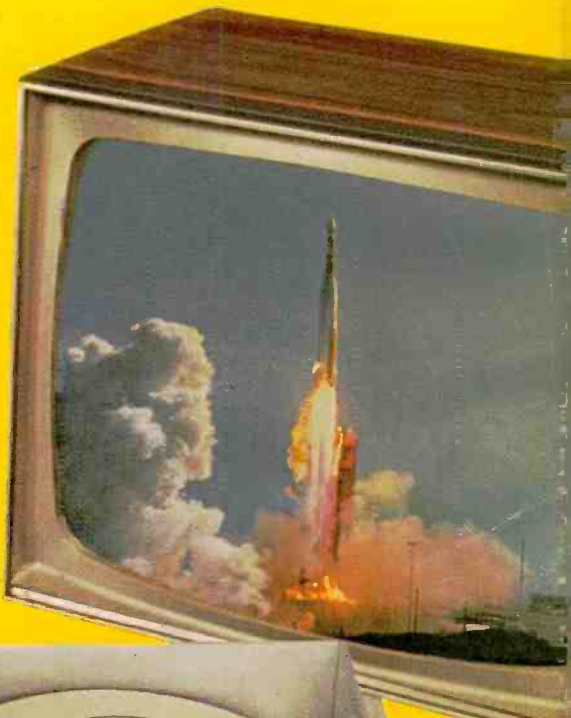
HUGO GERNSBACK Editor-in-chief

SPECIAL ISSUE

SOLID STATE Microelectronics

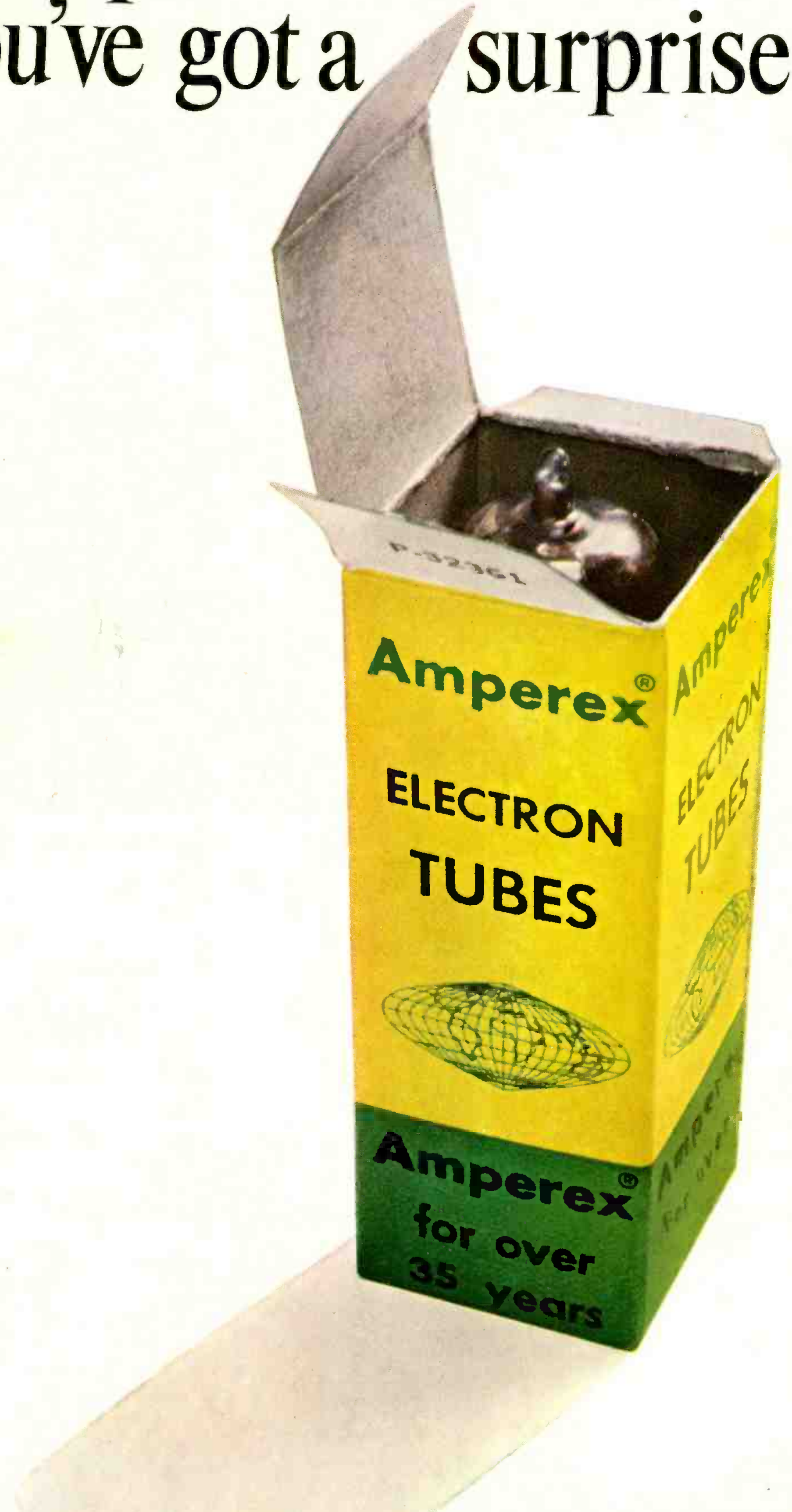
NEW! LOW-COST Color VTR

p38

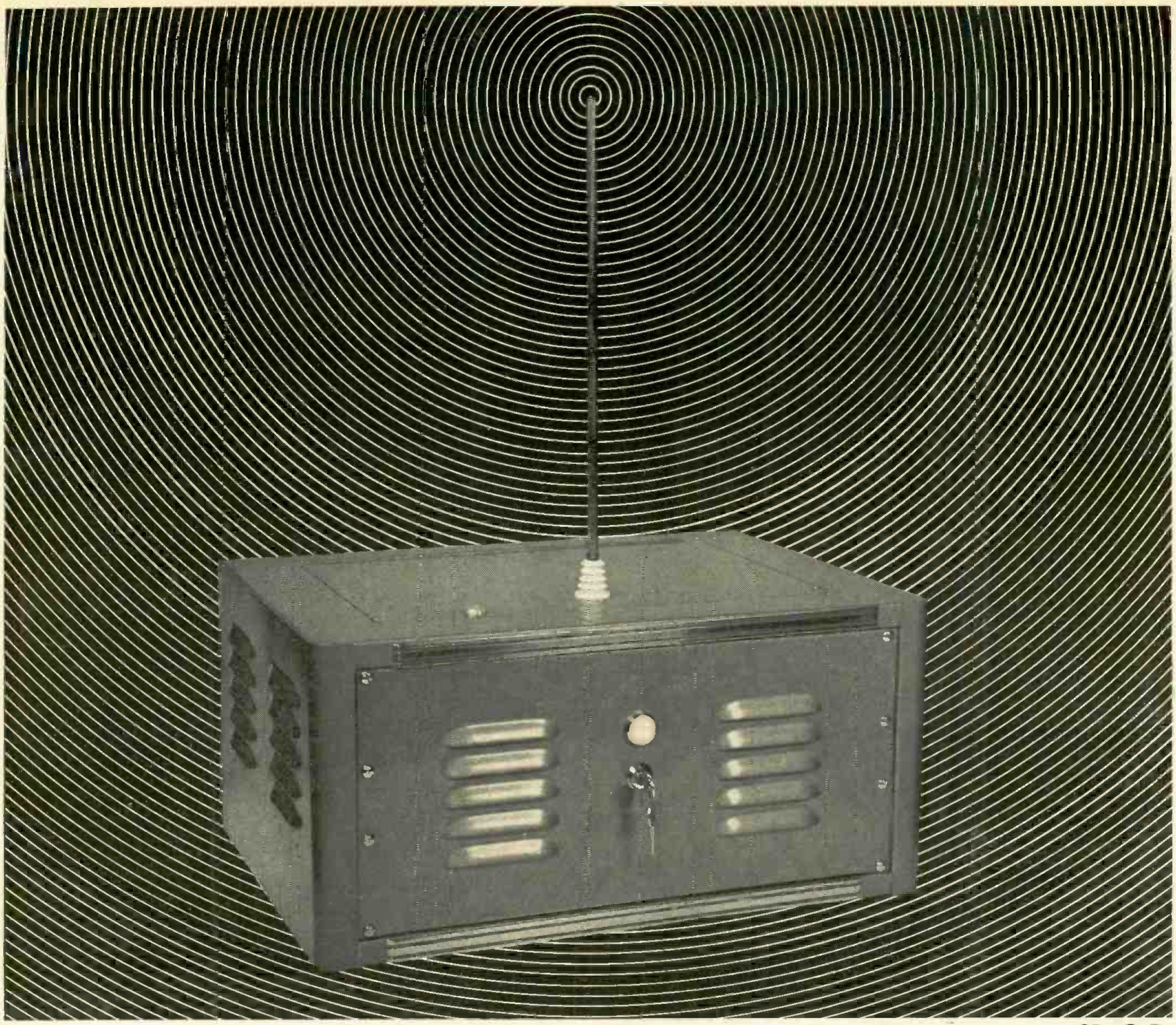


Directory of Low-Cost IC's
Auto-Intruder Alarm to Build
IC and Transistor Circuit Design

If you think all replacement tubes are alike, you've got a surprise coming



Circle 7 on reader's service card



FROM THE EDITOR

Can Electronics Get Much Smaller?

"It is easier for a camel to go through the eye of a needle . . . ." That doesn't sound easy at all, nor was it intended to. We're getting closer and closer every day to trying it in electronic miniaturization. It seems we're reaching the hump, however, and it's time we took a look at what to do next.

There are practical limits to just how small electronic devices can become. At least, there seem to be.

For example, the electronics of a low-powered two-way radio can go on a chip no larger than the head of a pin, but the microphone and speaker require many times that space—their size determines how small a personal communications system can be.

For example, the electronics for an AM–FM tuner and the i.f. strips can be put inside a module no larger than a pilot lamp, and another silicon chip added to it can provide the entire multiplex decoder for FM stereo. But what about the tuned circuits and—more important—the dial itself? Imagine trying to spread 10, 20, or 30 FM stations around the small circumference of that lamp.

For example, the electronics of a stereo preamp can be put in a thimble. But, then, who could adjust the volume, tone, loudness, balance, etc.? Even if controls were miniscule, you'd still need knobs large enough to get a thumb and finger on.

Other limitations are inherent in microelectronics itself. Capacitances of any large size are still very expensive, if not impossible. A watt is a watt, and even at high efficiency there is still plenty of power lost as heat that must be dissipated. Power supplies, even batteries, take up disproportionate space.

Is this the limit of size reduction? Have we reached the ultimate in miniaturizing electronic systems? Not likely. There are still many ways to overcome the present limitations—all that is required is a little different thinking. Here are some examples of what is already in sight.

As efficiencies go higher and higher, a watt of dc power will be converted into almost a full watt of signal power or acoustic power. Result: virtually no heat waste. With efficiency so high, supertiny batteries will last indefinitely and be continually recharged by microscopic cells activated by daylight or artificial light.

Tiny solid-state tuned filters will take the place of bulky LC circuits. Touch-controlled variable tuning and small luminescent cubes with station numbers will replace huge tuning dials. Touch switching, gate-controlled on IC chips, will take the place of panel controls as we know them today.

There will be no need for wiring. An IC transmitter in the stereo cartridge of your turntable will send the sound signals directly to a receiver chip in your preamplifier. Ditto from the preamp to high-efficiency speakers, two small squares that resemble wallpaper, each with its own tiny power amplifier.

You will be able to carry the tuner and control center for the system in your pocket. Tiny phones in your ears, with individual receiving chips, will give you private AM-FM-stereo listening. They will be fed by wireless signals from the preamp-transmitter in your cigarette-pack-sized control unit. At your office, the control center can feed your private system of speakers there. A plug-in short-wave module, about the size of a pencil eraser, will be available for the SWLer. Similar accessories for CB, ham, personal communications, etc., will be available.

The foregoing ideas are merely examples of what's possible. The only real limitations on the size and versatility of electronic devices lie in the minds and imaginations of us in the field of electronics. The limitations we endure now are only obstacles to be overcome.

Forest H Belt

Radio-Electronics

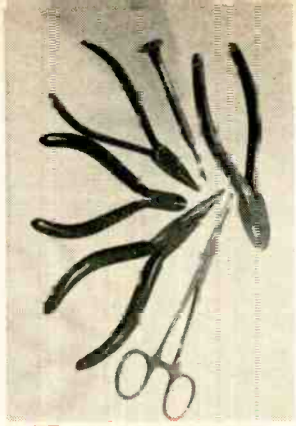
March 1967 VOL. XXXVIII No. 3
Over 55 Years of Electronic Publishing

EDITORIAL

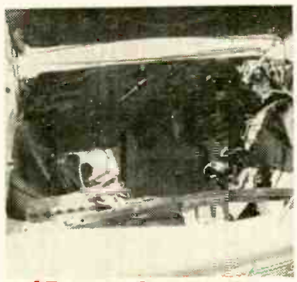
MICROELECTRONICS AND SOLID STATE

GENERAL ELECTRONICS

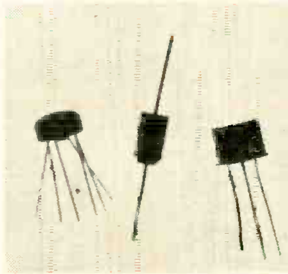
THE DEPARTMENTS



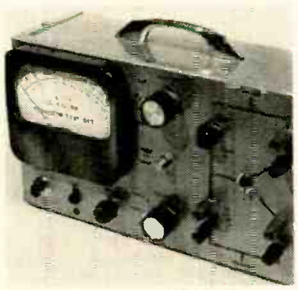
p 35—TINY TV TROUBLE



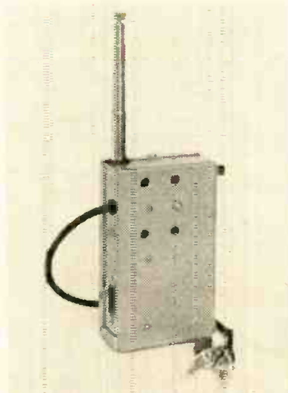
p 47—STOP CAR THEFTS



p 55—EPOXY-CASE XSTRS



p 57—TEST SEMICONS



p 60—CB POWER AMP

p 49—PHOTO LIGHTING

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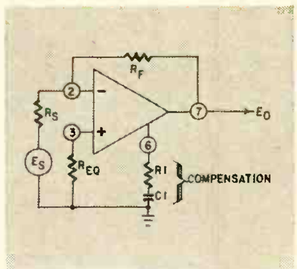
COVER FEATURE

p 38—The color boom has reached the low-cost video tape field. Here's the low-down on the first nonbroadcast color recorder for home, educational and industrial use. It employs a novel technique of preserving chroma information.

DESIGN IC STAGES



p 32—The newest and most flexible electronics building blocks are tiny solid-state chips called integrated circuits. These plug-in signal processors make it easier to assemble the kind of amplifier or receiver you want.

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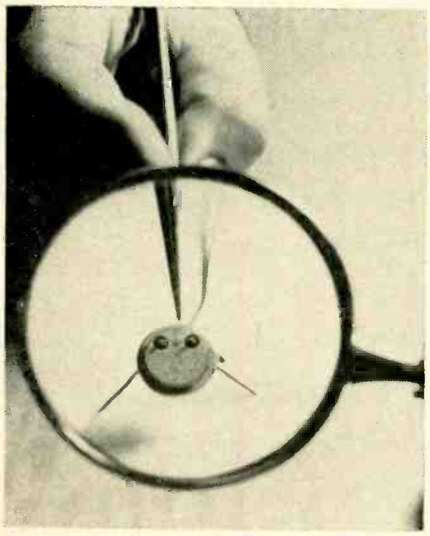
NEWS BRIEFS

MICROWAVE MICROTRANSMITTER

Electronics is getting to sound like science fiction—remember *"The Incredible Shrinking Man"?* Latest near-disappearance: an FM *transmitter* (range 60 MHz–2.5 GHz) slightly larger than a pinhead.



The device—shown in the photo dwarfed by its mounting holder—is made of gallium arsenide. The application of relatively high voltage to the semiconductor, causes *Gunn effect* and microwave emission. Field-effect principle is then used to modulate the microwave carrier. The new device has three terminals, is effectively a junction diode with a modulation gate added.

The tiny transmitter was developed by a team of RCA scientists, who envision hand-held microwave transmitters that would open up a new range of personal-communication possibilities.

SAY AGAIN?

Hearing aids—usually associated with advanced age—may be needed by youngsters before long. According to Robert A. Larabell, who runs an acoustics firm in Phoenix, Ariz., most rock 'n' roll music played in discotheques is simply too loud. The kids don't realize it, but they're doing serious damage to their eardrums.

Continual exposure to high sound levels causes permanent damage to hearing. While most people can tolerate loud sounds if they're brief, few would care for high-level audio for hours at a time. Unfortunately, once your ears adjust to a high sound-pressure level, damage has already begun.

Inside a quiet house late at night, a sound-pressure level (SPL) meter registers about 40 dB. In a business office, the range is from 60 to 70 dB. Factories register from 75 to 85 dB. Larabell has measured *90-95 dB* at 20 feet in front of a teenage rock 'n' roll band. This is roughly equivalent to the sound heard from a riveter 35 feet away. Although the threshold of pain begins at an SPL of 120 dB, ear damage can result from continuous exposure to much lower levels.

Perhaps the next teenage fashion should be a pair of Air Force jet earmuffs.

ENGINEERS STILL EARN MOST

Students who are graduated from engineering colleges this year will be paid an average starting salary of $166 per week. That's the highest beginning wage ever paid to a new diploma holder, and tops all other graduates in business and industry. These estimates are compiled annually in a study of industry hiring practices by Frank S. Endicott, director of placement at Northwestern University. Since 1947—when Endicott's surveys started—engineering graduates have consistently received top starting salaries.

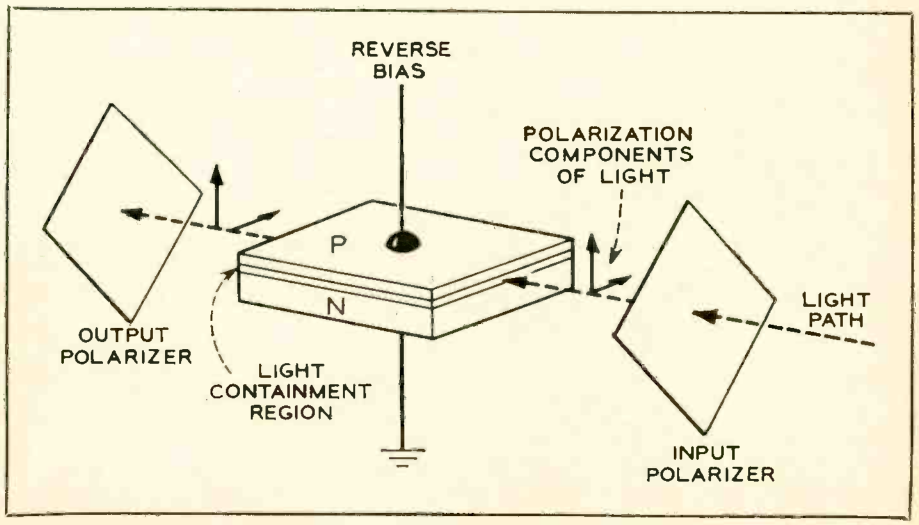
BROADBAND LIGHT MODULATORS

The modulation of a laser beam, for transmitting information, has required much power and hasn't been possible with much bandwidth in the past. Now, Bell Telephone Laboratories scientists have discovered three ways to impress broadband signals on laser beams, using modulating powers of less than 1 watt.

The gallium-phosphide diode is one system (see sketch). Reverse bias is applied to the diode, and an incoming light wave is polarized and focused on the diode's pn junction region. The two polarization components of the light wave then travel at different velocities along the plane of the pn junction. They emerge from the junction out of phase with each other. This is equivalent to phase modulation. Finally, the phase-modulated components are passed through an output polarizer, where PM is converted to AM.

The gallium-phosphide diode can modulate light because of the linear electro-optic effect—which takes place in the diode pn junction when a reverse bias is applied. The semiconductor requires only 1.5 mW of power per MHz of modulation bandwidth.

The second device is a lithium



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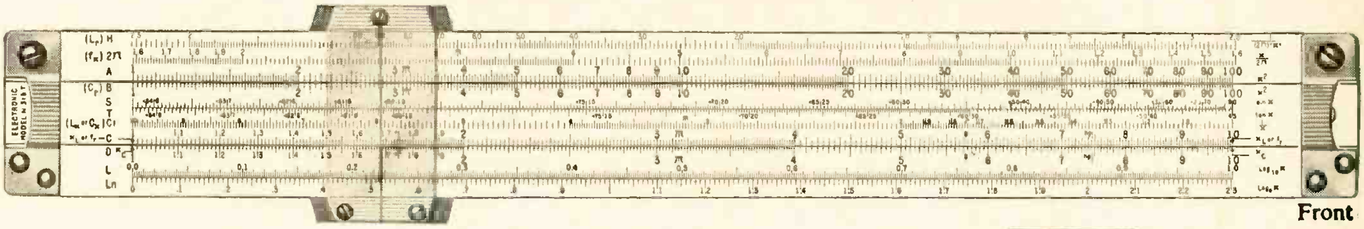
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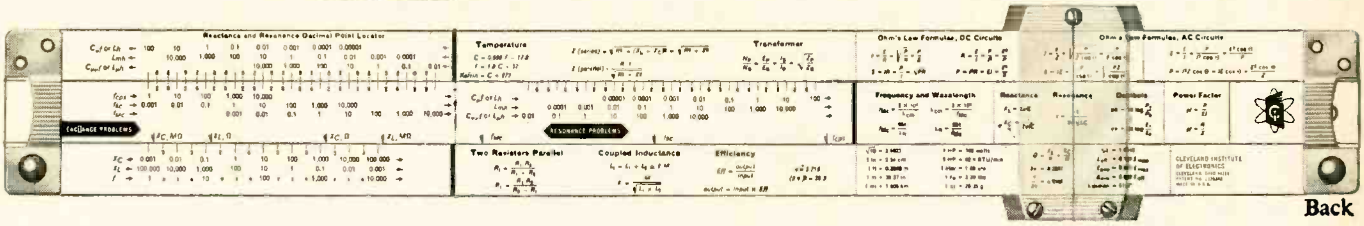
Back

This amazing new "computer in a case" will save you time the very first day. CIE's patented, all-metal 10″ electronics slide rule was designed *specifically* for electronic engineers, technicians, students, radio-TV servicemen and hobbyists. It features special scales for solving reactance, resonance, inductance and AC-DC circuitry problems . . . an exclusive "fast-finder" decimal point locater . . . widely-used formulas and conversion factors for instant reference. And there's all the standard scales you need to do multiplication, division, square roots, logs, etc.

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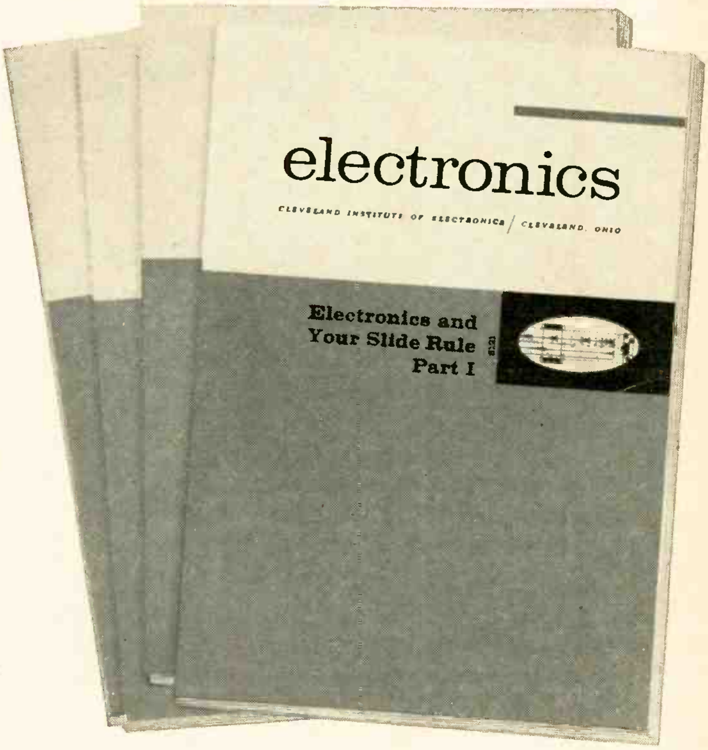

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tantalate electro-optic modulator. It uses a coded sequence of high-speed electrical pulses or digits to modulate an equally fast, uncoded train of light pulses from a helium-neon laser. The lithium tantalate modulator is most useful in pulse-code modulation of digital information; it can handle up to 896 million bits per second.

The third device is an infrared modulator, consisting of a thin rod of gallium-doped yttrium iron garnet. Infrared light waves traveling through the crystal are continuously modulated when the direction of the crystal's internal magnetic field is varied. With power of only 0.1 watt, this device has a bandwidth of 200 MHz.

LASER BRAKE FOR CARS

A new combination of radar and laser techniques could decrease traffic accidents. A solid-state injection laser (see photo), in this case a semiconductor that emits coherent light, is being considered as the heart of a new form of automobile collision-avoidance system. Infrared light from the laser would be bounced off the car ahead —as in a radar system—and would warn if a collision was impending. Warning would be given with lights or audibe signals; if the driver failed to take corrective action, brakes would be applied automatically.

The laser device also has possibilities as fog penetrator, burglar alarm, and private communications system. As the solid-state laser can be modulated, it could be used to aim a narrow beam of infrared "signals" at a receiver. Intercepting the message

continued on page 12

Radio-Electronics

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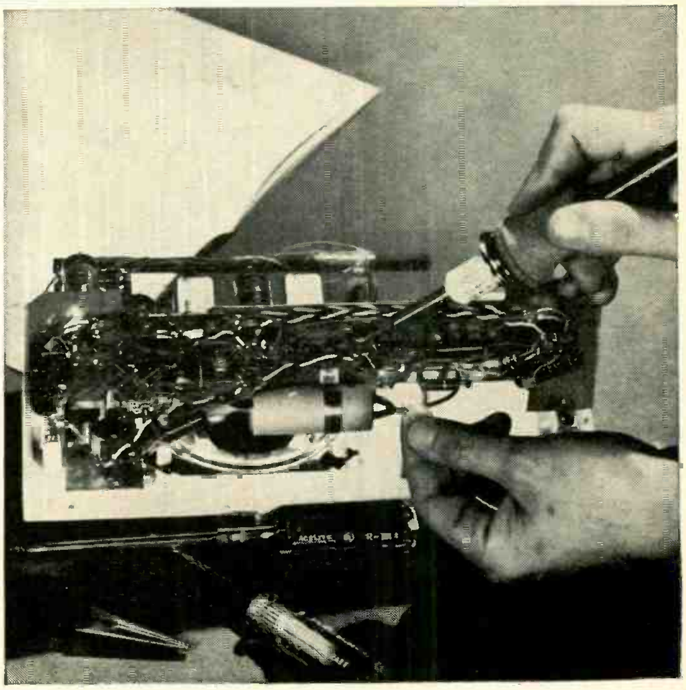


would be nearly impossible without knowing which way the transmitter was aimed.

Devices available from the developer (RCA) include a 50-watt injection-laser diode array about the size of a pencil eraser, a 2-watt unit smaller than a kernel of corn, and IR light emitter close to the size of the head of a pin.

SOLID-STATE RADAR

The transistor trend is making inroads in radar circles. In January 1966, Raytheon offered the first small-boat solid-state radar system. Now two other firms have brought out similar equipment.

Raytheon's model 1900A has a range of 18 miles, uses a 7-inch CRT, and consumes 220 watts. The unit offered by the British firm of Decca Radar, Inc. has 15-mile range, a 6-inch scope, and draws 165 watts. The Kaar Engineering Corp. system ranges up to 16 miles, uses a 10-inch scope display, with 156-watt power consumption.

None of these radar systems are completely solid-state, for the magnetron tube is still used in the transmitter. Substituting transistors for vacuum tubes in supporting circuitry, however, has reduced power consumption considerably. Standard small-boat radars using tubes draw around 500 watts. The use of semiconductors also results in a more rugged unit, better able to withstand the buffeting a ship receives in bad weather.

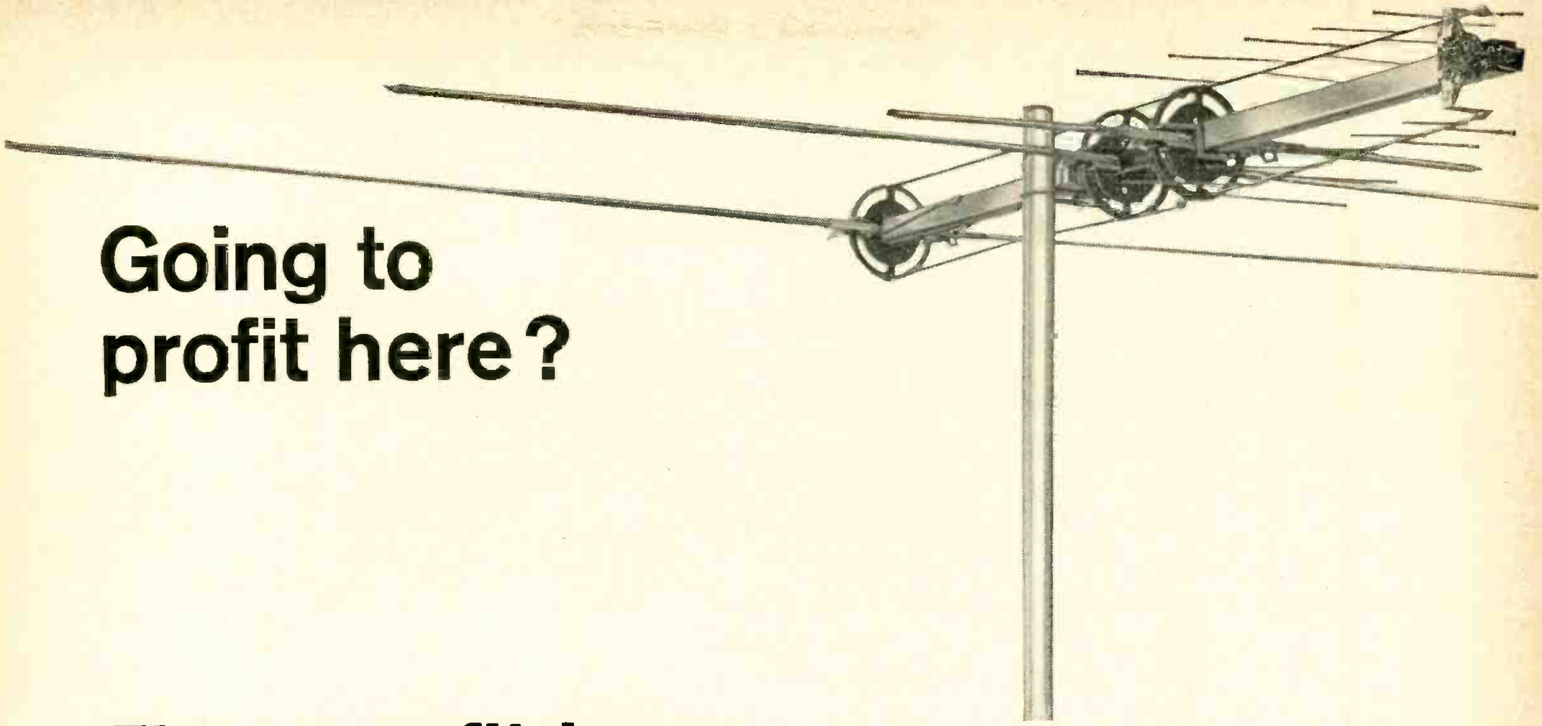
None of these radar systems is cheap. Prices range from $2,400 to $2,850.

TEENAGE STUDENTS DISCOVER SOVIET MISSILE BASE

As a man-made satellite moves across the sky, its radio transmissions change pitch slightly with respect to a fixed receiving station—due to Doppler effect. Using this principle, a group of English school students tracked Russian space launches. Working backward from the orbit records they accumulated, and using a computer, they pinpointed the location of a new missile base unknown to the West until now.

The students have a surplus WW II military radio, a 40-foot antenna, and an ordinary globe of the world. Since 1962, the group of 100 boys and girls—aged 15 to 18—have made 1,700 radio observations, recording the orbits of 75 USSR satellites. In some cases, they have recorded a missile launch before the Soviets have an-

Going to profit here?



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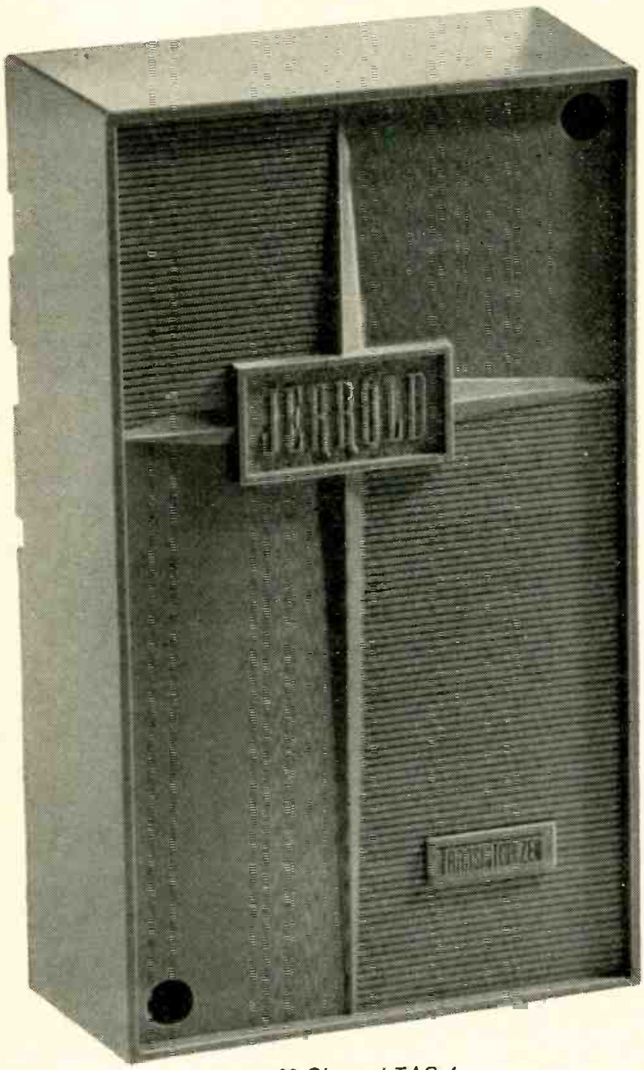

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TAC-4 handles all 82 TV channels (color and black and white) as well as FM. It's the industry's *first* amplified coupler that can handle all present and future channels. Just connect the antenna to the input and then connect four or more sets to the outputs.

TAC-4 is easy to install. Coaxial inputs and outputs make connections simple. Coaxial cable can be run right along with other electric wires—without interference with the signal. And call backs are practically unheard of because the amplifer is completely solid-state.

TAC-4 pleases customers. It's the first truly professional installation for assuring better TV and FM reception anywhere in the house. It's the superior amplifier-coupler to sell with any TV set or antenna such as the Jerrold Pathfinder series. Sell them together. Customers get top reception. You get top profits.

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NEWS BRIEFS continued

nounced it. All data gathered by the students is sent to the British space agency.

It has been known that the Russians have been using space-launch bases at Kapustin Yar and Tyuratam for several years. Site found by the British students is at Plesetsk, 400 miles north of Moscow and the USSR's first far-north space base.

BRIGHTER COLOR TV AHEAD

Rare-earth elements—used in at least one type of color CRT—now make possible a new glass filter plate which improves color brightness and contrast. *Opticolor* (trademark of the manufacturer, Chicago Dial Co.) is laminated to the faceplate of the CRT. The filter absorbs room light while permitting greater transmission of colored light from the screen outward.

Opticolor filters are made with neodymium oxide, a rare earth which contributes the unique ability to produce greater saturation of color hues. The class used is dichroic; its light transmission varies with different colors. (The same type of glass is used for the splitting mirrors in color TV cameras.)

CB REVOCATIONS

The Federal Communications Commission recently revoked the licenses of 12 Class D Citizens' Band radio stations. Several revocations involved more than one violation of FCC rules. In each case, however, the person holding the license had *failed to respond* to at least two official notices of violation and one show-cause order. (Failure to respond to a violation notice within 10 days is *itself* a violation of FCC rules.)

Reasons for the revocations were: five for off-frequency operation, and five for failure to properly identify the station. Three stations were also cited for hobby use, and two for communicating with another station for a period exceeding 5 minutes. Two stations failed to have their licenses posted at the control point.

Other violations: transmission not directed to a specific station; communicating or attempting to communicate over a distance of more than 150 miles; excessive power output; no transmitter identification card; communication concerning the technical capability of radio equipment; antenna over 20 feet in height; no current copy of Part 95 of FCC rules on hand; unauthorized transfer of station control.

END

Correspondence

COMPETITION

Dear Editor:

In your editorial "A Shortage of Service Technicians" in the October 1966 issue you mention that electronics schools find their television and radio courses aren't nearly so popular as their industrial electronics and advanced technology curricula. I find that understandable, because when you finish a radio and television servicing course and start your business you'll soon find out that you are competing with RCA and Sears. Both of these giant corporations compete with the independent serviceman who is trying to make a success of his business.

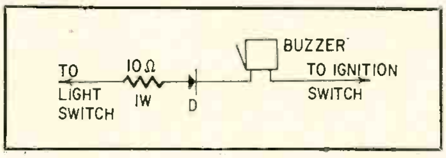
THOMAS GARBLER
Wilkes-Barre, Pa.

ALWAYS A BETTER WAY

Also see June p 14

Dear Editor:

There is an easier solution than the one given in "Lights-on Reminder For Your Car" (RADIO-ELECTRONICS, December 1966, page 53).



Both the diode and resistor can be mounted under the buzzer cover. The diode is reverse-biased with lights off and ignition on. With lights on and ignition off, one side of the buzzer is grounded through the low-resistance ignition system, the diode conducts and the buzzer sounds. When lights and ignition both are either on or off, no potential difference exists. Simply reverse leads for positive-ground cars.

I guess all this explaining is unnecessary to readers of this magazine.

ARNOLD NECKER
Medicine Hat, Alta., Canada

PROBLEMS IN SERVICING

Dear Editor:

Art Margolis' story "Selling the Chassis Overhaul" in the December 1966 issue is quite true and shows a problem of mine in this business. Being handicapped, I drive no service car or pickup truck. My business sign is a homemade one of jigsawed letters.

In my shopping center, a small neat radio-TV sales and service store with two pickup trucks has opened. Most of my service business has gone to them, even though their prices are higher than what I charged. The pickup truck and display has taken over my instruments and knowledge.

The return promise Art mentions, I handle differently. Customers that want their sets fixed in too short a time, I give no guarantee. If the set is left overnight, I can watch the repaired receiver with its cover removed and the picture reflected in a large mirror. When the customers come for their set the next day, I can safely return it with a written guarantee on the repaired circuits.

The serviceman is a superman to the children when he's in time to save their programs. This you expect from kids, but many mothers and dads will not sacrifice an evening of TV so the serviceman can check the receiver on his bench for better results.

As Art Linkletter says, "People are funny."

PETER LEGON
Malden, Mass.

SATISFIED CUSTOMER

Dear Editor:

I have completed building the transistor stereo amplifier with the *C*omplementary *O*ut*P*ut circuit described by Richard J. De Sa in July 1966 RADIO-ELECTRONICS on page 48. The sound is surprisingly top quality. This amplifier was quite easy to build. The only problem was in getting some of the parts. Parcel post to Hawaii is a month away and two items were back-ordered. Well worth waiting for, though, and I want to thank Mr. De Sa and the editors of RADIO-ELECTRONICS.

J. F. HARRIS
Kailu, Kona, Hawaii

END

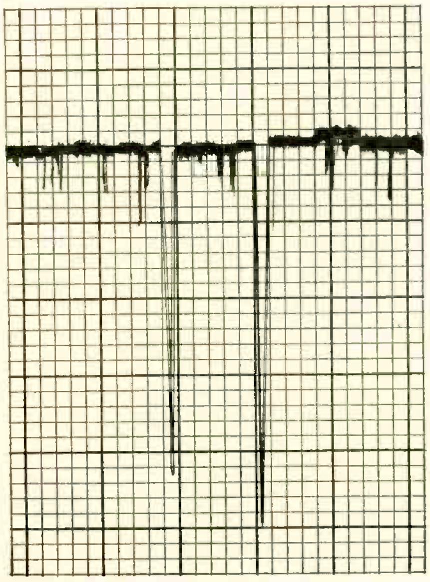
Some plain talk from Kodak about tape:

Uniform magnetic sensitivity

(or the lack thereof)

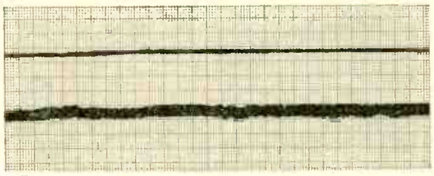
Uniformity for a tape is like kissing babies for a politician. Without it, you're hardly in the running. We take uniformity in all of tape's characteristics very seriously at Kodak. Maybe it's all those years of putting silver emulsions on film that's made us so dedicated to the idea. Uniformity in terms of magnetic sensitivity is one of the most important measures of a tape's performance. Non-uniformity can result in all sorts of bad things like level shifts, instantaneous dropouts, periodic non-uniformity, output variations, distortion, and variations from strip to strip.

Testing for all these possible flaws on a tape is a simple procedure in the lab. Standard industry practice is to record a long wavelength signal (37.5 mil) at a constant input level. The signal from the playback amplifier is then filtered and the output at particular critical wavelengths is permanently charted by a high-speed pen recorder which registers variations on a chart. Instantaneous dropouts caused by foreign matter on the tape surface, for example, would look like this:

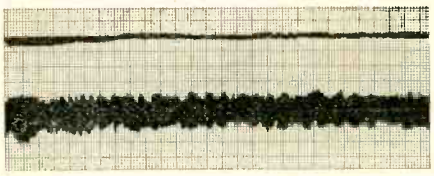


The long and the short of it

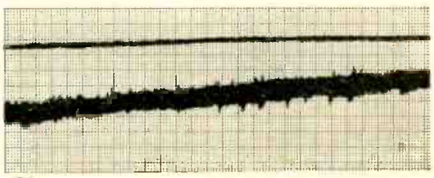
The low frequency procedure gives a good picture of variations in oxide thickness. We take it one step further ... also test for short wavelength—1.0 mil. This helps evaluate surface smoothness and tape-to-head contact. Taken together, they aid in evaluating the level of lubrication, slitting, and oxide binder characteristics. The smoother the lines, the more uniform the magnetic sensitivity. Guess which graph below is KODAK Sound Recording Tape (the other two graphs represent quite reputable brands of other manufacture):



A.



B.



C.

What looks good sounds good

Congratulations if you picked brand A, Kodak tape. It is notably more uniform ... doesn't vary more than ¼ db within the reel . . . no more than ½ db from reel to reel.

You benefit as follows:

1. *Within-reel uniformity.*

(a) Less instantaneous and short term amplitude modulation of the signal, which results in a cleaner signal on playback.

(b) Reduced drift gives less variation in frequency response.

(c) Better uniformity across the strip width (no lengthwise coating lines) results in a more nearly balanced output for stereo recordings.

2. *Reel-to-reel uniformity.*

(a) Better coating uniformity gives a more uniform low-frequency sensitivity. This allows splicing of sections of tape from one reel with tape from other reels without obvious signal level changes.

(b) Better coating uniformity also results in a minimum change in optimum bias which allows the professional to establish an operating bias nearer the optimum bias.

KODAK Sound Recording Tapes are available at most camera, department, and electronic stores. New 24-page comprehensive "Plain Talk" booklet covers all the important aspects of tape performance, and is free on request. Write: Department 940, Eastman Kodak Company, Rochester, N.Y. 14650.

Circle 17 on reader's service card

"He's a good worker. I'd promote him right now if he had more education in electronics."

Could they be talking about you?

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SERVICE CLINIC

In the Shop . . . With Jack

By JACK DARR

TRANSISTORS HAVE BEEN WITH US FOR a long time. Yet too many of us still don't *know* them—know them in the sense that we know vacuum tubes—how to test and repair solid-state circuits. I just went to a service meeting held by one of the bigger TV manufacturers, and they were handing out booklets of transistor *fundamentals!* Worst of all, the men were reading the books as if they'd never seen semiconductors before!

Let's face it; transistors are here, and they're not going to go away if we ignore 'em. So, we might just as well heave a big sigh and get down to dealing with the things. Actually, semiconductors are a blessing in disguise. They're going to eliminate one of our worst financial troubles.

Fact No. 1: There's no such thing as a drug-store transistor tester! Only a *trained technician* can make repairs to transistorized equipment; here *we* are, ready and waiting!

Fact No. 2: Transistor amplifiers and receivers *are* hard to work on. The chassis are small, the parts crammed in so tightly it's hard to see 'em, let alone get one out. The actual repair isn't too difficult, but the gear is hard to test, *if* we use the same old test methods that have worked in bigger equipment.

What do we do? If we can't lick 'em, we join 'em. We get tools and test equipment that will let us troubleshoot solid-state gear with the same ease as vacuum tubes. Oh yes—with magnifying glasses, tiny tools and soldering irons we're in business.

The worst problem lies right between our ears, in our *thinking* about transistor equipment. Quite frankly, we've been snowed with so much complicated stuff about holes, majority carriers, depletion layers, Y-parameters, and even, save the mark, h-parameters, that we're scared! A great deal of this is *design* information. It's necessary to the man building transistor gear, but not to the guy troubleshooting.

Transistors complicated? No! A vacuum tube is about as complex as you can get, yet we work with them every day and think nothing of it. We can work with transistors, if we use the right approach.

Stop worrying about complicated ideas—think of a transistor as a "package of gain." What does a tube do? Amplify a signal. You put a little bit of signal in at the grid and get a lot of signal out at the plate. A transistor does the same thing. You put a little signal in at the base and get a bigger signal out at the collector.

Transistor circuitry is practically all on PC boards. What we need is a test method that eliminates a lot of the hard-to-get-at tests and puts us at the "scene of the crime" faster. There's a way, one of the oldest—signal tracing. Follow the signal through the circuit, find out where it stops, and there's the trouble. Now we make detailed tests, but we've cut the problem down to one transistor and a few small parts!

The method isn't hard. All we need is a test signal and an ouput indicator. A signal generator and a scope are preferable, 'cause they're fast, but the signal source can be one of those penlight-sized noise generators, and the indicator the speaker itself. For something like a tiny radio, try this: Feed an audio signal into the output stage base (input). If it comes through, go on back, one stage at a time, to the detector.

Now switch to a modulated i.f. signal, and work your way back through the i.f.'s, one at a time, until you get to the mixer/oscillator. There, switch to an rf signal, and go on to the antenna. If you've fixed all the troubles you found along the way, the set ought to work. There is only one difference between transistor- and tube-radio testing: always use a blocking capacitor in the signal-generator output lead. That keeps you from upsetting the tiny bias voltages on the transistors.

Hi-fi and stereo amplifiers are even simpler to check. All we need is an audio signal. We can check stage gain at

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.

any point in the circuit by feeding the signal to the input and tracing it through the circuit with an output meter. Incidentally, use a blocking capacitor in the meter circuit, too; a rectifier-type ac voltmeter will often give false indications if dc is present in the circuit! You can read the signal voltage at the input and output of a transistor, check coupling capacitors for opens, and things like that.

The concept of transistor "current amplification" has thrown a lot of us. It shouldn't. A transistor *does* amplify current, yes; so does a tube. Think of it like this—you have a stage working into a *fixed* load. It's usually a resistor, but that makes no difference. If you change the current through the load, how can you keep from changing the *voltage* across it? You can't. So, we can use voltage measurements in testing transistor circuits just as easily as we have in tube circuits all these years. This is especially true of *signal* voltages. They might not be very big in transistor circuits, but they're there, and they do the same things they do in tube circuits!

Also, voltage tests are simpler. You must break the circuit to read current, but you can make voltage tests with the quick jab of a test prod. So, let's use the fastest method. Make voltage tests until we find the trouble, and then, if necessary, make current tests.

Here's one practical hint: I've watched real hot-shots working on transistor circuits, and they all check *emitter* voltage first. Many transistor stages use common-emitter hookups, with a small resistor in the emitter circuit. This resistor is common to both base and collector circuits. If the emitter voltage isn't there at all, or if it's 'way off, there is trouble.

Transistor testing, something that has bugged a lot of us, is getting easier. There are now testers that will check transistors in the circuit, with ease and accuracy. They're actually faster than tube-testers! Three connections, push the button and there you are.

Try this technique yourself; use the one thing that's common to all kinds of equipment—the signal. Doesn't matter what kind of signal—a simple sine wave, a TV signal, sync—anything. As long as you know what it is, you can trace it, and find out what's happening along the way. When you find the place where the signal stops, you're home. Up magnifying glasses and at 'em!

Pushoff adjustments on changer

My Webcor stereo record player will cycle, but the records won't drop. The record holes aren't worn, but the

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- Lightning Arrestor for CB Antennas
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The APRIL 1967 Special Issue of Radio-Electronics

discs won't fall when they should. Should I replace the spindle?—J. P., Springfield, Mass.

Not yet. Cycle the changer by hand with motor off, and watch the "pushoff finger" in the spindle. It should come up and out exactly *flush* with the side of the main spindle. If it won't come out far enough, the record won't be pushed off the holding notch.

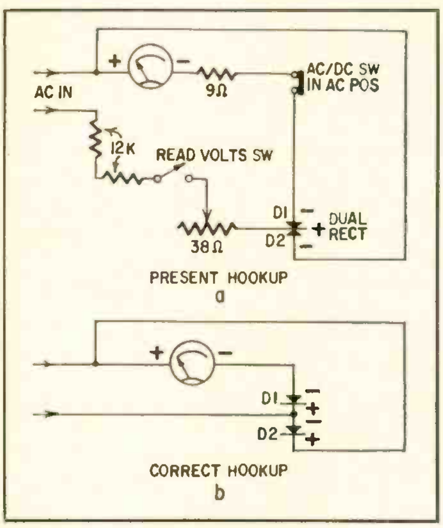
Look underneath; you'll find a slab-headed screw and locknut on the bottom end of the spindle. Loosen the locknut and turn the screw in about half a turn. Recheck cycling by hand, and readjust if necessary to make the pushoff arm come out far enough. If it won't, then replace the spindle. Be sure to retighten the locknut firmly.

Ac meter-rectifier hookups

I have an old volt-amp-wattmeter made by Radio City Products, model 417. The meter rectifier and a couple of resistors have burned up. These were for the 0.25- and 1-amp scales. I replaced the rectifier, and have problems! Now the meter reads only half the line voltage, unless I take one wire from the rectifier off! Also, I can't get the two resistors right; if I get the voltage right on one scale, the other one is off. Help! —F. Z., Cicero, Ill.

Let's take your troubles one at a time. There are several ways of hooking up meter rectifiers. From your sketch of the whole circuit, it looks as if this one used a series-shunt connection, as in Fig. 1-a. Trace the circuit through the meter, and you'll see that one rectifier's in series, rectifying one half-cycle of the applied voltage, while the other rectifier is shunted across the meter.

Now the fun starts. Look at the rectifier *polarities*. If you disconnect the shunt rectifier (D2) what remains is D1, a simple half-wave rectifier, and the

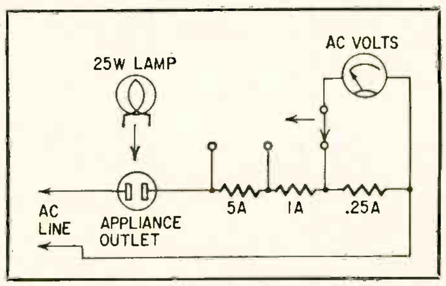


meter reads full line voltage. Connecting D2 produces a "bucking-out" effect! D2 is feeding a *negative* voltage back into the positive terminal of the meter! This E_{neg} cancels much of D1's output, and the meter reads low.

Your present hookup—using only one rectifier—might be okay. Check the voltage reading against another ac voltmeter to see if it is. A tube-tester filament supply is a handy source of variable ac voltage. If your meter doesn't read correctly, get a meter rectifier with a different polarity, as in Fig. 1-b, and try that.

You might be able to use a standard horizontal afc diode, for a test; try it. This will give you the right series-shunt hookup. One rectifier is in series with the meter, and the other shunts the unused half-cycle around the meter (but doesn't cancel the first's output).

Now, for the resistors: your meter is not a true ac ammeter, with the meter in *series* with the circuit. Instead, to read watts you are putting a resistor in series with the circuit, and reading the ac voltage drop across this resistor with the ac voltmeter.

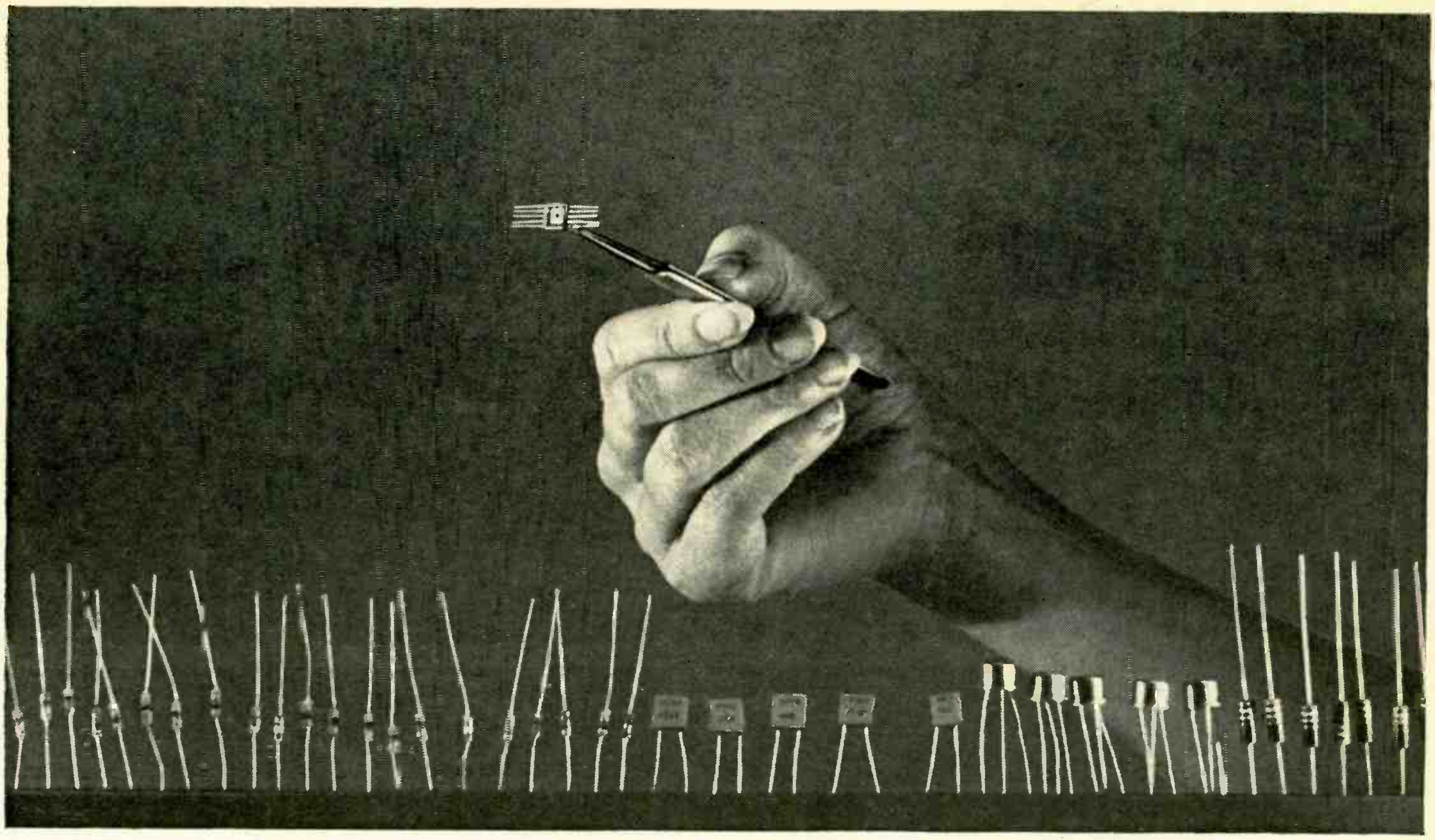


You can "cut and try" this method and get surprisingly close: Put a known load (say, a light bulb) in series with several resistors, across the ac line. (Fig. 2) For the 0.25-amp scale you'll need about 0.25–0.5 ohms, and the 1-amp scale will require about 1 ohm. A guess—better too small than too big!

Try these shunt resistors with a known load; start with the 0.25-ohm resistor, for in this hookup the smallest is in the circuit at all times (like a switch tuner). So, the little one has to be right, first; then you can work your way up the scales. For a small load, use a 117-volt Christmas-tree lamp of, say, 7 watts, which ought to give you a good near-center-scale reading. Use higher-wattage bulbs for the higher ranges. END

Radio-Electronics Is Your Magazine!

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.



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

The "Chip"

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

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

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

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

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

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

Miniature Miracles of Today and Tomorrow

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

And this is only the beginning!

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

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

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

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

New Opportunities for Trained Men

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

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

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

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

How To Get The Training You Need

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

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

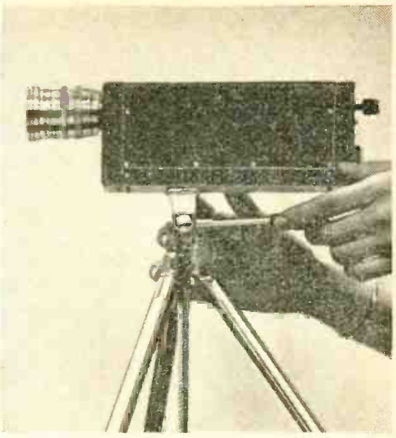
The Cleveland Institute of Electronics has everything you're looking for. We teach only electronics —no other subjects. And our courses are designed especially for home study. We have spent over 30 years perfecting techniques that make learning electronics at home easy, even for those who previously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

Your instructor gives your assignments his undivided personal attention—it's like being the only student in his "class." He not only grades your work, he analyzes it. And he mails back his corrections and comments the same day he gets your lessons, so you read his notations while everything is still fresh in your mind.

Always Up-To-Date

Because of rapid developments in electronics, CIE courses are constantly being revised. Students receive the most recent revised material as they progress through their course. This year, for example, CIE students are receiving exclusive up-to-the-minute lessons in Microminiaturization, Logical Troubleshooting, Laser Theory and Application, Single Sideband Techniques, Pulse Theory and Application, and Boolean Algebra. For this reason CIE courses are invaluable not only to newcomers in Electronics but also for "old timers" who need a refresher course in current developments.

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



Praised by Students Who've Compared

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

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No matter what kind of job you want in electronics, you ought to have your Government FCC License. It's accepted everywhere as proof of your education in electronics. And no wonder—the Government licensing exam is tough. So tough, in fact, that without CIE training, two out of every three men who take the exam fail.

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This has made it possible to back our FCC License courses with this famous Warranty: you *must* pass your FCC exam upon completion of the course or your tuition is refunded in full.

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Designing With Integrated Circuits

It beats using conventional transistors or tubes

THIS ISN'T THE BEST TITLE. *Designing with signal processing packages* would probably be better . . . but the Editor says the title has to catch your eye.

The point is that engineers and experimenters can now work with signal-processing packages rather than discrete components. After years of miniaturization and microminiaturization, one technique has finally won the honors. This technique is the epitaxial/diffusion process by which a complete electronic circuit—in fact, several can be built on a tiny chip of single-crystal (monolithic) silicon.

One reason for the popularity of these monolithic integrated circuits, aside from space economy, is cost economy. RCA's CA3014, for example, is priced at $3.15 each. In it are 12 transistors, 12 diodes, and 15 resistors. Just consider the cost of transistors alone. Some low-cost high-frequency transistors I know of sell at 40¢ each, and each one takes up the same amount of space as the entire CA3014.

Prices keep tumbling at almost unbelievable rates, and companies are packing more and more circuitry into each chip. The process has reached the point where external components cost more than the IC.

One serious question has concerned *who* would decide what goes into the IC. Some said the set maker, others the IC manufacturer. Also, the question has been raised whether microminiaturization would trend to monolithic, thin film, or a hybrid combination. I believe the answers are beginning to emerge.

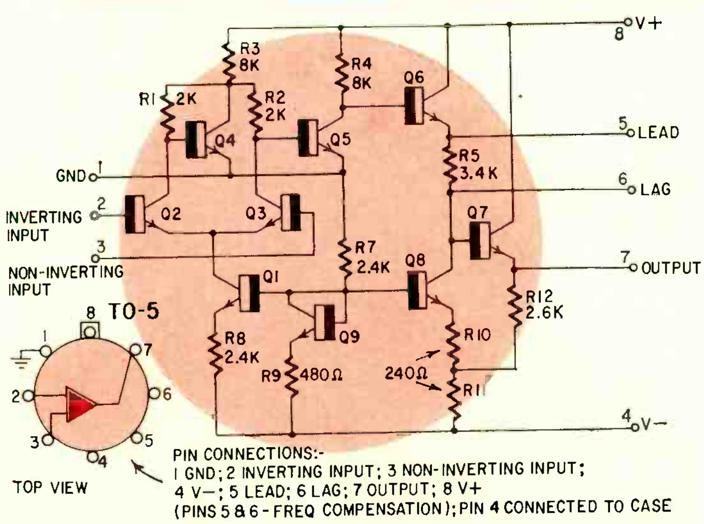
First: the IC manufacturers continue to develop new circuits at quite a rate. The circuits are fairly well standardized and have enough external connections left available that engineers can fit them to system needs. This way, circuits can be mass-produced and engineers can make best use of them.

Second: the trend is definitely to monolithic circuits. The most common packages for IC's are the multiple-pin TO-5 case and the dual-in-line packages (DIP).

Men are needed in the engineering, technical and servicing activities of this IC-oriented industry. The ones who'll be most successful are the innovators with a knack for seeing or making a market for the hundreds of new devices that are becoming available. However, you'll need to understand how designing with IC's differs from developing systems the old way.

Signal-processing-package approach

In the past, the normal approach to circuit design has been first to determine the input to the system and what output is desired. Then transistors of the proper gain, noise level and frequency range were chosen, and a general circuit laid out to achieve the desired result.



Inside An Integrated Circuit: Here is the internal schematic and basing diagram of the Fairchild μA7702C used as a design example in this article. Note absense of capacitors; all stages are direct-coupled. Complementary transistors are also used, for dc level shifting to provide full output swing. The nominal overall open-loop gain of the whole circuit is 2,500.

The next step was to calculate biases, and determine resistor sizes and current requirements. After all this was complete, the circuit was laid out in breadboard fashion for tests to determine whether the circuit would function. Next followed a period of adjusting biases, resistors, capacitors and the like to obtain exactly the result we wanted. We worked mainly with (discrete) *components*, making up a signal-processing package (which might be thought of as one functional block or stage in a complete block diagram).

Now, with integrated circuits, the story is something else. Most of the work is already done. We have a *signal processing package* that can deliver, under certain well defined circumstances, a given output over a given frequency range with a given input. The complete circuit package, often consisting of several stages, is ready to function with the addition of only a few external components and a little power.

So, if you work with IC's, you become a *system designer*. You determine what input will be used and what output you expect. You adjust feedback, compensation and other external configurations to achieve the desired output level and frequency response from the *signal processing package* (IC).

One of my first reactions to all of this was . . . what's left? The IC designers have done all of the work and left me with nothing to do.

If this were really true, there would be *one* device which you would simply stick into the circuit or string together in cascade to get what you want. That simply is not the case. Well over two dozen *low-cost* IC devices are currently available, and each functions a little differently from the next—has more or less gain, uses different power-supply voltages, requires different lead and lag compensation or covers a different band of frequencies.

Linear integrated circuit

Certain manufacturing limitations make it difficult to construct either large capacitors or large resistors on the monolithic chip. Although resistor tolerance values are very broad (in excess of 20%) and values generally low (under 10K), two IC resistors can nevertheless be closely *matched* by placing them near each other on the chip. Differential amplifiers, with low-value but closely matched resistors and matched transistors, are easy to make, so differential inputs are used for IC linear amplifiers more often than single-ended inputs.

A differential amplifier requires two transistors which operate in opposing phase. If a signal is applied to both base terminals of a common-emitter differential amplifier, the output should be zero. How well a differential amplifier cancels a signal applied simultaneously to both input terminals (common-mode signal) is measured by its *common-mode rejection ratio*. In this same circuit, if one of the inputs is held at some fixed voltage and the signal is applied to the other, a "difference" output equal to the input signal times the gain will appear between the collectors.

Most linear IC's use direct coupling between stages to avoid coupling capacitors. Direct coupling also allows operation from dc to whatever upper frequency limit is imposed by other circuit characteristics. Many work well to 30 MHz and above.

Currently available IC's contain various differential-amplifier arrangements with outputs either single-ended or push-pull. Of the more than two dozen low-cost linear IC's listed on page 45, only two use both single-ended input and output.

Breadboarding and design

Some general precautions are useful in handling IC's. Leads from the package should not be bent excessively, especially at the point where they enter the header.

Interconnecting leads for compensation and feedback networks should be kept as short as possible. High gain means stray capacitance and lead inductance can cause parasitic oscillations.

Most of these devices are very rugged. They can stand momentary shorts and reverse voltages that are hard to believe, but I do not recommend mistreating them just to see what they will withstand.

Supplying dc operating power to an IC can sometimes be a little unusual. Some require power supplies with both a negative and a positive output. Most require equal voltages (i.e., +9 and −9) with respect to ground. A few will function acceptably with a single power supply.

In my first days with radio, we had little trouble with power-supply polarities. All voltage measurements were referred to ground. B+ was automatically understood to be a positive voltage with respect to ground. B− was nearly always understood as ground. C− was a voltage negative with respect to ground.

With transistors, it has become the practice to label one power-supply lead negative and the other positive without specifying which, if either, is common or ground. With IC's we must be cautious and return to the habit of labeling or listing all voltages with reference to a common or ground point. We must always specify voltage with respect to some other point in the circuit. Fig. 1 shows how this works.

Some linear IC manufacturers use the symbols V_{EE} and V_{CC} to represent the negative and positive (with respect to ground) supply leads, while others use V+ and V−. So if a spec sheet calls for +9 volts on one terminal and −9 on another, the circuit requires two power sources with the positive lead of one and the negative lead of the other tied to ground. An alternative is an 18-volt supply, with a center tap to ground.

The capacitors shown are connected very close to the power pins of the device. They should be .01- or 0.1-μF disc ceramics, and are used for power-supply decoupling—to prevent parasitics or motorboating that could creep in through feedback via the common power-supply impedance.

Since, as we've said, most linear IC's use the differential configuration, they have two input terminals and for the most part one output terminal. The inputs of many operational amplifiers are labeled "+" and "−". The "+" input will develop an inphase (noninverted) output and the "−" input will cause an inverted output (180° out of phase). They're called inverting and noninverting inputs.

Another factor you'll have to consider is feedback, because that is what controls the gain of an operational amplifier. To explain feedback in an almost oversimplified way, we can say that feedback applied from the output to the inverting (−) terminal will be degenerative and reduce overall gain, while feedback applied from the output to the noninverting (+) terminal will be regenerative and cause oscillation.

So far we have covered the main operating requirements of a linear IC: the power-supply configuration and voltages, power-supply decoupling, input arrangements, output and feedback. Most IC's have other leads available for various purposes. One is frequency-response compensation to adjust the gain-rolloff characteristic for circuit stability. How this *lead and lag* compensation is accomplished will be covered separately. For now, we will consider how the monolithic IC processes the signal as a circuit package.

Designing the stage

Power requirements are determined from data sheets, and the hookup depends on the available power supply (battery or rectified ac). Frequency compensation will be made to obtain the desired frequency response. You can determine gain from the data sheets, so we are left with just a basic input–output stage or package with which to process the signals.

One manufacturer calls the operational amplifier a "circuit-activating device." Input impedance of the amplifier approaches infinity (which is the theoretical value) and output impedance approaches zero. Gain is almost infinite. Operation, therefore, becomes almost completely a function of the input, output and feedback circuits. For practical purposes, a very simplified formula can be used in most applications to secure results as accurate as most external components will allow.

Most IC's in the list on page 45 are not called operational amplifiers but those with differential inputs and single-ended outputs can be treated like operational amplifiers. The first step in designing any stage using IC's should be to specify what we want the stage to accomplish. Let's say we have a 10-mV signal (the output from some phono pickups) that we want to amplify to 1 volt to feed a power amplifier. Two or three transistors might give us good results, but in all probability we wouldn't achieve the con-

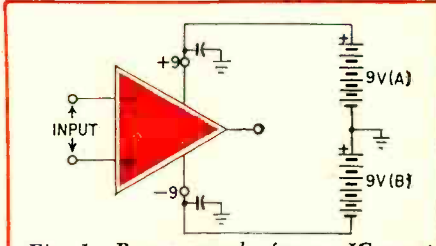


Fig. 1—Power supply for an IC must be referenced to ground as shown.

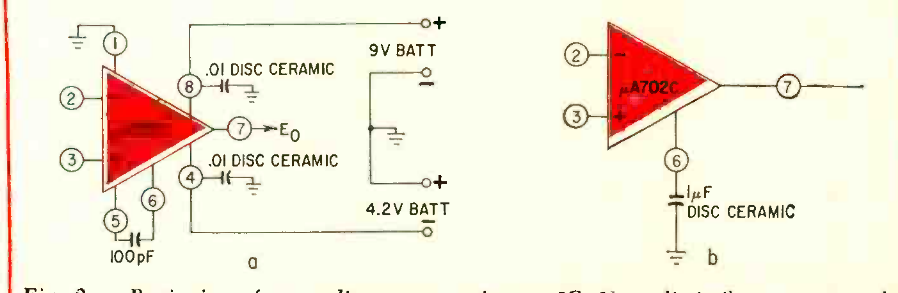


Fig. 2-a—Beginning of an audio preamp using an IC. Note dissimilar power-supply voltages; this is a differential amplifier. b—Capacitor used for low-frequency cut.

sistently low distortion and excellent response we can get from an IC amplifier.

Our amplifier is to be an audio amplifier, so we'll stretch the response to 200 kHz to insure good square-wave response. The Fairchild μA702C (now μA7702C) is a wideband amplifier with high open-loop gain. With lead and lag compensation, it can be treated as an operational amplifier. Design can proceed using the same formulas that apply to operational amplifiers. So let's work out our preamp, using the μA7702C.

First, taking our cue from the manufacturer's specifications and the basing diagram, we will apply power for battery operation—9 volts to pin 8 and −4.2 to pin 4 (Fig. 2-a). Include a pair of small disc ceramic decoupling capacitors right at the pin terminals. The case of the μA7702C is tied to pin 4 electrically, so it will be −4.2 volts "hot" with respect to ground.

Next, pin 1 is to be grounded, says the basing diagram. Pins 5 and 6, we find, are used to compensate the amplifier for stability. The response of most general-purpose operational amplifiers is rolled off at the rate of 6 dB per octave above 350 Hz to insure stable operation. Linear IC's must be rolled off externally.

In the case of the μA7702C, open-loop (no feedback) rolloff starts at 7 MHz and is rated at 12 dB per octave. With gain decreased by feedback and with proper compensation (determined from the data sheets), the amplifier can be used to 30 MHz.

Interaction between gain and rolloff makes it impractical to determine compensation without actually trying the circuit. So, if your amplifier oscillates, one consideration should be the lead–lag rolloff components.

The spec sheet gives some additional information on the μA7702C. For a dc instrumentation amplifier, a single 0.1-μF disc ceramic capacitor from the *lag* terminal (pin 6—Fig. 2-b) to ground will cause correct rolloff for dc and very-low-frequency ac. Instead, since we want wide bandwidth, we use the *lead* terminal (pin 5). A 50- to 100-pF capacitor between pins 5 and 6 will spread the response to the full 30-MHz range.

The response we want for our preamp is 0 to 200 KHz with gain of 100. Compensation values—selected from the data sheets—were originally 2,000 ohms and 100 pF (R1 and C1 in Fig. 3) connected to the *lag* terminal. In the final model, the resistance was reduced to 100 ohms because the amplifier tended to oscillate at low gain. Even with that low value, the amplifier will oscillate at 1 MHz at gain levels below the lowest setting for audible output. Since 1 MHz is not audible, no effort was made to eliminate this oscillation.

The basic idea behind this approach so far has been to design circuitry for those pins that represent auxiliary parts of the circuit, leaving a device that requires only input and output consideration. The easy-to-use formulas in the figures are simplifications of much longer formulas. They ignore the fact that both open-loop gain and input impedance (Z) are always something less than infinity and that output Z is never actually zero.

Particularly interesting is the formula in Fig. 4 that relates closed-loop gain (A_v) to feedback resistance R_F. It turns out that gain equals R_F divided by input resistance R_S. The R_S is usually replaced by Z to indicate impedance. So, if input impedance is 1K, gain will be 10 with a 10K feedback resistor and 100 with a 100K feedback resistor.

If in doubt about the source impedance (R_S), put in a precision resistor at R_F, apply a signal to the amplifier from the source in question, and measure the gain. R_S will equal R_F divided by the gain.

The preamp stage we have achieved (Figs. 4 and 5) has a modest overshoot on the leading edge of a negative-going square wave and, as mentioned earlier, will oscillate at extremely low gain settings. Other than that, square-wave response is very good and sine-wave response is nearly perfect.

Either preamp would drive a power amplifier with more than adequate gain for a variable-reductance cartridge A ceramic cartridge would overdrive the stage, but a lower-value feedback resistor could be used to decrease gain.

With a little reading and experimenting, you will find the world of monolithic integrated circuits infinitely fascinating. The field of low-cost IC's is so new the surface has only been scratched. The rapid commercial advance and adaptation of IC's to consumer products is almost beyond belief. If you learn even the basics of how to design with IC's, you can put them to work in new devices of your own imagination. END

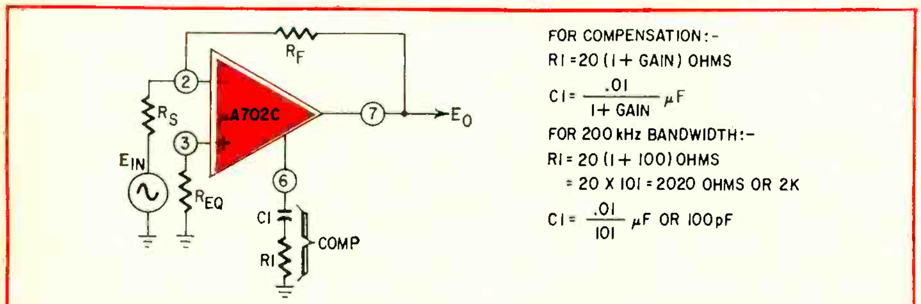


Fig. 3—How to design desired frequency response into the IC audio preamplifier.

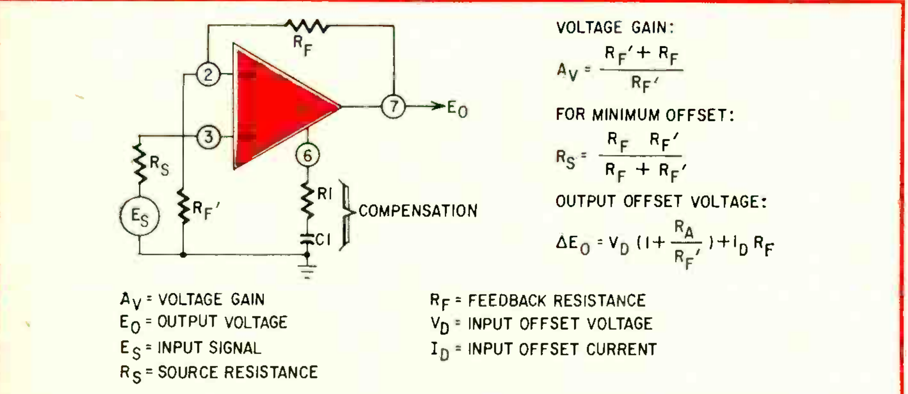


Fig. 4—Circuit gain is a function of feedback, set by value of feedback resistor.

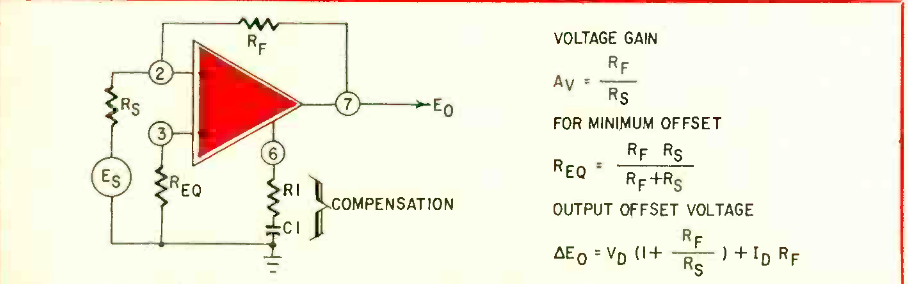


Fig. 5—With this connection, noninverting circuit of Fig. 4 becomes inverting.

Tools and Tests for Transistor TV

Little-bitty video means big-big problems unless you scale those problems down. Think small, work close, and use small-size tools

By JACK DARR

INDISPUTABLE FACT NO. 1: TRANSISTOR TV sets are hard to work on. Indisputable Fact No. 2: Transistor TV sets are here, in growing numbers, and we've *got* to work on 'em.

You can work on them, find trouble, fix them, and make money at it, if you use the right tools and techniques. Here are some practical hints and test methods, worked out at the test bench. Not only from my own bench, but from peeking over the shoulder of some real transistor servicing hot-shots.

The right tools

Big vacuum-tube receivers have lots of chassis room, and using big tools in 'em is no sweat. But tiny solid-state TV means we're going to be working in very close quarters. Tools *have* to be small, so there's room to use them. You can't fix a watch with blacksmith's tools.

The tool most of us use most often to *find* trouble is a test prod, hooked up to a vtvm, vom, scope, etc. Wait a minute? A *vtvm?* For transistors? Yep. Despite what it says in the books about transistors being "current amplifiers," we are still going to take *voltage* readings. Voltage tests are faster, for we don't have to break the circuit to make them. Until someone repeals Ohm's law, the voltage across a circuit will still be in direct proportion to the current. So initial checks, at least, will still be good old voltage measurements.

Getting these readings is the problem. The itsy-bitsy TV's are nearly all printed circuit, and these PC boards are covered with insulation, plastic, varnish, etc. Test prods must have sharp points to get through the coating and into the conductor. Also, the rest of the prod must be well insulated, to prevent accidental shorts to other circuits. Quite a few types of test prod do this work nicely: The photo shows several. The two skinny prods have insulation all the way to the tips. The spring-loaded hook-tip prods can be used two ways: With the hook retracted, they can be used as points to pierce insulation. Push a button on the handle and the little hook comes out; it can be clipped on wires and leads, and will stay.

Next is the old faithful needlepoint, in a standard-size prod. It uses a steel phono needle that can be replaced when it gets dull. The scope probe shown has been insulated with short pieces of spaghetti; it has a spring-clip needle tip.

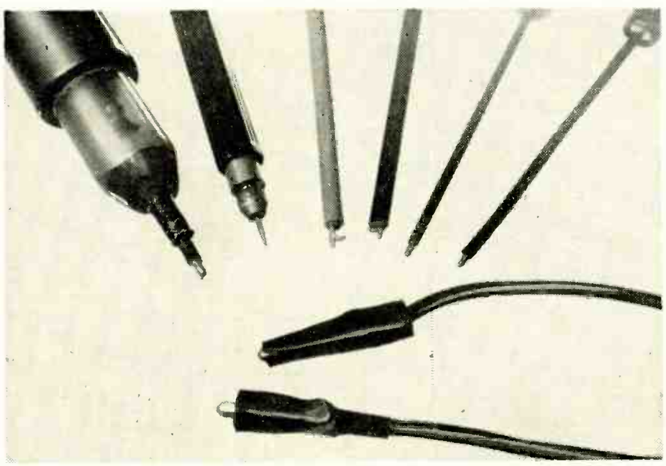
Finally, notice the miniature alligator clips, with the insulators put on both ways. Jumpers using these clips are very useful—you can clip one end to a test point and the other to the tip of a scope probe lying on the bench. This gets away from having to hold or fasten the heavy probe inside the tiny chassis. Alternative: a short lead with clip on one end and long test prod of any type on the other.

Even with small, sharp-pointed prods, there are problems in making test measurements. There are PC boards and there are PC boards. Many makers cleverly clip off all the wire ends at board connections, so that you have nothing but solder blobs to clip to. Some manufacturers leave short pigtails on the leads, which are handy. If there aren't any, add some.

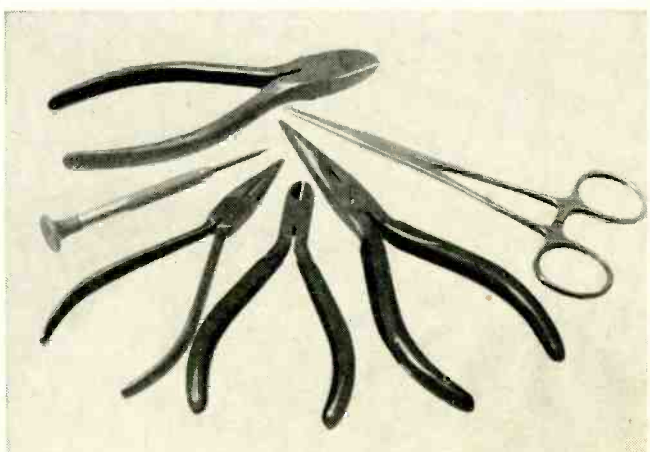
Take about 6 inches of bare No. 20 hookup wire, and tack-solder an end to a place you want to check. When it sets, clip it off leaving about ¼ inch of wire. Then, go on to the next. This takes about 2 to 3 seconds each time, by actual check, and is *very* helpful! If you want to, bend a tiny hook or loop in the end of each pigtail; this'll hold the clips or test prods better. These pigtails can be left on the board without bothering a thing.

Apart from test prods, most hand tools ought to be small, too. See the photo for a few examples. The small diagonals are very useful for getting into tight places; so are the two pairs of small long-noses. The thin locking pliers are copied from surgeon's hemostats and sold in parts houses. They're good for getting into narrow places to retrieve that screw you dropped. They're also nice for holding tiny parts while soldering. The jeweler's screwdriver is a must for the tiny screws used in tiny TV's.

Socket wrenches (nut drivers) are available now as small as $\frac{3}{16}$ inch, and they're sure handy! The nut-holding type can save a great deal of time; an internal magnet or clip holds the screw or nut. A screw-holding screwdriver is another time-saver in places where you have to hold the set with one hand and start a screw with the other. It makes the number of hands and jobs come out



The indispensables of tiny-TV service—small prods and clips.



A tightly crammed chassis requires small tools for service.

even and prevents headaches.

A small soldering iron is a necessity. Get one with a fairly long, thin barrel. Why? Well, there will be lots of times when you have to go deep down inside a narrow space and unsolder a joint, without burning up everything else you pass along the way. You can make up special tips for the old faithful solder gun: Slip a couple of pieces of asbestos or fiberglass tubing over each side, leaving only the tip exposed. This tubing can be bought from appliance dealers or any place where they repair electric irons or heating elements. If you need a longer tip, make one up from a piece of bare No. 4 or No. 6 copper wire. You can use tips as long as 4 inches. Be sure to get good tight connections, because these tips will take a little longer to heat up. An iron shouldn't be *too* hot for this kind of work, anyhow.

Another useful tool is a magnifying lamp. I mean the kind with a circular fluorescent bulb and a good-size magnifying glass in the middle. One of these is also nice for tuner work in big receivers (so are the wee tools!)

There are quite a few other special tools that come in awfully handy for this fine work. Keep a sharp eye out whenever you go to your distributor's store. Few small tools cost more than a buck, and all are worth the price in time saved.

Localize troubles

Now we come to the hard part—finding the trouble. Repairs aren't hard to make, but testing and making the diagnosis is usually rough. One reason is the difficulty in identifying parts and stages. Let's look at a few more indisputable facts. Teeny-weeny receivers *are* very hard to get at. We can't pull the chassis and have all the test points exposed as in older tube sets. So, what to do? We learn to use all the *short-cut tests;* in other words, the ones we should have been using all along! We test the set by checking *functions.* When we find a function that isn't working, then we check *stages.* Eventually we wind up checking *components.* (If you think this is a new method, just remember that some of us were using it back in 1933 on radios!)

There are surprisingly few functions in a TV set: power supply, horizontal and vertical sweep, and the signal paths: video and sound. Five, all told. Look at the set in operation, and question the customer, and you ought to have a good idea of where to begin. Of course, brace yourself for answers like: "Well, it works pretty good but it falls out of horizontal sync about every three days!" (This is what engineers call "worst-case" testing!)

In these sets, service data are very important—as a time-saver in *locating*

Fig. 1—Typical voltage waveform at collector of horizontal-output transistor.

parts, mostly. We still have the old questions, "*What* part is it, and *where* is it on the chassis?" Especially on crowded PC boards, this becomes most important. You can always find a few key points, such as the tuner output or i.f. input, high-voltage lead, video output and so on, but this can take up a lot of time. And you have to identify stages by parts. The idea is to get to the stage with the least delay.

Sometimes, if you don't have the data for one model, you will have it for another made by the same people, and you'll be able to find enough similarity in construction to help out. (This is another practice that goes back to radio days!) Also, you'll find that designers tend to use "typical" circuits in several models. So, even if the rest of the set doesn't match the circuit you need, the horizontal, or the vertical or the sound, etc. may be identical.

You can also get some dope by checking the power supply. Look for big filter capacitors and power rectifiers, by following the ac line cord through the power transformer. You can follow a video signal by starting at the CRT cathode and tracing back. This will get you to the video output transistor, a good checkpoint. Go through this stage and the first video, and you can locate the video detector. Inject an af signal here, watching the screen for bars, and you'll be able to clear up these two stages in short order.

Notice that we're dusting off one of the oldest test methods in the business, outside of dc voltage measurements? Sure, signal tracing. There's a darn good, logical reason for this. Small TV chassis construction makes our favorite disconnect-and-check technique impractical. So, we must locate the defective function first, then make more detailed tests to find the defective stage. *Then* we can start disconnecting and checking! If we don't get a pretty close fix on the cause of the trouble, we're going to be wandering around in that maze of conductors and semiconductors like Hansel and Gretel for a couple of hours!

Signal tracing's not hard. All you need is the right equipment, which you should already have. A signal source can be an rf generator or, better still, a color-bar generator. It makes a lovely unmistakable pattern on the scope and has its own sync. Also, something is needed to detect the presence or absence of the test signal, and that's the scope. Feed the bar-dot signal into the antenna, and follow it through the tuner and i.f. with a crystal-diode (demodulator) probe, then use the direct probe and follow it on to the picture tube. This is also the *only* instrument that will let you check for the presence or absence of sync at any given point in the circuit.

In transistor TV horizontal and vertical output circuits, we're going to *have* to use the scope. We don't have the trapezoid waveforms of tube circuits; transistor sweep outputs are all driven by *shaped pulses!* Fig. 1 shows the horizontal drive pulse from an RCA KCS-154. The ratio of on to off time must be set with a scope, by adjusting the horizontal oscillator coils. This turns out to be a simple job, *if* you follow the instructions. Fortunately for us, most of this circuitry is low-impedance, so the waveforms we get on our service-type scopes are going to look a lot more like the ones on the service data!

Voltage and parts testing

When we locate a stage that isn't working, *then* we stop and make detailed tests: voltages, transistors and other components. As far as operating voltages are concerned, we're still going to have to go to the service data, for a while yet anyhow. There isn't enough standardization to give us a set of "typical voltage readings" for, say, an i.f. amplifier stage, and so on. In imported sets without service data, this is going to be rough. However, the *signal* is still common to all stages, and we can use it to find a stage that isn't working. Then we take the stage apart, and find out what kind of transistor is used. Resistor values can be checked by the color code. Desperate measures, yes, but they're about all we can do.

Valuable hint in transistor-stage checking: A lot of hot-shot transistor men and factory service engineers habitually check the *emitter* voltage first. I mean when they're going through something like an i.f. strip. Fortunately for "our side," common-emitter circuits are very popular. These all have emitter bias resistors—low value—and most are bypassed to help frequency response or control feedback. If the bias is wrong, or particularly if the transistor is shorted, up or down goes the emitter *voltage.* So, if you find a stage with too much or no emitter voltage, stop and check it out. Fig. 2 shows how.

A good transistor tester will be very handy. In-circuit testers will give you an accurate reading on the condition of a transistor *without* taking it out.

The worst headache we've got seems to be that old question, "Is the *transistor* good?" If we know this, then we can go on to other stages, or stop and check into this one: resistors, voltages, etc.

In these solid-state circuits, you can use our old favorite method, parts substitution, but you'll have to change the procedure a little. *Don't* bridge filter capacitors, etc., with *power on*. You'll take the chance of causing a current surge or voltage spike, either of which can pop a perfectly good transistor in a split second. Since transistor stuff has no warmup period, you're not going to lose time by turning it off, clipping the test part in and then turning it back on. A pair of 6-inch test leads with miniature clips is very handy; clip to the capacitor, and then to the circuit. Leave the big, heavy capacitor on the bench out of the way. If you use a "parts substitutor," as I do, you can change the big alligator clips that came on it to the miniature type. The little clips are safer.

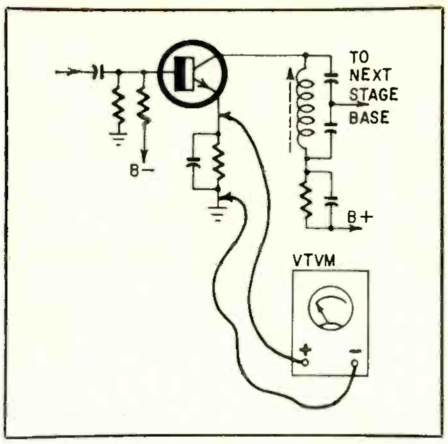


Fig. 2—In a common-emitter i.f. amplifier, check emitter voltage first. If it's too high or absent, the transistor's bad.

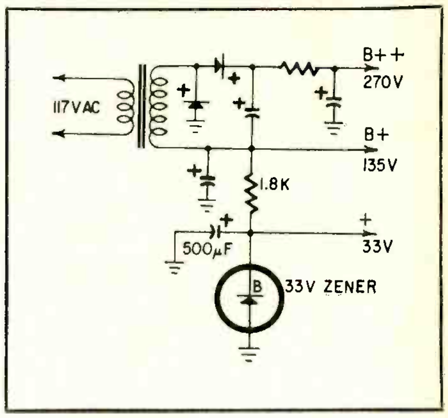


Fig. 3—A solid-state power supply for a solid-state receiver. Note the two B+ voltages that aren't regulated. The 33-volt line is direct-regulated by a Zener.

The common problem

In better transistor TV sets, you'll find some kind of voltage regulation in the power supply. The voltages will be different, but the principles and tests are the same as for any power supply. Some use Zener diode regulation, as in Fig. 3. Others use transistor regulators. In some cases, you'll even find circuits with series regulator transistors, controlled by a separate error-amplifier transistor. Its emitter is usually clamped by a reference Zener, as in Fig. 4. Also, you'll find this same type of circuit with a higher-voltage Zener and a regulated 12 volts taken off the reference diode.

Basically, all these regulators work the same. They put the collector–emitter junction of a power transistor in series with the supply line. Then, the supply voltage is regulated by the variation in the resistance of this junction—in other words, the current flow through it. Current flow is controlled by the base *voltage* (the bias), which comes from a tap on a voltage divider across the output.

When the regulated voltage goes down, due to heavier current drain, the base voltage of the error-amplifier transistor changes. This makes the bias of the regulator transistor change and allow more current to flow; the voltage comes back up. Notice that we didn't mention any polarity of this change; you'll find both npn and pnp transistors used, and the voltages will be opposite in polarity. If you want to check up on other circuits, look in RCA's *Transistor Manual SC-10*, pages 292, 293 and 294. Lots of regulators there.

The control action of a regulator circuit can be made very fast. So fast, in fact, that it will actually serve as a filter! It will not only remove slow voltage changes, but also take out 60- or 120-Hz ripple. You'll find some of these circuits called *capacitance multipliers* because they act like very large filter capacitors.

Voltage regulators are simple to test—just read output voltage. If it's the rated value, it's okay. If you have any doubts, move the voltage-adjust control and see if the output voltage goes up and down. Alternately, vary the ac input voltage to the power transformer and see if the regulated output stays at the right value.

If you suspect the regulator, disconnect the load, and take a reading. The open-circuit voltage should be exactly the same as the full-load voltage. These regulators will hold the voltage up even if there is a small leakage in the load.

However, if there is bad leakage or a dead short, such as a shorted transistor somewhere in the load, the circuit breaker or fuse will usually kick out. Disconnecting the loads one at a time and resetting the breaker each time will tell you. If the voltage comes back up to normal, then there's a short in the load. Current measurements in the various high-current circuits, the vertical and horizontal sweeps and the audio output, will usually fix the cause. The most common cause is one or more shorted transistors. Be sure to check out all the bias resistors *before* you shove a new transistor into the circuit! Most transistor shorts will burn up the emitter resistor.

To check a Zener diode, just read the voltage across it. The Zener voltage will be given in the parts list, or check the schematic for the value. You can check a Zener for open circuits with an ohmmeter. Or vary the voltage-adjust control of the regulator, while checking the voltage directly across the Zener. If this voltage *changes*, look out. The Zener is probably open. You'll find Zeners listed in catalogues by the nominal or working voltage, from about 1.2 volts on up.

So, there you are. To sum up, get the correct-size tools. Learn to use localizing tests, to first pin down the trouble *area*, then the individual stage, and finally parts. It'll be rough for a while, but we'll probably think nothing of it in a few years! [*We'll have new problems to worry about then.—Editor*] END

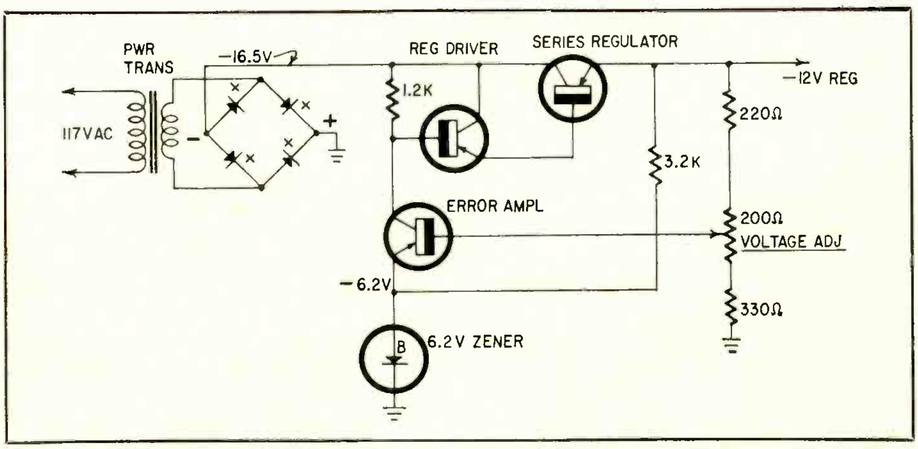


Fig. 4—This three-transistor voltage regulator also acts as an electronic ac ripple filter. The Zener provides a reference voltage for the emitter of the error amplifier.

A PORTABLE COLOR RECORDER

Newest type of helical-scan video tape machine has been colorized **By JOE ROIZEN***

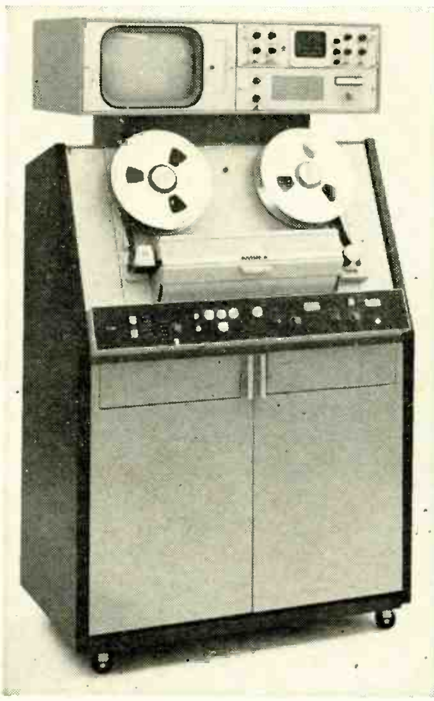
RECORDING COLOR TELEVISION SIGNALS on magnetic tape has been practical since 1958 when the first compatible color broadcast recorders went into service. These transverse studio machines use four heads which rotate at right angles to tape travel (see Fig. 1). The machines also contain very complex circuitry and time-base correction devices. The circuits are necessary to achieve studio-quality NTSC playbacks that meet FCC specifications for on-the-air transmission; such VTR's (video tape recorders) range in price from $40,000 to $100,000.

The development of inexpensive helical videotape recorders (Fig. 2) for monochrome industrial and home applications, coupled with the current color boom, has led to investigations into relatively simple, inexpensive ways to colorize these recorders. The *pilot-carrier* principle has proved a suitable system. Modifications to a normal monochrome recorder (Ampex VR-7000) and a home color receiver make it possible to record and play back color programs with a fidelity approximately equal to off-air home reception.

The time-base problem

The NTSC color signal is composed of interleaved monochrome and chrominance signals amplitude-modulated on an rf carrier. The monochrome portion of the video signal requires only that the horizontal sync coming from tape have less than a 0.15% per sec^2 rate change for stable monitor images. This is a fairly large and easy-to-meet requirement for modern videotape recorders with head-drum servos. The chrominance portion, however, has a subcarrier signal of approximately 3.58 MHz. The instantaneous phase of this subcarrier determines hue in the reproduced image. One cycle of the subcarrier (360°) has a 0.279-μsec period, and a 10° error in subcarrier phase will produce a noticeable hue shift. 10° represents only about 8 nsec. Allowing for the accumulation of record and playback errors, a time base of better than 4 nsec is needed to reproduce faithful color pictures. Such an extremely fine time base is not easy to attain.

Any rotating mechanism is subject to undesirable movement due to mechanical and electrical eccentricities, dynamic imbalance, walking bearings, etc. The head-drum assembly in a VTR will normally display such variations in angular velocity as a time-base displacement of the reproduced signal. A monochrome picture may exhibit slight jitter, which is usually masked by the flywheel effect of the horizontal sync circuit of the home receiver. But when color is added, the rotating-head displacements show up as constant changes in subcarrier phase and the image looks as though it has lost color synchronization.



A typical broadcast video tape recorder.

The pilot-carrier principle

The composite color signal used for recording in the VR-7000-A (the color version of the VR-7000) is also fed to a burst separator which phase-locks a crystal oscillator running at the color subcarrier frequency (see Fig. 3). The output of the crystal oscillator is divided by 7 in a tuned circuit that yields 511 kHz, as shown in Fig. 4. The 511 kHz is then multiplexed at a 5% level onto the FM signal applied to the recording head. The current through the head then has a 5% pilot-carrier content. The level must be high enough to be detectable in the playback circuits yet low enough to minimize interference visibility in the reproduced image.

In playback (Fig. 5) the 511-kHz signal is recovered at the head preamp output, and a bandpass filter isolates it from the FM signal carrying the video information. Two limiters amplify and clip the signal to a uniform level; the pulses now drive a Schmitt trigger whose square-wave output goes to a second bandpass filter centered at 3.58 MHz, the 7th harmonic of the 511-kHz pilot carrier. The 3.58 MHz is amplified and fed out of the recorder to the chrominance demodulation circuits of the modified home receiver. The set's own quadrature circuits form the 0° and 90° signals to decode the color information.

Since the pilot-carrier signal is subject to the same time-base displacement errors that the composite video signal is experiencing, the time relationship be-

*Ampex Corp.

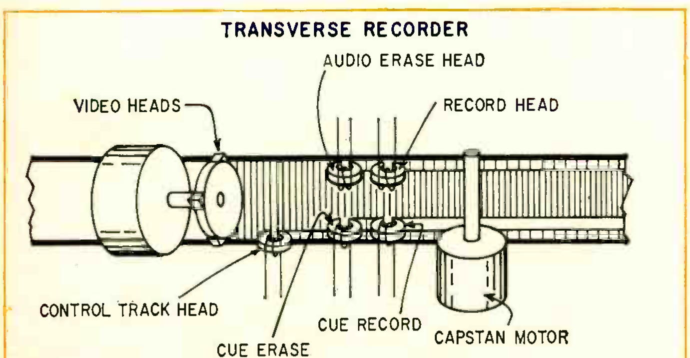


Fig. 1—Broadcast-quality VTR uses transverse scanning.

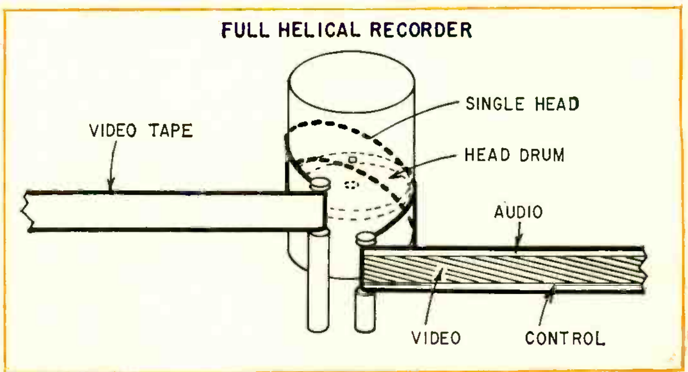


Fig. 2—Standard industrial video recorder has helical scan.

Ampex VR-7000-A can record and play back tapes in either color or black and white.

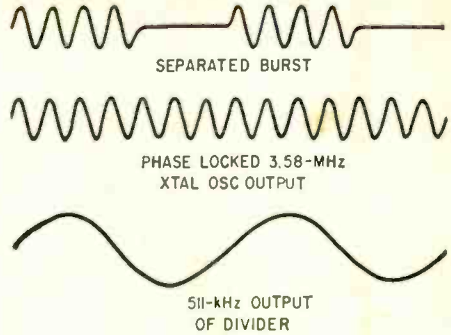


Fig. 4—The burst-to-pilot relationship.

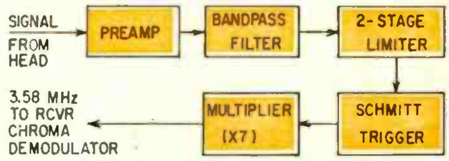


Fig. 5—In playback, pilot produces burst.

tween the pilot carrier and the desired signal remains constant. Hence the color signal can be decoded with reasonable time-base accuracy. The local oscillator in the color receiver is temporarily deactivated during VTR playback.

Recorder operation

The signal system of the VR-7000-A (Fig. 6) must be capable of handling a bandwidth of at least 4.2 MHz to not attenuate the color sidebands. To eliminate unwanted noise, spurious high-frequency signals, etc., the input is filtered by a phase-linear 4.5-MHz low-pass filter network.

A fast-switching multivibrator-type modulator converts the video signal to FM. The carrier and deviation frequencies are somewhat elevated from their monochrome counterparts to minimize intermodulation effects between the FM signals and the high-energy color subcarrier (Fig. 7). The modulator operates between 5.5 MHz at sync tip to 6.6 MHz at peak white. A rising pre-emphasis going up to 14 dB at the color subcarrier improves signal-to-noise ratio and differential gain and phase. The FM signal goes to a head-driver amplifier which provides a constant-current source to the recording head up to 15 MHz. A rotating transformer with an 8-to-1 ratio transfers the amplifier output to the transducer. A 50-microinch head gap is employed.

In playback (Fig. 8) a low-impedance preamp gives a flat frequency response. Aperture correction and equalization are applied to the FM signal before 50 dB of shunt limiters eliminate variations in signal amplitudes.

The output of the limiter is a constant-amplitude FM signal. A pulse-count detector and a 4.2-MHz phase-linear low-pass filter convert the signal back to video and remove residual carrier and deviation components. The output amplifier feeds two 75-ohm outputs, and the monitor (receiver) must be "jeeped" (rf and i.f. stages bypassed) to provide direct access to the video circuits.

Further development of a heterodyne signal-processing system will eliminate the need for modifying the home receiver. At that time it will be possible to modulate the composite video signal on a carrier and feed it into the set through the antenna terminals on an unused channel.

A color-kill circuit in the VR-7000-A detects the presence of bursts on the input signal and activates the pilot carrier in the record mode. If no burst is present, the pilot carrier is shut off so that the recording will not contain the 511-kHz signal. Under certain background conditions, faint vertical lines can be seen in the playback image due to interference from the pilot carrier. The level, however, is not high enough to be objectionable and with normal image conditions, is not noticeable.

The colorized VR-7000-A produces acceptable color pictures for most non-broadcast uses, such as educational, industrial and home applications. END

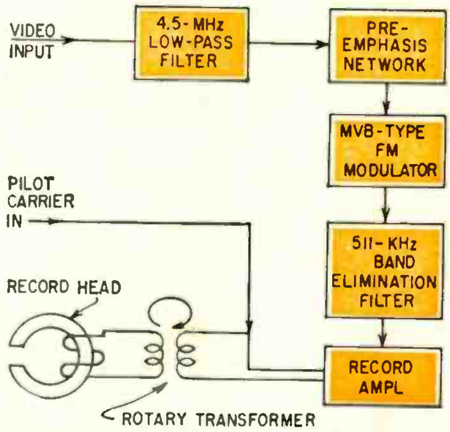


Fig. 6—The VR-7000-A in recording mode.

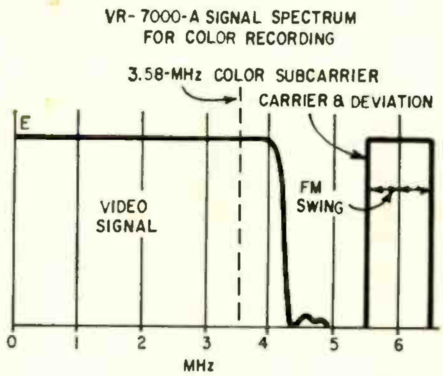


Fig. 7—The color recording bandwidth.

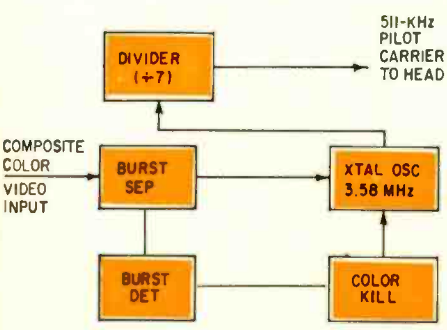


Fig. 3—Pilot carrier is manufactured from the 3.58-MHz reference-oscillator signal during the recording process.

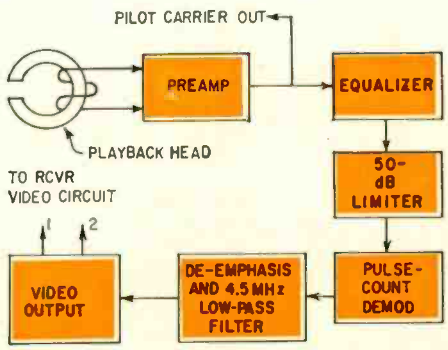


Fig. 8—Playback function of VR-7000-A.

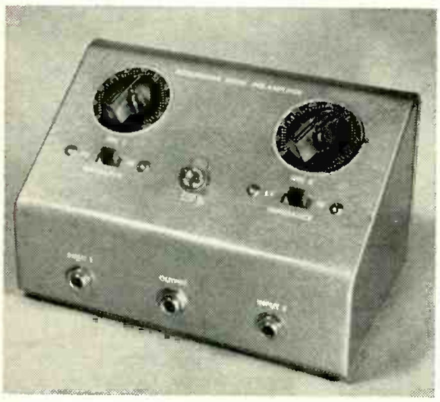
High-Impedance Transistor Mixer

How to convert an older transistor mixer for use with hi-Z mikes—or work up your own mixer design

By W. FORD LEHMAN

THE CIRCUIT OF FIG. 1 SHOWS A SIMPLE, basic way of making a transistor show a high impedance to an audio source. This *emitter-follower* (or common-collector) circuit is the semiconductor version of the tube *cathode follower* (common plate). Its input impedance is roughly the value of the emitter resistance (R3 in Fig. 1) multiplied by the current gain (beta) of the transistor. If the follower circuit works into a load much greater (10 or 20 times) than the value of R3, the input impedance of the follower stage can be between ¼ and ½ megohm, shunted by base-bias resistor R1. Larger values are possible with high-gain, low-leakage transistors and high values of emitter and base resistance.

The voltage gain of the follower circuit is less than 1, but not *much* less.



Ordinarily, that's a small sacrifice for winning a higher input impedance.

I first used this particular circuit with a two-channel mixer described in the March 1963 RADIO-ELECTRONICS. The mixer circuit supplied plenty of gain, but its input impedance was only 1,000 ohms—too low for many audio signal sources. Adding this follower circuit solved that problem.

The unit I built, shown in the photos, has switches for cutting the emitter follower out of the circuit so that the mixer can be used as originally intended—with low-impedance sources. Any three-pole double-throw switch will do (I used four-pole double-throw slide switches, Continental-Wirt G342). I made a dummy panel for the controls, jacks and switches, so the "works" of the mixer are self-contained and can be removed from the cabinet without a great deal of fuss.

My particular application for the mixer was to blend the separate bass and treble pickups on my accordion for feeding to a monaural tape recorder. But the circuit is equally useful for any recording or PA job in which you want to mix two signal sources.

[*Editor's note*: If you can tolerate the 10%-or-so signal-voltage loss from the emitter follower, you can make an even simpler mixer as shown in Fig. 2. An unlimited number of inputs can be tied together this way, but the values of all the mixer pots should be the same, as should the values of the isolating resistors. If you use an emitter follower at each input, you have a mixer with medium-high-impedance inputs and a medium-low-impedance output. That's ideal for many operations.

Noise from transistors and resistors may make this gainless circuit impractical for high-quality work with low-output microphones. It's best to stick to fairly high-output crystal or dynamic mikes, or high-level sources like the outputs of tuners, tape recorders or crystal phono pickups.] END

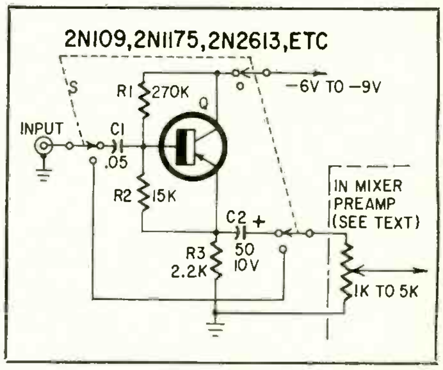


Fig. 1—Circuit of an emitter follower the author used to step up input impedance of a mixer described in R-E for March 1963.

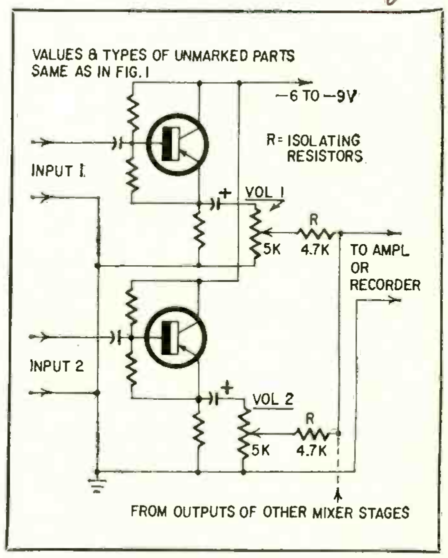
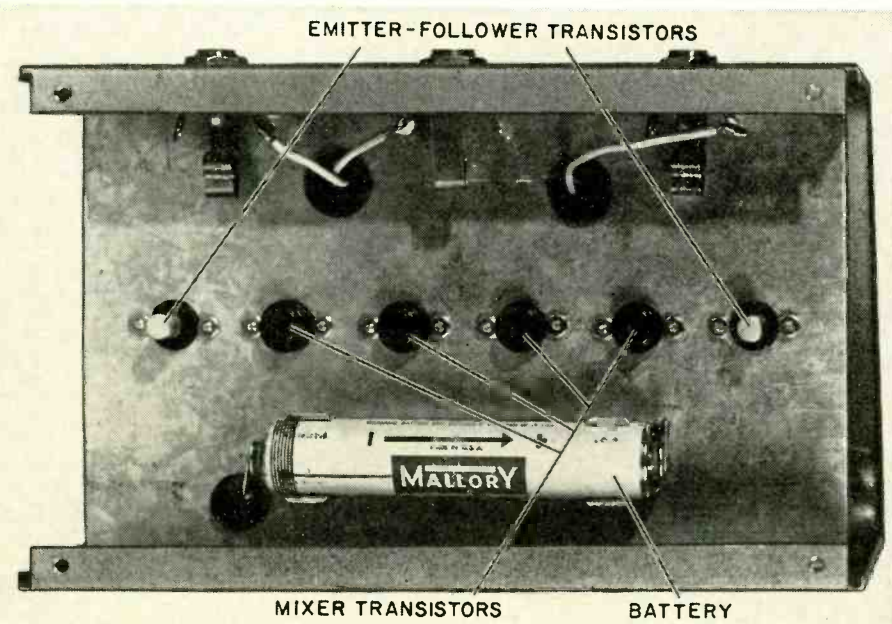


Fig. 2—Using the basic emitter followers in a simple passive resistance mixer. See text for explanation of circuits operation.



The six transistors (two for the emitter followers, four in the original mixer circuit) are mounted upside-down under the chassis, putting their terminals up close to the wiring.

C1—.05 μF, paper or ceramic
C2—50 μF, 10 volts, electrolytic
Q—germanium pnp high-gain audio transistor: beta around 100 (2N109, 2N1175, 2N2613, etc.)
R1—270 K
R2—15 K
R3—2.2 K
These resistors can be ½-watt, 10% types, but hiss will be lower with deposited-carbon or metal-film type.
S—3-pole double-throw switch (see text)

Transistor Circuits From Scratch

Semiconductors are plentiful and cheap—why not learn to use them?

By OTIS E. VAN HOUTEN

THERE'S NO SUBSTITUTE FOR THE FUN and practical experience you get from designing and building your own amplifier. For many years, it's been fairly easy to design vacuum-tube circuits, for there's lots of literature on the subject. The same isn't true of semiconductors. They're still unfamiliar to many people. This is unfortunate, for it's not difficult to design a transistor circuit. Want proof? Read on.

This method of transistor design that can be mastered by anyone who is able to use the various forms of Ohm's law and also has a transistor-specification manual for determining the characteristics of semiconductors. Two good references are the G-E and RCA manuals available from Allied Radio, 100 N. Western Ave., Chicago, Ill. 60680, and also from most other parts supply houses. Either will provide the required ratings and other specifications.

As for Ohm's law, the design method presented here will require practice in working problems, an approach that will increase your ability to solve equations.

In this method, which I call current-flow design, the equations are calculated to set up predetermined values of current flow in the chosen load and bias resistors. Only three steps are necessary to complete the design: load current selection; load resistor selection; and bias selection, to produce the desired value of load current.

Any RC-coupled class-A transistor amplifier employing the circuit configuration illustrated in Fig. 1 can be designed using the three-step method.

Before you get too deeply involved in the manual, make a list like that shown in Table 1. These factors give you a good idea of where you're heading and indicate the type of transistor to use. The values shown in parentheses may be employed in the design method for any values which cannot be determined from the available specification sheets. These values will produce a working amplifier from most general-purpose, low-power pnp or npn transistors.

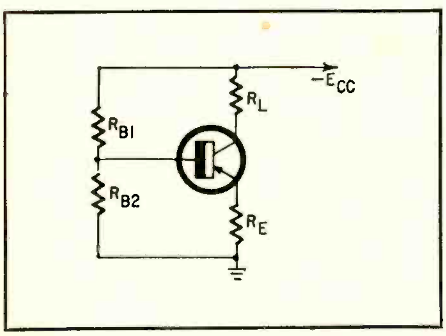


Fig. 1—This is the basic circuit used in the design method described in text.

Collector load current in an amplifier stage must fall between two limits. It must be many times higher than the I_{CBO} (collector leakage current)—at least 10 times or more—$I_C = 10\ I_{CBO}$ minimum. The current also must be less than the I_C max and less than that value which would exceed the power-dissipation (P_C) rating of the collector—

$$I_C = \frac{P_C}{V_{CC}} \text{ maximum.}$$

To determine the load current required in your amplifier, refer to your table of factors and calculate the values of the two limits. Select a value which lies between these limits. Normally, a current equal to one-half the difference between the two values would be selected. A value near the low limit could be selected for battery-operated devices.

For general-purpose audio-frequency amplifiers in which the upper frequency limit lies below 100 kHz, the value of collector-load resistance should be determined using the previously calculated load current (see above). The collector load resistor should drop approximately one-half the collector supply voltage (V_{CC}) when the selected collector current (I_C) is flowing. To determine the correct load resistance, compute the value using the formula from Ohm's law,

$$R = \frac{E}{I}. \text{ Therefore, } R_L = \frac{0.5\ V_{CC}}{I_C}.$$

Consulting your table of factors, calculate the value of resistance required for your amplifier. Select the stock value nearest to the actual calculated figure. The next lowest value will provide proper operation in almost every case.

For special-purpose amplifiers such as wideband oscilloscope or meter preamplifiers where the highest frequency to be amplified is above 100 kHz, a different selection process must be used to determine R_L.

In high-frequency amplifiers, the load resistance must be reduced to extend the high-frequency response. We accomplish this by reducing the resistance through which the circuit capacitance must charge and discharge. (All transistors have a built-in capacitance between the collector and base and between the colector and emitter. Circuit wiring adds additional capacitance.) In general, the frequency response will be down by 3 dB at the frequency where the reactance of the total shunt capacitance

Table I—Primary Design Factors

f_2	—	The highest frequency desired to be amplified, in Hz. 20 kHz to 100 kHz for audio and 1 to 2 MHz for oscilloscope preamplifiers. Must be much lower than the cutoff frequency (f_{ab}, or f_t) of the transistor used (1/10 or less).
V_{CC} (10 V)	—	The available (or required) power-supply voltage, in volts. Must be lower than the collector–emitter breakdown voltage (BV_{CEO}) of the transistor used.
P_C (100 mW)	—	The power-dissipation rating of the transistor in watts. Use ½ to ¼ of the published rating at 25°C if the transistor will be mounted enclosed with heat-producing components.
I_C max (10 mA)	—	The maximum current rating of the transistor in amperes.
I_{CBO} (20 μA)	—	The leakage current of the transistor in amperes. Use 2 to 4 times the published ratings at 25°C if the transistor will be mounted enclosed with heat-producing components.
C_T (70 pF)	—	The total shunt capacitance across the output in farads. $C_T = C_O + C_I + C_S$, where C_O = output capacitance of the transistor (C_{ob}), C_I = input capacitance of the following circuit, C_S = total stray capacitance of wiring, coupling capacitors, etc.

(C_T) across the output is equal to the value of the load resistor.

In the formula for capacitive reactance (X_c),

$$X_c = \frac{1}{2\pi fC}$$

f = frequency in Hz, C = capacitance in farads, $2\pi = 6.28$.
Substitute R_L for X_c, since they will be equal at the highest frequency the amplifier will amplify satisfactorily. Insert the value of shunt capacitance (C_t) taken from your table of factors along with your desired f2, and solve the equation to determine the value of R_L that will produce the desired response.

The resulting formula is

$$R_L = \frac{1}{2\pi f_2 C_t},$$

where R_L is required load resistor in ohms, f_2 is the desired high-frequency response of amplifier in hertz, C_t is total shunt capacitance in farads.

Calculate the value of load resistance required to drop one-half of the V_{CC} as before. Then, for your amplifier, use the smaller of the following two values: the value obtained from the formula just mentioned, or the value as calculated to drop half the V_{CC} as mentioned before.

To illustrate how simple it is to determine the load current and the value of the load resistor to be used, let's look at a typical design problem. A 2N388 germanium npn switching transistor is to be used as an audio preamplifier. Highest required frequency (f_2) is 100 kHz. A 12-volt supply is available.

Step 1—prepare the table of factors

f_2 = 100 kHz
V_{CC} = 12 volts
P_C = 150 mW* at 25°C (50 mW used in calculations)
I_C max = 200 mA*
I_{CBO} = 10 μA* at 15 volts (20 μA used in calculations)
C_T = 70 pF

Step 2—Determine the required load current

$10 \times I_{CBO} = 20\ \mu A \times 10$
$= 0.2$ mA

$$\frac{P_C}{V_{CC}} = \frac{50\ mW}{12} = 4.16\ mA$$

*Values from 2N388 data sheet.

One-half the difference is about 2 mA, so this value will be used in the calculations as I_C.

Step 3—Determine the required load resistor

As this is a general-purpose audio amplifier, select the value of R_L so half the collector-supply voltage will be dropped when the design value of load current flows.

$$R_L = \frac{0.5\ V_{CC}}{I_C} = \frac{0.5 \times 12}{2\ mA}$$

= 3,000 ohms. This is a stock 5% value and will be used.

A 2N123 germanium pnp type will be used in an oscilloscope preamplifier. We have a 10-volt collector supply, and the 2N123 must amplify signals as high as 500 kHz. Here's the set of factors:

f_2 = 500 kHz
V_{CC} = 10 volts
P_C = 100 mW (50 mW used)
I_C max = 125 mA
I_{CBO} = 2 μA at 20 volts (4 μA used)
C_T = 70 pF
I_C determination: $10\ I_{CBO} = .04$ mA

$$\frac{P_C}{V_{CC}} = 5.0\ mA$$

2.5 mA used as selected current.

In this special-purpose amplifier, the additional calculation for the value of R_L must be employed in addition to the method employed in the basic amplifier:

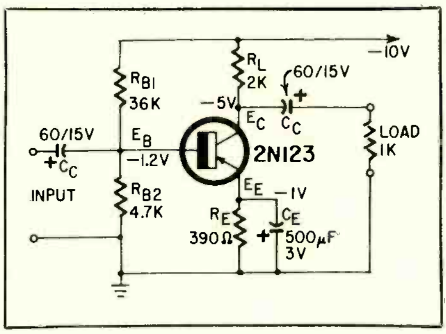


Fig. 2—Example of amplifier design. Component values determined as described in text. Table II gives actual voltages and performance of this circuit.

$$R_L = \frac{1}{2\pi f_2 C_T}$$

$$= \frac{1}{6.28 \times 500\ kHz \times 70\ pF}$$

$$= \frac{1}{.00022} = 4{,}545\ ohms.$$

Determining also the value of R_L to drop half of the collector supply voltage;

$$R_L = \frac{0.5\ V_{CC}}{I_C}$$

$$= \frac{0.5 \times 10}{2.5\ mA} = 2{,}000\ ohms.$$

Select the lower value to use in your amplifier. A 2,000-ohm resistor (standard 5% stock item) would be used. Using this value will insure a high-frequency response in excess of the desired value; the lower the value of load resistance, the higher the frequency response of the amplifier.

You now have two examples of the most difficult job in designing an amplifier stage: selecting the collector load resistor and establishing the load current.

A good reference book is a big help in designing amplifiers. Several are available from technical publishing companies and from some parts supply houses. I recommend the *Datadex Transistor Reference Book,* published by M. W. Lads Publishing Co., 46 South 40th St., Philadelphia, Pa. The latest edition of this book will supply the necessary specifications on virtually every transistor produced, and it also can serve as a valuable cross-reference publication.

The final task in designing the amplifier is to obtain the desired load current by choosing the correct bias components. Assume the base current is zero. Actually it isn't, but the base current will be so small in relation to the other currents flowing in the circuit it may be safely ignored.

If the base current is zero, emitter current equals collector current. Therefore, a current equal to I_C flows through the emitter resistor (R_E). To determine the required value of R_E, choose a resistor that will drop 1/10 of the V_{CC} across R_E when collector current (I_C) flows. A value of resistance one-fifth the value of collector resistor R_L will produce this result: $R_E = 1/5\ R_L = \frac{2{,}000}{5}$ = 400 ohms. Select a 390-ohm resistor from the stock list of 5% values.

To determine the value of bias resistors R_{B1} and R_{B2}, assume that a current equal to $1/10\ I_C$ flows through them. The voltage at the junction of R_{B1} and R_{B2}, the base connection, must be equal to $1/10\ V_{CC} + K$. K is the voltage drop across the forward-biased emitter–base junction. K will be very nearly 0.2 volt for germanium and 0.5 volt for silicon transistors.

Table 2—Amplifier Performance

Q	E_c	E_b	E_e	f_{low}	f_{high}	Gain with 1K load
1	5.7	0.91	0.80	<20 Hz	335 kHz	16
2	5.3	1.0	0.88	<20 Hz	335 kHz	20
3	4.8	1.1	0.96	<20 Hz	200 kHz	22

In the second example given above, the voltage at the junction of R_{B1} and R_{B2} is 1.0 + 0.2 = 1.2 volts. R_{B1} and R_{B2} form a voltage divider across the V_{CC} supply, and the voltage across R_{B1} must be the remainder of the V_{CC} supply. The voltage across R_{B1} (V_{RB1}) = $V_{CC} - (1/10\ V_{CC} + K) = 8.8$. The voltage across R_{B2} (V_{RB2}) = $1/10\ V_{CC} + K = 1.2$.

To determine the resistance values required, again use the Ohm's-law relationship $R = \frac{E}{I}$. Current through R_{B1} and R_{B2} is $1/10\ I_C = 0.25$ mA.

$$R_{B1} = \frac{V_{RB1}}{1/10\ I_C} = \frac{8.8}{0.25\ \text{mA}}$$
$$= 35{,}200 \text{ ohms (use 36K)}$$

$$R_{B2} = \frac{V_{RB2}}{1/10\ I_C} = \frac{1.2}{0.25\ \text{mA}}$$
$$= 4{,}800 \text{ ohms (use 4.7K)}$$

The nearest 5% resistors normally will work very well, and adjustable resistors very seldom will be required to provide bias for amplifiers designed in this manner.

The completed circuit is illustrated in Fig. 2. The voltages noted are the design-calculated values. Actual voltages measured from ground with a 20K ohms/volt vom should be within 20% of these values.

Note that bypass and coupling capacitors are used in this amplifier. Since any practical amplifier must use them, a quickie design method will be given. The value of each capacitor depends on the lowest frequency to be amplified by the amplifier. For most high-quality audio work, even for many special purpose amplifiers, 10 Hz is generally adequate for low-frequency response. A simple formula to determine the capacitance required to provide amplification flat to 10 Hz is

$$C = \frac{160}{R_X \text{ in K ohms}}$$

To determine the required value for the emitter bypass, R_X is taken as R_E, and $C_E = \frac{160}{R_E} = \frac{160}{0.39} = 410\ \mu F$. Referring to the lists of standard capacitance values, use 500μF.

To determine the required value of coupling capacitance required, R_X is taken as R_L in series with the input resistance of the following circuit. The input resistance of most junction transistors will be in the vicinity of 1,000 ohms. So, R_X will be 2,000 + 1,000 = 3,000 ohms, and $C_C = \frac{160}{3} = 54\ \mu F$. Use 60.

You may use capacitors as low as one-fourth the value calculated above with only a slight effect on the low-frequency response. However, good quality requires the large capacitors.

The voltage rating of the capacitors used should be at least 1½ times the maximum voltage that could appear across them in the circuit. Observe proper polarity when installing electrolytic capacitors and when connecting the collector voltage supply.

Note that transistor gain (H_{fe}) has not been mentioned in this design method. Voltage gain achieved in the circuit will depend upon the transistor gain, of course, but it is not important to produce a working amplifier. Gain will also depend greatly on the nature of the load attached to the amplifier.

Practical example

An actual amplifier stage was constructed using the values of example two. Three 2N123 transistors were selected at random and circuit measurements were made. The results are tabulated in Table 2.

As can be seen in the table, the current-flow design method produces a usable amplifier with predicted specifications. The reduced high-frequency response found in the amplifier constructed from the design of example 2 was expected. The circuit was haywired on a Vector board with lots of stray capacitance. The 500-kHz f_2 selected is near the high end of the useful frequency range of the 2N123 transistor when used as an amplifier. 500 kHz was selected purposely to allow an illustration of the design of a special-purpose amplifier.

Transistor design using this very conservative method will produce amplifiers that will perform up to the specifications selected, within the capabilities of the transistor. The circuit will be stable over all temperatures encountered in normal use.

So, there you have it. When considering your next experimental project, why not transistorize it? It's easier than you might think. END

Electronics Culture Corner

BY PHYLLIS BARLOW

Technicians cannot live by bread alone, nor even by spending all their time studying schematics, designing new wonders, or dipping around in sets with a hot soldering gun. All work and no play keeps the cash register ringing and the pay envelope fat, but dulls the happy gleam in the eye of modern electronics geniuses.

Relax, then, and enjoy this little diversion, put together for RADIO-ELECTRONICS readers by Phyllis Barlow, our electronic poet laureate.
—The Editor

Remote Repair

You can switch the channel
By remote control today;
It would make me very happy
To fix up sets that way!

Credit Haiku

My client wants set
Not tomorrow, now, today;
Will he pay that soon?

Of All Glad Words . . .

No other words give me a thrill
Like these: "I've come to pay my bill!"

Deaf-Inition

Some hi-fi fans
It's plain to see
Think VOLUME means
FIDELITY!

Messy Service

There was a technician named Hopp
Who ran a confused kind of shop;
The sets he acquired
He always miswired;
His income soon took quite a drop.

Priority Rating

The night I tried to stay in late
And get my work all up to date,
There was a real emergency;
Dashed home to fix my own *TV!*

Getting to Know Low-Cost IC's

From vacuum tubes to transistors was quite a leap. Get ready to jump a little further—into IC's!

By ROBERT F. SCOTT

IT WASN'T MANY MONTHS AGO THAT integrated circuits or IC's were very expensive bits of electronic hardware made by a few manufacturers for use in computers and in sophisticated aerospace, military and industrial equipment. Almost overnight, more manufacturers entered the field, and prices have dropped to the point where many types of IC's are well within the budgets of hams and other electronic hobbyists. Too, some manufacturers have developed lines of low-cost IC's intended especially for consumer items and experimenters and hobbyists.

We are going to take a look at this field to see what they are and how we can use them in projects. In many catalogs and data sheets, the words used to identify and specify IC's are peculiar to computer and semiconductor technology and you might not be familiar with them. A table and a glossary (page 85) are included to help you find your way around the new world of IC's.

A typical IC consists of transistors, resistors and diodes mounted on or etched into a tiny silicon chip or wafer and connected to perform a specific circuit function or operation. A stage using an IC may have many more transistors and diodes than its equivalent discrete-component transistor or tube circuit, because the transistors in the IC are used for other purposes. You won't find inductors in IC's—they are impossible to make in reasonable values. Capacitors above 50 pF are rare, as they require so much area on the tiny chip that transistors are used instead, whenever possible. (A number of transistors can be made in less space than one capacitor of conventional value. Too, transistors are the cheapest component to make on an IC, so they are substituted for resistors in many applications. When inductors and large capacitors are needed for circuit operation, they are mounted outside the IC.)

One way to eliminate capacitors—particularly in interstage couplings—is to use direct coupling with an additional transistor for isolating incompatible voltage levels. Fig. 1-a shows coupling capacitor C between two stages of a differential amplifier. Fig. 1-b shows how Q3 replaces the capacitor in a similar integrated circuit. Q1–Q2 and Q4–Q5 are the first and second stages used in RCA's CA3012 wideband IC amplifier.

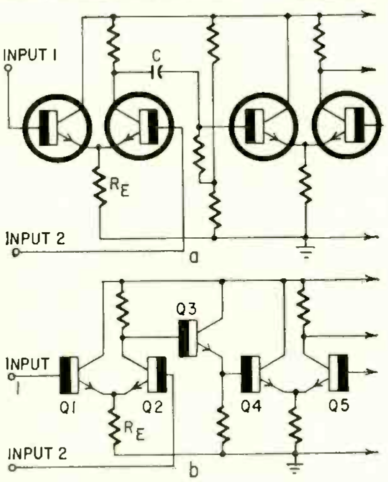


Fig. 1—Coupling capacitor at (a) is replaced by transistor Q3 in IC at (b).

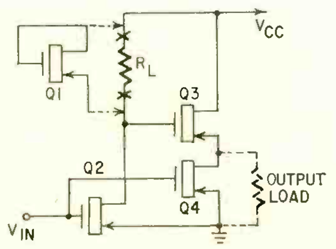


Fig. 2—Q1 is used in place of RL in IC.

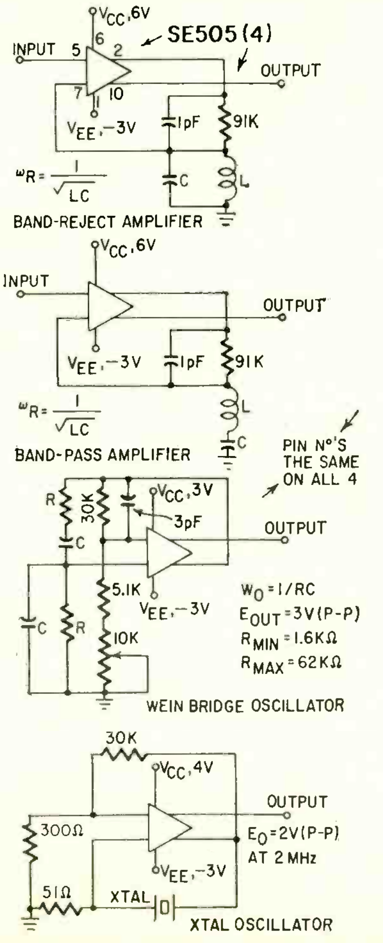


Fig. 3—Signetics SE-505, a differential IC.

Thin-film resistors—made by depositing 1-mil layers of tin oxide or similar material on the silicon wafer—are not practical in some circuit applications because their inherent power dissipation rating is too low. Such resistors are often replaced by an MOS field-effect transistor.

In Fig. 2 we have push-pull output stage Q3–Q4 driven by phase inverter Q2. If load resistor R_L is replaced by a MOSFET (Q1) with its gate returned to the negative side of the supply, we then have, in effect, a resistor with a much higher value and dissipation rating than we could get with a thin-film resistor. Too, this transistor occupies far less space than the thin-film resistor it replaces.

Linear IC's

IC's are of two basic types, linear and digital. Linear IC's are generally used for such familiar applications as audio, rf and video amplifiers, sine-wave oscillators, mixers, frequency multipliers, phase detectors, limiters and modulators. The basic linear IC is a direct-coupled amplifier.

The most common linear IC is perhaps the differential amplifier. Its purpose is to deliver an output signal that is linearly proportional to the *difference* between two signals applied to the input. The typical differential amplifier used in IC's consists of two emitter-coupled transistor amplifiers whose emitters are returned to ground through a high-value resistor such as R_E in Fig. 1. Their collectors are connected to a constant-current source. Some have equal resistors in the collector circuits. In this case, the output signal voltages—taken from the collectors—are equal and 180° out of phase.

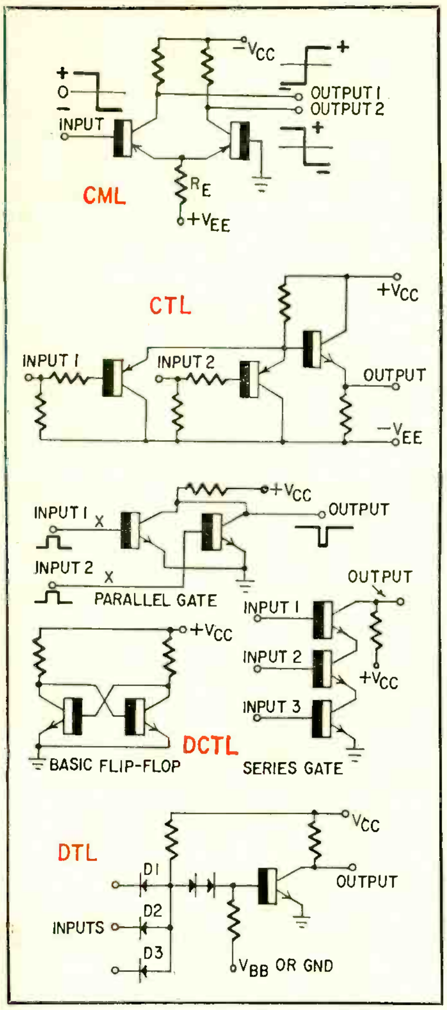
If a signal is applied to one input, and the other input is grounded or returned only to its bias source, the stage gain is approximately half that of the differential amplifier. The output signal will appear between the two collectors as usual.

Let's look back at input stage Q1–Q2 of Fig. 1-b. When a single-ended signal is applied to input 1, we have an emitter follower direct-coupled to a common-base amplifier (input 2 must be at ac ground). This gives us a circuit with high input impedance and in-phase (noninverting) input and output signals. Grounding input 1 and applying the signal to input 2, we have the very low input impedance of the common-emitter amplifier and the input and output signals are 180° out of phase (inverting).

The operational amplifier is another common form of linear IC. It is a high-gain direct-coupled circuit whose gain and response can be controlled precisely by external feedback networks. It is designed for use in dc

IC'S YOU CAN AFFORD TO EXPERIMENT WITH

Device	Price	Function	Input	Output	Pkg	Pins	Mfgr
CA3000	$4.70	Dc amp	Diff	Push-pull	T05	10	RCA
CA3001	6.40	Video amp	Diff	Push-pull	T05	12	RCA
CA3002	4.40	I.f. amp	Diff	Single-ended	T05	10	RCA
CA3004	4.40	Rf amp	Diff	Single-ended	T05	12	RCA
CA3005	2.80	Rf amp	Cascode or diff	Single-ended/PP	T05	12	RCA
CA3006	6.80	Rf amp	Cascode or diff	Single-ended/PP	T05	12	RCA
CA3007	6.00	Af amp	Single-ended or diff	PP emitter foll	T05	12	RCA
CA3008	13.60	Op amp	Diff	Single-ended	Flat	14	RCA
CA3010	12.00	Op amp	Diff	Single-ended	T05	12	RCA
CA3011	2.00	Wide-band i.f. amp	Diff	Single-ended	T05	10	RCA
CA3012	2.25	Wide-band i.f. amp	Diff	Single-ended	T05	10	RCA
CA3013	2.65	I.f. amp-discriminator	Diff	Discriminator	T05	10	RCA
CA3014	3.15	I.f. amp-discriminator	Diff	Discriminator	T05	10	RCA
CA3015	12.00	Low-cost op amp	Diff	Single-ended	T05	12	RCA
CA3016	13.00	Low-cost op amp	Diff	Single-ended	Flat	14	RCA
μA7703C	4.10	I.f. amp	Diff	Single-ended	T05	6	FA
μA7709C	15.00	Op amp	Diff	Single-ended	T05	8	FA
μA7710C	7.50	Diff comparator	Diff	Single-ended	T05	8	FA
μA7712C	9.60	Wide-band amp	Diff	Single-ended	T05	8	FA
μL9900	.80	Buffer amp	Computer amp		T05	8	FA
μL9914	.80	Dual 2-input gate	Computer NAND/NOR gate		T05	8	FA
μL9923	1.50	J-K flip-flop	Computer counting and shift register		T05	8	FA
HEP553	4.10	Half adder	Digital binary half adder		T05	10	MO
HEP554	1.69	Bias driver	Voltage regulator		T05	10	MO
HEP556	2.29	3-input OR/NOR gate	Computer logic element and amp		T05	10	MO
HEP558	5.94	J-K flip-flop	Computer storage element and divider		T05	10	MO
WC183T	10.50	Low-level audio amp	Diff	PP Class B	T05	12	WE
WC1146T	10.50	Wide-band amp	Single-ended	Single-ended	T05	8	WE
SE505K	15.00	Small-signal diff amp	Diff	Diff	T05	10	SIG
SE518K	15.00	Analog comparator	Diff	Single-ended	T05	10	SIG
PA7713	10.00	Tuned rf, i.f. amp to 200 MHz, video amp to 60 MHz	Single-ended	Single-ended	T05 & flat	10	PHIL
SN723	17,85	Diff amp	Diff	Diff	T05		TI
SN724	12.15	Op amp	Diff	Single-ended	T05		TI
TFF 3031	4.25	Gated 2-phase flip-flop			T05	8	TRAN
TNG 3231	3.60	Dual 2-input NAND/OR gate			T05	8	TRAN
MIC 945	5.45	R-S or J-K flip-flop			T05	10	ITT



servo systems, analog computers, low-level instrumentation and for generating special linear and nonlinear signals and waveforms. You can use operational amplifiers as tuned af and rf amplifiers and as rejection circuits by using suitable RC networks in the external feedback loop. Fig. 3 shows typical applications of a small-signal differential amplifier—the Signetics SE-505.

Digital IC's

These consist mainly of logic circuits especially useful in computers. They include multivibrators, gates, counters, choppers and shift registers. Experimenters can use them in square-wave generators, signal injectors for radio and TV servicing, bar generators, keyers and tone sources. It shouldn't be too difficult for you to develop an inexpensive linearity or color-bar generator for your lab or workbench, using digital IC's.

There are many digital circuit configurations. The table below and the diagrams show the basic circuit arrangements with pertinent functional information.

The number of linear and digital IC's costing less than $20 is far too great to detail here. The chart on page 45 lists those that we feel will be most interesting and useful to you. END

Don't miss the glossary of terms used in IC data sheets, on page 85.

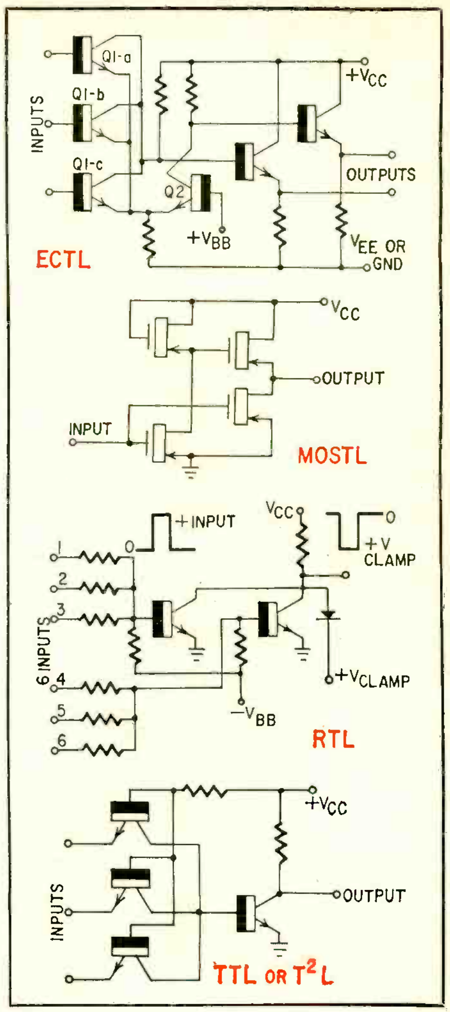


TABLE OF DIGITAL IC'S AND TERMS

CML—*C*urrent-*m*ode *l*ogic. Generally a split-load differential amplifier with complementary outputs. A circuit design for single-ended output may have Q2 omitted and the emitter clamped to ground by a diode. Input and output voltage levels are different, thus making it difficult to cascade stages directly in a logic system. One solution is to use complementary transistors in alternate stages.

CTL—*C*omplementary *t*ransistor *l*ogic. Has complementary transistors in input and output circuits. The emitter-follower output increases the number of fanouts that can be used.

DCTL—*D*irect-*c*oupled *t*ransistor *l*ogic. Transistors in gate, flip-flop and inverter circuits are coupled directly. Diodes, other transistors, resistors and RC combinations are not used as coupling components.

DTL—*D*iode–*t*ransistor *l*ogic. Used for NOR/NAND circuits. A NOR circuit for negative-going input and NAND for positive.

ECL—*E*mitter-*c*oupled *l*ogic. See ECTL.

ECLO—*E*mitter-*c*oupled-*l*ogic *o*peration. See ECTL.

ECTL—*E*mitter-*c*oupled *t*ransistor *l*ogic. A form of CML operated in the nonsaturated mode. Consists of one or more input transistors connected in parallel as a multiple-input split-load amplifier, emitter-coupled to common-base amplifier Q2. The base of Q2 is biased positive so it is always conducting while the input or gate transistors (Q1-a, b, c) are off. The emitter followers provide voltage-level restoration and increase the number of fanouts that can be used.

LLL—*L*ow-*l*evel *l*ogic. See DTL.

MECL—Motorola trade name for CML series.

MOSTL—*M*etal-*o*xide-*s*emiconductor *t*ransistor *l*ogic. A logic circuit using MOS devices. Features extremely high input impedance, high transconductance and high fanout capability.

RTL—*R*esistor-*t*ransistor *l*ogic.

TCL—*T*ransistor-*c*oupled *l*ogic. See TTL.

T^2L—Same as TTL.

TTL—*T*ransistor–*t*ransistor *l*ogic. A low-level logic circuit in which gating diodes D1, D2 and D3 in the DTL are replaced by transistors Q1, Q2 and Q3. Requires less operating power and provides faster switching.

V-TL—*V*ariable-*t*hreshold *l*ogic. A form of DTL in which the input threshold voltage can be varied over a wide range.

Crusade Against Car Thieves

By JOHN H. FASAL

EACH YEAR 28,000 CARS ARE STOLEN IN New York City (where I live). Those figures didn't impress me until my car was taken for a joyride. Although the car was recovered with almost no damage, the incident was inconvenient. Recently, however, my newly purchased car was stolen by professional thieves, who stripped it. This outrage made me want to fight back. The alarm described in this article is my weapon against car thieves.

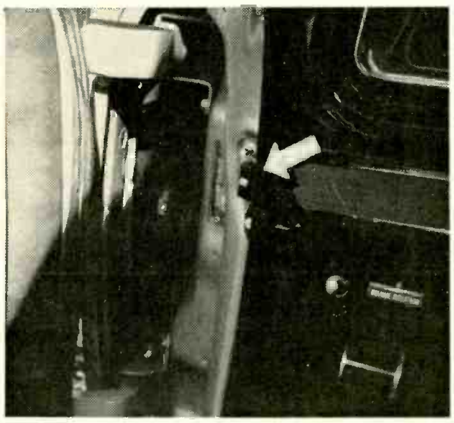
Philosophy of car protection

Complete protection against any and all crime is impossible. There's a weapon to overcome every defense. How can you minimize theft? By making it difficult or impractical to steal the protected object. It's not *impossible* to rob a bank, but it's so difficult that few robbers succeed. The bank, you see, is well protected. Let's examine the steps a thief takes to steal a car, and see how he can be stopped.

1. *Attack*: The thief tries to enter the car using a master key.
1. *Defense*: Door switches with normally closed contacts. When a door is opened, the switch opens and triggers an alarm circuit, turning on the car horn. If the thief hastily jumps in and shuts the door, the alarm must remain on. A more sophisticated alarm system may use a motion detector or a photoelectric cell.
2. *Attack*: The thief tries to silence the alarm.
2. *Defense*: Hinder access to the battery and horn by locking the engine compartment. This means the intruder will have to lose time and use heavy tools to break the hood.
3. *Attack*: The thief breaks the hood and disconnects the horn, the battery, or both.
3. *Defense*: A standby battery, which has been under continuous trickle charge, is automatically switched on. It drives a separate alarm—a bell, a siren or a second horn. This backup alarm continues for at least 10 or 15 minutes.
4. *Attack*: The thief becomes increasingly nervous and tries to start the car, despite the alarm.
4. *Defense*: The ignition system is dead. A hidden switch has bypassed the ignition coil. Most thieves will either quit or be caught by the police at this point.

There are, then, three basic requirements for the auto burglar alarm:

1. *Make the thief lose time.* He must have to perform difficult and tedious operations to steal the car.
2. *Make the thief nervous.* His breaking into the car must trigger a loud, persistent alarm which will arouse the suspicion of citizens and police.
3. *Protect the alarm system itself.* It must be nearly inaccessible and must require more than a few minutes to be discovered. Duplicate vital components and hide them well.



Simplest way to mount door switches is with double-faced tape applied to doorwell.

The typical alarm system contains three basic sections:

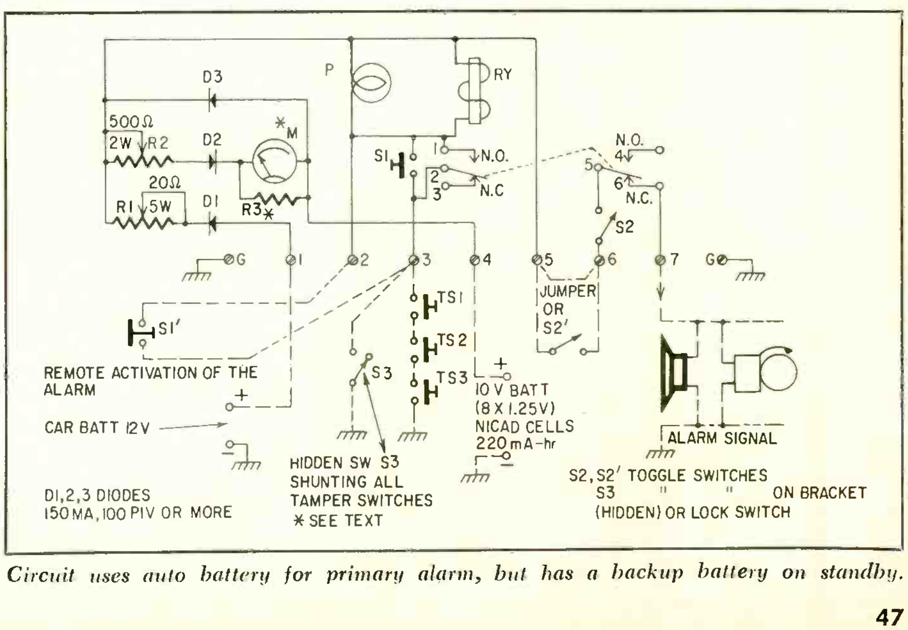
1. *The trigger circuits*—door switches, an ultrasonic motion detector, a PE cell or a body-capacitance circuit.
2. *The monitoring circuit.* It fires the alarm if the trigger circuit is interrupted (fail-safe circuit). It latches "on" when triggered, and must be reset (turned off) by a hidden switch. This circuit also allows trickle charge of the standby batteries and switches them on when the main battery is disconnected. Of course, a means must be provided to disarm the whole circuit when the owner uses the car. And there must be a way to test the functioning of the system.
3. *The sounding devices*—horns, sirens, buzzers or bells.

Here is an alarm circuit which meets the above requirements.

The schematic diagram—a simple, efficient and reliable alarm device—is shown below. Normally, the system is powered by the 12-volt car battery. Assuming negative ground, the positive battery terminal is wired directly to terminal 1 of the alarm monitor. (In cars with trunk lights a positive line is available in the trunk.) So long as the alarm is not armed, switch S2 is open. Hence the relay is not energized because relay contacts 2–3 and pushbutton S1 are open.

During such an inactive period (when the car is being driven) the auxiliary battery (a nickel-cadmium type) is continuously trickle-charged. Since the voltage of the car battery is slightly greater than that of the standby battery, current flows from the positive terminal of the car battery through diode D1, series resistor R1, variable resistor R2, diode D2 and the shunted milliammeter. Current then flows through terminal 4 into the standby battery.

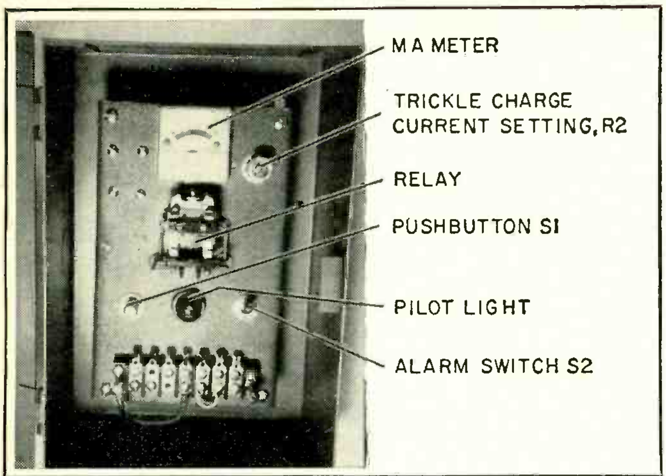
Trickle-charge current, which is



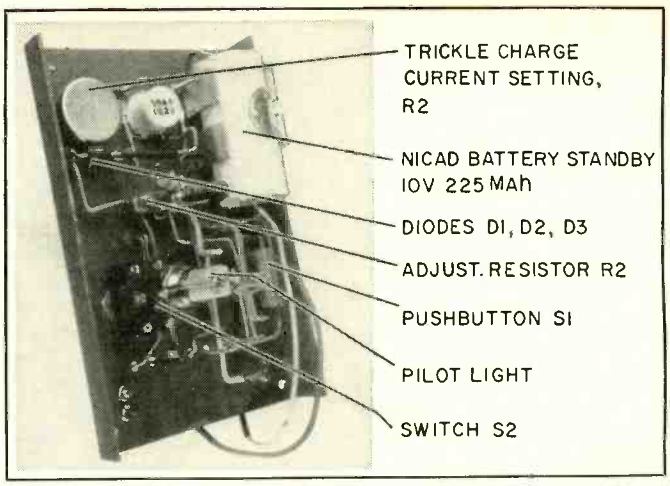
Circuit uses auto battery for primary alarm, but has a backup battery on standby.

PARTS LIST

R1—20 ohms, 5 watts, adjustable
R2—pot. 500 ohms, 2 watts
R3—see text
D1, D2, D3—silicon diode, at least 150 mA, 100 piv
RY—dpdt relay, 12 Vdc (Potter & Brumfield KA-11DY or equivalent)
P—pilot lamp, 24V, #1815
S1, S1'—pushbutton switches, NO
S2, S2'—spst toggle switches
S3—spst toggle switch
M—milliammeter, 20 or 25 mA full scale (see text)
TS1, TS2, TS3—door switches, spst NO microswitches
BATT—battery, 10 volts (8 cells, 1.25 volts each, nickel-cadmium; 220 mA-hr); 8 Eveready B225T cells (or equivalent)



Front panel of the alarm. Meter is used to set trickle charge.



Rear view shows battery mounting and components layout.

critical, is set by variable resistor R2 and is read on the milliammeter. In the model I built, the Nicad battery is composed of 8 button cells, with a capacity of 225 mA-hr and about 10 volts open-circuit, or roughly 1.25 volts per cell. For such a battery the trickle-charge current should not exceed 10 mA. For extended standby action, larger batteries, located outside the control unit, may be used.

You can use a 0–25-mA meter without external shunt R3. If you have a 0–1-mA meter on hand, simply determine the value of R3 by experimentation. Connect a vom on the 50-mA range in series with the 1-mA meter. Try different values of shunt around the 1-mA meter until it reads "10" when the vom reads 10 mA.

If for any reason (such as starting the engine), car-battery voltage drops below that of the standby battery, the Nicad can't discharge back into the car battery. Diode D1 blocks any reverse current. Diode D3 protects the Nicad battery from overcharge. And diode D2 protects the meter from overload. In case of main-battery failure, the standby powers the relay and if necessary the alarm circuit through diode D3.

Here is how to arm the alarm system:

1. Close all windows and doors which are protected by tamper switches TS1, TS2 etc. connected in series. This establishes continuity in the relay circuit.
2. Close pushbutton S1, thereby energizing the relay. The relay latches "on" because contacts 1–2 bypass S1. At the same time contacts 5–6, which control the signal circuit, open. They hold the signal circuit open independent of the position of switch S2.
3. Close switch S2. (Terminals 5 and 6 are supposed to be connected by a jumper.)

Alarm triggering

If one of the door contact switches is opened, the relay drops out and the contacts return to the N.C. position. The latching circuit opens, the signal circuit closes, and the alarm is triggered. Even if the open tamper switch is again closed, the relay remains de-energized because both S1 and the latching circuit remain open.

Disarming the alarm

When the owner wishes to drive his car, he must disarm the alarm circuit. The procedure is very simple; there are only two steps:

1. He interrupts the signal circuit by opening switch S2.
2. He releases the relay by opening a door and getting into the car.

In the preceding example, it was assumed that there is free access to the control box which was located in the trunk. The trunk is protected by a conventional key lock.

A better system would include the trunk in the alarm-protection circuit by installing a tamper switch on the trunk lid. How does the owner disarm the circuit in this case? There must be a hidden switch to bypass the tamper switches. To arm the circuit, all doors and windows are closed and the hidden switch is thrown. To disarm, the hidden switch is thrown and then the trunk may be opened to kill the signal circuit.

The reliability and effectiveness of the whole alarm system depends on the correct location of the hidden switch. A simple spst switch (dotted lines in the diagram) is connected between terminal 3 and ground. The switch should be mounted at a place which cannot be detected easily, and yet a place that's not exposed directly to rain or splash. Moisture may cause a slow but continuous corrosion. One way to prevent this is to use a watertight switch that's protected by a rubber sleeve. At least one is commercially available and is excellent for outdoor mounting.

Another solution is to mount a magnetic reed switch anywhere inside the car (for instance, on a window behind a sticker). It can be activated by placing a magnet against the window.

Additional security against silencing of the triggered alarm is obtained by hiding the control box with all interconnecting cables in a difficult-to-reach location. In this case it is necessary to provide extensions for switches S1 and S2. The extensions must be well hidden—perhaps inside the trunk. This is illustrated in the diagram in dotted lines (switches S1′ and S2′). (S2 remains closed and the jumper between terminals 5 and 6 must be removed.)

The simplest way to obtain an audible alarm signal is by using the car horn. Installation is easy, since the horn contacts behind the steering wheel have only to be bypassed by relay terminals 6 and 7 or the control panel. All connections between 5 and 6 have to be removed in this case. This solution has the disadvantage, however, that silencing is relatively easy and the use of the standby battery to drive the horn becomes impractical.

A better solution is to use a siren, buzzer or bell, or any other device which produces a loud alarm. It must be mounted in an inaccessible place, well protected against rain and dirt. The engine compartment is a good place, but the hood must be locked or provided with a tamper switch. To provide for extended standby action, power consumption of the signal device should be low.

This is but one example of the many possible ways to protect a car from theft. From it, you've learned something about the basics of automotive burglar alarms, and I hope you'll find this system a useful accessory for your car. END

Twin 200 Watt-Second Solid-State Strobe Slaves

This easy-to-build construction project has 4 light-output settings, direct or slave triggering, and is portable

By E. F. RICE

PHOTOGRAPHY AND ELECTRONICS GO together both technically and as hobbies. The new breed of camera may have an electronic shutter, a built-in strobe unit, and various electronic accessories. Professionals and hobbyists in one field often have more than a casual interest in the other. If you often find yourself behind a camera wishing you had a more versatile lighting arrangement, this twin 200-watt-second transistorized slave strobe will be well worth the effort required to build it.

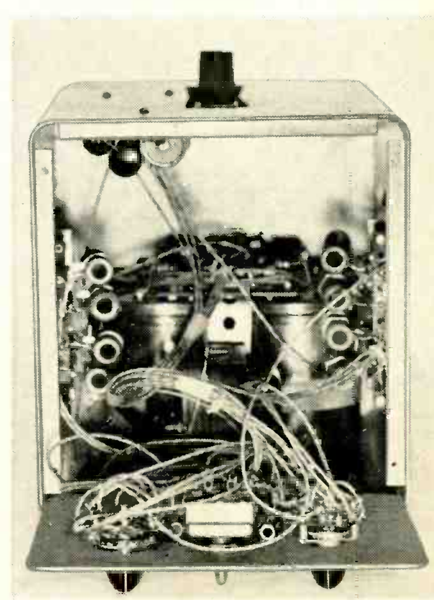
Expense is moderate—well under commercially produced units of comparable power and usefulness—and construction is simple, although dangerous if certain precautions (which we'll explain later) aren't observed. Even if you don't need or want a strobe, you may learn enough from studying the circuitry to feel capable of handling a few strobe repairs you might previously have turned down.

A survey of slave units available commercially quickly showed the lack of several features we wanted, so we had a pretty good idea of how to go about laying out the circuit. Solid-state devices reduce the input-power requirement and give cooler operation and fewer failures. Using a single photocell to trigger both lamps simultaneously avoids the possibility of "ghost" images due to delayed firing of one lamp.

The trigger unit with its light-sensitive cell is separate from the slaves themselves and can be placed anywhere within the radius of its 20-foot cable. This feature insures that the trigger cell will "see" the firing of the main light, regardless of the position of the slave lamps.

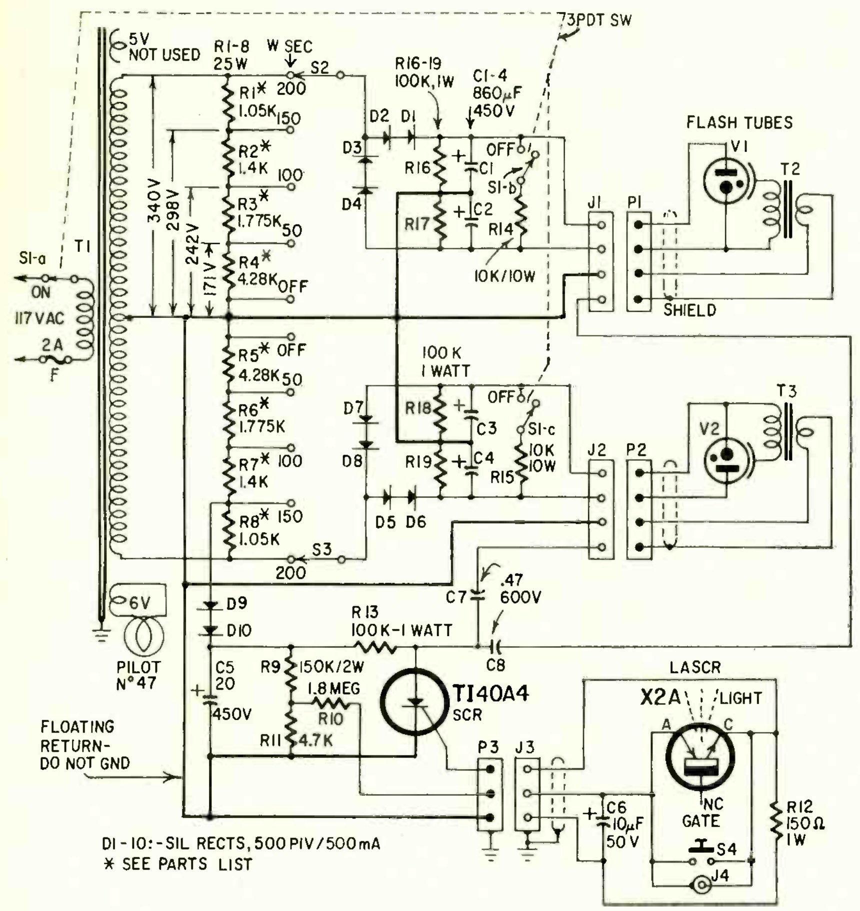
The dual power supply allows you to select four power levels: 200, 150, 100 and 50 watt-seconds. The resulting versatility of light levels gives fine shadow and highlight control.

The complete slave assembly consists of two flash lamps, the remote trigger unit, and the power supply/timer. Cables may be any convenient length, depending on your needs.



This inside view of the power supply and timer shows parts placement. Be certain that the common-return bus does not touch either chassis or cabinet at any point.

see sept p 6



This is the complete schematic of twin-strobe unit. Be sure that you clip off the LASCR gate lead, don't ground the common bus, and install electrolytics carefully.

PARTS LIST

R1, R8—1.5K, 25 watts, wirewound, adjustable (set to 1.05K)
R2, R7—2K, 25 watts, wirewound, adjustable (set to 1.4K)
R3, R6—2.5K, 25 watts, wirewound, adjustable (set to 1.775K)
R4, R5—6K, 25 watts, wirewound, adjustable (set to 4.28K)
R9—150K, 2 watts
R10—1.8 meg, ½ watt
R11—4.7K, ½ watt
R12—150 ohms, 1 watt
R13, R16, R17, R18, R19—100K, 1 watt
R14, R15—10K, 10 watts
S1—3pdt switch (Cutler-Hammer 7613K2 or equivalent)
S2, S3—5-position rotary switch, 15 amps, 125V ac (Ohmite Power Tap 111-5 or equivalent)
S4—spst miniature pushbutton, NO (Grayhill 30-1 or equivalent)
D1, D2, D3, D4, D5, D6, D7, D8, D9, D10—silicon rectifier, 500 mA, 500 piv
C1, C2, C3, C4—electrolytic, 860 µF, 450 volts dc (Sprague 861F450DC type 36D, Allied Industrial Electronics 43D5153 or equivalent)
C5—electrolytic, 20 µF, 450 volts dc
C6—electrolytic, 10 µF, 50 volts dc
C7, C8—0.47 µF, 600 volts dc
T1—power transformer, 117V pri. to center-tapped sec., 340-0-340V (Stancor PC-8408, Newark 1F014, or equivalent)
T2, T3—flash-tube trigger transformer (Amglow MT-55, Allied Industrial Electronics 60D9387 or equivalent)
V1, V2—flash tubes (Amglo HD-3—Amglo Corp., 4325 Ravenswood Ave., Chicago, Ill.—or equivalent)
J1, J2—4-connector female socket (Amphenol 91MC4F or equivalent)
J3—3-connector female socket (Cannon XLR-3-13 or equivalent)
J4—miniature mike connector (Switchcraft 5501-F or equivalent)
P1, P2—4-connector male plug (Amphenol 19MC4M or equivalent)
P3—3-connector male plug, Cannon XLR-3-12C
LASCR—light-activated silicon controlled rectifier (G-E type X2A or equivalent)
SCR—Texas Instruments type TI-40A4 (or equivalent) with 60-amp surge current and 480 volts forward breakover voltage
Pilot lamp—#47
Cabinet—9 x 8⅛ x 12 inches, Bud Portacab WA-1541 (or equivalent)
Cable—60 feet of 20 AWG 3-conductor shielded (Belden 8403 or equivalent)
Miscellaneous—(2) back covers for flash tubes (Amglo R65D—Amglo Corp., 4325 Ravenswood Ave., Chicago, Ill.—or equivalent)
(2) reflectors for flash tubes (Amglo AR365D, Allied Radio 60A6637 or equivalent)
(1) small chassis box for remote trigger
(1) panel-mount pilot-lamp jewel (clear)

The circuit: a "double doubler"

The schematic diagram shows how full-wave doublers are connected on both sides of the center-tapped secondary of an ordinary receiver-type power transformer. Rectifying and doubling this rms value (340 volts each side of center) charges the capacitors to slightly over 900 volts. Two 860-µF capacitors in series give a total of 430 µF, conservatively rated at 900 volts.

A voltage divider—R1, R2, R3 and R4—across half of the secondary allows the ac input to be reduced in four steps. The resistors are 20-watt units with adjustable sliders. With a total capacitance of 430 µF, the rms voltage required at any tap on the divider is easily calculated using the formula

$$E_{rms} = \frac{\sqrt{\text{watt-sec}}}{41.4} \times 10^3$$

If you want 50 watt-seconds of power, for example,

$$E_{rms} = \frac{\sqrt{50}}{41.4} \times 10^3 = 171 \text{ volts ac}$$

For 200 watt-seconds,

$$E_{rms} = \frac{\sqrt{200}}{41.4} \times 10^3 = 342 \text{ volts ac}$$

The voltage required for 200 watt-seconds is not 4 times the voltage for 50 watt-seconds, because the power increases as the square of the voltage. Identical circuitry is used on both halves of the secondary winding to supply power for each of the twin slave lamps.

Some safety precautions

A little explanation is in order regarding the use of a very high voltage and a relatively small capacitance to get 200 watt-seconds. At first glance, you might think it would be safer to use a lower voltage and put the two capacitors in parallel instead of in series. We tried this and found that the flash tubes, which were designed for a maximum of 250 watt-seconds, do not flash reliably below 500 volts. To obtain the lower powers, we would have to switch capacitors in and out of the circuit as well as change voltages.

Flash tubes designed to operate at lower voltages are available, but these have maximum ratings below the desired 200-watt-second level. Considering all aspects, therefore, the high-voltage approach is the least expensive and most efficient way to get the needed power in four steps.

If not for several safety measures incorporated in this unit, the voltages present would be a serious hazard to the builder. High voltage, of course, is always risky. It's especially so when applied to large capacitors. The instantaneous current available at 900 volts is over 100 amps! If you shorted a screwdriver across the terminals of a charged 860-μF capacitor there would be a blinding flash, and part of the blade would disappear. Obviously, the damage to a careless builder could range from serious burns and shock to death.

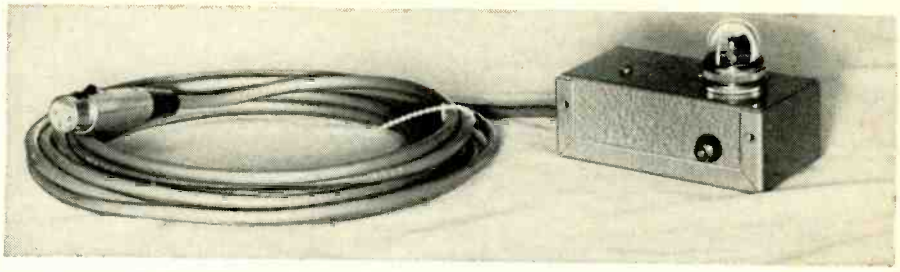
Don't try the "screwdriver test," even out of curiosity. Not only is it tough on your tool supply and dangerous, it also may rupture the dielectric material in the capacitor. And, as you'll soon learn, they don't give away for nothing capacitors of the size required here.

To avoid serious injury, the following safety measures must be followed very carefully:

1. Solder a piece of wire across the capacitor terminals *immediately* on receiving them from the supplier. If you make a careless mistake and apply power prematurely, the fuse will blow, and no voltage will be applied to charge the capacitors. The last step in construction is to remove this short—don't forget.

2. Install the line fuse before any power is applied to the unit.

3. Install the special 3pdt on–off switch and resistors R14 and R15 *before* connecting the capacitors in the circuit. Make certain the switch is wired so that when the 117-volt ac line is *open,* R14 and R15 *are connected across the capacitors.* The switch/resistor combination discharges the capacitors when the unit is turned off. In this way, the charge is gone by the time the front panel is removed for service or testing.



The remote trigger assembly. LASCR is mounted inside the clear pilot-lamp jewel.

Light-sensing unit

The trigger circuit, shown in the lower part of the schematic, uses a light-activated silicon controlled rectifier (LASCR) instead of a conventional photocell. This simplifies the circuitry and provides excellent light sensitivity. It also produces a strong pulse which is used to gate the main SCR (TI-40A4) that energizes the two trigger transformers simultaneously.

A 298-volt potential, taken from the tap between R7 and R8, is rectified, filtered and reduced by R9 and R10 to about 15 volts dc. This voltage charges C6. When light strikes the LASCR, the device switches from its high-resistance state to a low resistance, discharging C6 through R12. The resulting positive pulse from the top of R12 gates the TI-40A4 into conduction. When C6 discharges, the LASCR turns off again, because R10 limits the supply of current from the power supply to a level below the minimum required to keep the silicon junction in a conducting state.

When the TI-40A4 conducts, C7 and C8 discharge rapidly through the trigger-transformer primaries. The sudden current surge through these primaries produces the high-voltage pulses required to flash the Xenon lamps. The TI-40A4 turns off as soon as C7 and C8 are discharged, because R13 limits its current. The capacitors then recharge slowly.

Components for the light-sensing trigger unit are attached to a board mounted in a 4¼ x 2 x 1½-inch Minibox. Miniature pushbutton switch S4, mounted on the side of the box and connected across the LASCR, activates the trigger and fires the lamps manually for test purposes. A large pilot-light assembly houses the LASCR. It is mounted by soldering its anode and cathode leads into the base of an old pilot bulb. The gate lead is not used; snip it off. This is done to obtain maximum LASCR sensitivity. A small microphone connector (J3) is mounted on the side of the box opposite S4 and connected in parallel with it. This can be used for attaching a sync cable, if it ever becomes necessary to fire the lamps directly from the camera shutter.

The schematic shows which parts are mounted at the ends of the cables. The main cabinet is a 9 x 8⅛ x 12-inch Bud Portacab. Placement of parts is not critical. The four capacitors are mounted in the back, and the power transformer is located in the center. The doubler diodes are mounted on a board secured to the top of the capacitors. The eight voltage-divider resistors are mounted between pairs of terminal strips running vertically on each side of the cabinet.

Trigger capacitors C7 and C8 are mounted with C5 on a small board fastened to the top of the cabinet. On–off switch S1, along with R14 and R15, is located in the center of the front panel. Power-selector switches S2 and S3 are on either side of the on–off switch. The TI-40A4 and other small parts are soldered to terminal boards on the bottom just in front of the power transformer. No heat sink is needed for the SCR; it is supported on stiff wires soldered to a terminal board.

Trigger transformers T2 and T3 are mounted inside the back covers of the flash lamps to keep the high-voltage trigger leads as short as possible. Three 20-foot sections of three-conductor shielded cable connect both flash heads and the light-sensing unit to the main cabinet. Cable connections are indicated in the schematic.

Identical plugs are used on the two lamp cables. The cable from the LASCR box has a different type of plug to prevent accidentally plugging it into a socket leading to the high voltage. The two sockets for the lamp plugs are wired so the high voltage is fed to the internal terminals rather than to the external prongs, to reduce the possibility of accidental contact.

The cabinet is *not* connected to the negative side of the power supply. A floating common bus is run throughout the chassis. The box used for the trigger unit is connected to the main cabinet through the shield in the cable. Also, the microphone-type connector mounted on the side of the box is insulated from the box as an added precaution.

Operation is simple

Set the two lamps on stands wherever they are needed, plug in the sensing unit, and attach your regular flash unit to the camera. Select the desired power for each slave light. When you release the shutter, the camera-operated flash unit will actuate the LASCR and the slaves will flash. As noted earlier, you can test the slave units without operating the camera by pressing the button on the side of the sensing unit. Recycle times range from about 5 seconds on full power to slightly over 30 seconds on low power.

If you have trouble getting either or both the flash tubes to fire on the 50-watt-second position, the fault may be that the voltage obtained from this tap is near the minimum for which the tube was designed. Occasionally a tube is slightly less sensitive than normal. To cure the problem, simply increase the 4.28K resistor in the voltage divider (R4 or R5) to about 5K. At the same time, it's a good idea to decrease the 1.775K resistor (R3 or R6) to about 1K. END

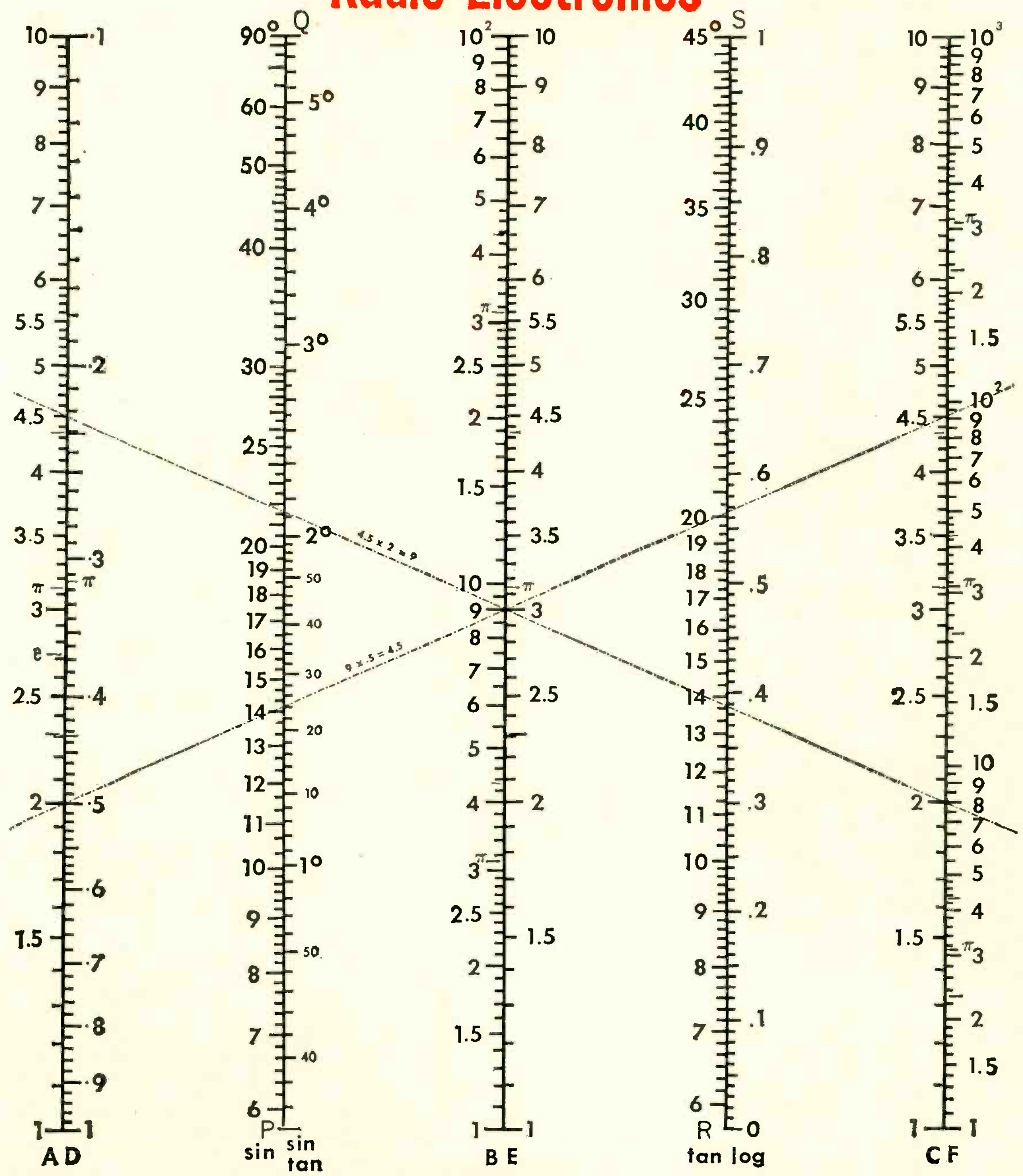
NOMORULE:
A Complete Calculator on a Sheet of Paper

Part 1—Use it wherever you would use a slide rule. Keep your results as long as you like! A portable computer on paper for desk or workbench

By JOHN H. FASAL*

YOU'VE PROBABLY HAD IT DRUMMED INTO you by now that a slide rule is a tremendous time and labor saver for anyone who works with numbers. But do you use one? Whether you do or not, you're in a bit of a bind if you work in several places. You can have several slide rules, or you can carry one with you. The first is expensive, the second a nuisance.

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



NOMOGRAPH $A = \frac{B}{C} = \frac{B}{\sqrt[3]{F}} = \frac{E^2}{C} = \frac{E^2}{\sqrt[3]{F}} = \frac{1}{D}$ **CALCULATOR**

Fig. 1—This is the Nomorule. Simply cut it out, back it with cardboard, and you're all set for calculations.

For you, here is a calculator—with a memory, yet—one that you can fold up and put in your pocket, make copies of for all your working places, distribute to your friends, scale up or scale down as you please. Make a few copies right away; when one gets dirty and dog-eared, throw it away and use another. We call it "Nomorule."

Actually a generalized nomograph calculator, the Nomorule has one big advantage over a slide rule: memory. You can "store" mathematical operations as long as you need them for comparison and checking.

RADIO-ELECTRONICS has set up the Nomorule so you can simply cut it out and use it immediately, just as it is. But to keep it neat and accurate, you'll want to protect it.

Nomorule (Fig. 1) should be cut from the pages of this magazine and cemented to a hard surface, such as a bakelite board. Cover with a sheet of matte-finish Mylar or acetate (art supply stores), frosted side upward. The Mylar should be held firmly by a spring-loaded clamp fixed to the board. The scales must be well visible through the Mylar, so that you can trace alignments in tiny pencil lines on the frosted surface.

After you complete a problem, just remove the alignment tracings with a damp sponge, or erase with a soft eraser. If you want to keep the solution for further reference, you'll have to put at least two reference points on the Nomorule and the Mylar cover. Line them up perfectly before starting to "read out" the chart.

Fundamentals

Here are some of the principles on which Nomorule is based.

You can find the product (or quotient) of two numbers, A and B, by adding (or subtracting) their logarithms, like this:

$$\log(AB) = \log A + \log B$$
$$\log(A/B) = \log A - \log B$$
$$\log A^m = m(\log A) = -m(\log \frac{1}{A})$$
$$\log \sqrt[n]{A} = (\log A)/n$$

In a nomogram, we add and subtract logarithmic calibrated scales *geometrically*, rather than by moving a slider within a frame as in a slide rule.

Consider a simple nomograph with vertical scales A, C, B, (Fig. 2). All scales are identical and equally spaced. Let a straight line intersect the scales at P, Q, R. Then the section O_2Q equals one-half the sum of sections O_1P plus O_3R. If the scales are logarithmic we

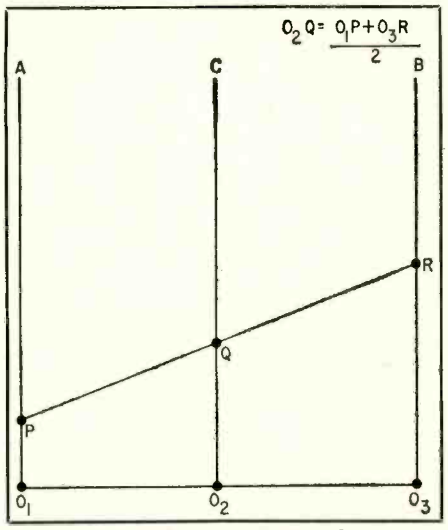


Fig. 2—Principle of the Nomorule: Length O_2Q is arithmetic mean of O_1P and O_3R. Hence O_2Q represents geometric mean.

have the relation, $Q = \sqrt{P \times R}$.

If we are interested in a product only (not its square root) we can change the calibration of middle scale C. We make its *modulus*, or unit length, equal to *one-half* the modulus of the other scales. Then $\log Q = \log P + \log R$, or $Q = P \times R$, directly.

The reciprocal of a number comes easily by using the two sides of the first scale, A and D, in Fig. 1. For example, $D = 0.5 = ½$, and $A = 1/D = 2$. The reverse, then, is also true—i.e., $D = 1/A$. Dividing by a number is the same as multiplying by its reciprocal. From $B = AC$, we get $B/A = C$ which then becomes $BD = C$, since $1/A = D$. The dotted line shows that $9 \times 0.5 = 4.5$, or $BD = C$.

Squares and square roots come out of scales B and E, cubes and cube roots from scales C and F. Other relationships,

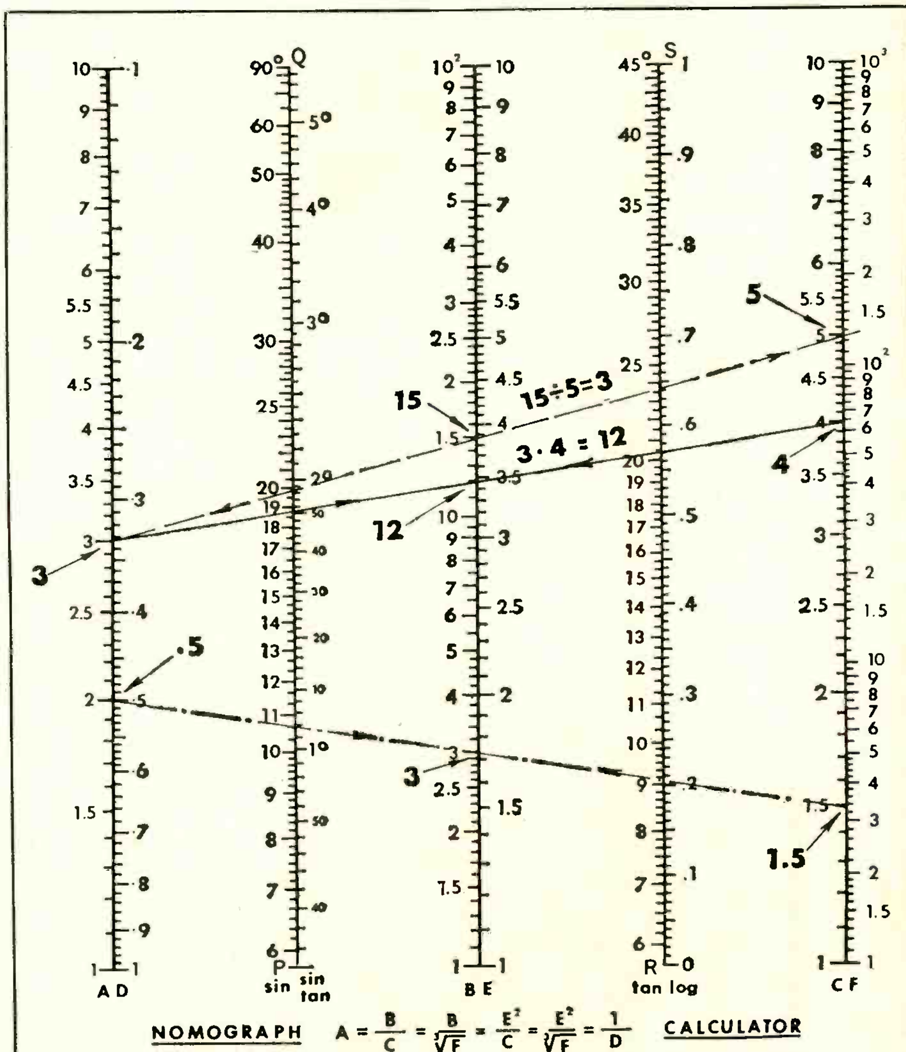


Fig. 3—Some simple examples of multiplication and division you can easily perform.

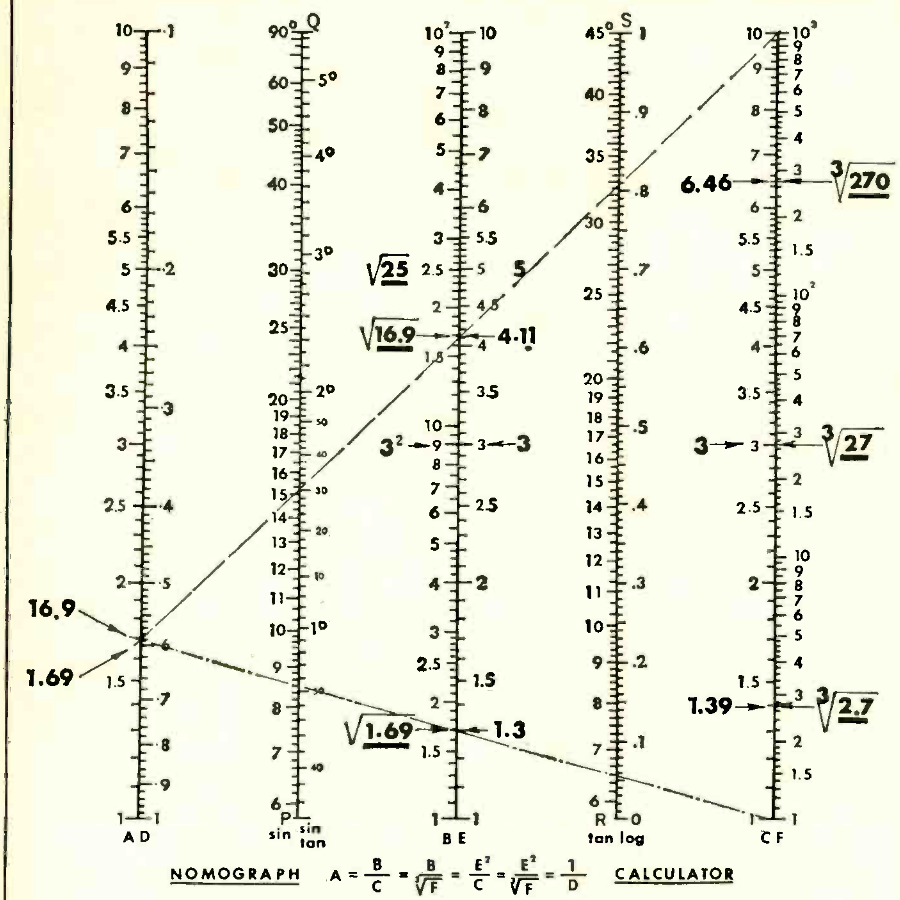


Fig. 4—The Nomorule is a real timesaver for extracting roots of squares and cubes.

including trigonometric and logarithmic functions, can also be read off. We'll come to that in a moment.

Basic operations

Once you know the basic rules, you can handle any combination of operations quickly and easily, and with sufficient accuracy for most practical problems.

Multiplication: Connect 3 (on A) with 4 (on C) to find 12 (on B). This is shown in Fig. 3, solid line.

Division: To find 15/5, intersect 15 (B) with 5 (C) to get 3 (A). This is shown by the dashed line in Fig. 3, and uses the equation $B/C = A$. Note that we chose 1.5 on the *higher* decade of B, above the 10, so it actually represents 15. Another way to divide is to apply the equation $B = C/D$ mentioned earlier. Intersect 1.5 (C) with 0.5 (D) to obtain 3 (B) shown by the dot-dash line.

Finding the decimal point

Like a slide rule, the Nomorule determines numerical values, not the decimal position. But, as with a slide rule, finding the decimal point is easy.

Numbers can be expressed as some value between 1 and 10, multiplied by some power of 10. For example:

$$13{,}200 = 1.32 \times 10^4$$
$$.0061 = 6.1 \times 10^{-3}$$

To multiply these numbers, express the product as $1.32 \times 6.1 \times 10^{(4-3)}$. Using the nomorule, we find the answer is $8.05 \times 10 = 80.5$.

To divide 975 by .0003, express the numbers as

$$\frac{9.75 \times 10^2}{3 \times 10^{-4}}$$

and we obtain $3.25 \times 10^6 = 3{,}250{,}000$. As before, division of the significant digits is handled by the Nomorule. This result is multiplied by the proper power of 10.

Squares and square roots are read directly from scales B and E. Fig. 4 shows that $\sqrt{25} = 5$, and that $3^2 = 9$. Now let us find $1{,}200^2$. Write $1.2^2 \times (10^3)^2 = 1.44 \times 10^6 = 1{,}440{,}000$. To find $.003^2$, write $3^2 \times (10^{-3})^2 = 9 \times 10^{-6} = .000009$.

Take special care in extracting square roots. To find $\sqrt{169{,}000.}$ first split the number into groups of two digits each, beginning with the decimal point. This points off a number between 1 and 100, whose square root must lie between 1 and 10. Thus, $\sqrt{169{,}000.} = \sqrt{16|90|00.} = \sqrt{16.9} \times \sqrt{10^4} = 4.11 \times 10^2$. We cannot write 1.69 or 169, multiplied by some power of 10. Likewise $\sqrt{.0169}$ is written $\sqrt{.01|69} = \sqrt{1.69} \times \sqrt{10^{-2}} = 1.3 \times 10^{-1}$.

Squares may also be found by using scales A and E in conjunction with point 1 (C). For example, the dot-dash line (Fig. 4) shows that $\sqrt{1.69}$ (A) = 1.3 (E). The reason? We know that $A = B/C$ and that $B = E^2$. Then $A = E^2/C$. When $C = 1$, $A = E^2$ directly. The same figure shows $4.11^2 = 16.9$, if we use 10 (C) as pole. We have used the equation $A = E^2/10$ in this case, so the answer on A (1.69) must be multiplied by 10 to arrive at the *correct* solution, 16.9.

C and F determine cubes and cube roots directly. Note that F has *three* decades, and we must use the correct one. For example, 2.7 is in the first decade, 27 in the second decade, 270 in the upper decade.

For cube roots of large numbers, first split the number into groups of three digits, beginning with the decimal point. For example, $\sqrt[3]{270|000.} = \sqrt[3]{270} \times \sqrt[3]{10^3}$; also $\sqrt[3]{.002|700} = \sqrt[3]{2.7} \times \sqrt[3]{10^{-3}}$. Then extract the roots.

Part 2 of this article will continue with scale transfer, trig functions, and other topics. TO BE CONTINUED

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THUNDERBOX PARTS HARD TO FIND?

A number of readers have reported difficulties in obtaining the Delco, Triad and Jensen components specified for the Thunderbox guitar amplifier described in the November issue. You can write to Mr. P. N. Cook, Triad Distributor Div., 305 N. Briant Street, Huntington, Ind. 46750; Mr. Hamlin Welling, Delco Radio Div., General Motors Corp., Kokomo, Ind. 46901; and Mr. Frank D. Lintern, Mgr, Consumer Products Div., Jensen Manufacturing Div., 6601 S. Laramie Ave., Chicago, Ill. 60638 for the name and address of their distributors in your area. Or, you can order from the following mail-order supply houses:

Newark Electronics Corp., 500 N. Pulaski Road, Chicago, Ill. 60624
Triad TY-160X Stock No. 4F450 $5.47
Triad R-206B Stock No. 4F453 $10.48

Allied Radio, 100 N. Western Ave., Chicago, Ill. 60680
Triad TY-160X Stock No. 54 D 3536 $5.47
Triad R-206B Stock No. 54 J 3538 $10.48

Harvey Radio, 2 W. 44th St., New York, N.Y. 10036

Delco transistor DTG-110B (Specify that both transistors have the same color code.)	$2.70 ea.
Delco heat sink No. 7270725	$0.90 ea.
1N3209 silicon diode	$1.77 ea.
1N3209R silicon diode	$1.77 ea.
Jensen EM-1250 speaker	$34.62

Plastic Transistors–The Future Billions

The newest type of solid-state package **By KEITH W. BOSE**

THE GROWTH OF SOLID-STATE TECHNOLOGY from the early days of germanium to the silicon field-effect transistor has been marked by lulls and spurts of activity. Now there is another surge of action caused by the introduction of a line of low-cost solid-state devices with plastic encapsulation. The use of plastic makes possible a dramatic price drop in transistors, thus opening new areas to electronics. Industry leaders are saying that by 1971 the world will use close to *two billion* plastic-encapsulated semiconductors.

A silicon field-effect transistor with a retail price of only a dollar is something to think about! The availability of such a low-cost device means more electronic applications in the automotive field. Safety devices and driving aids are simpler to manufacture, for instance.

The immediate use for plastic transistors, however, is probably in hi-fi, TV and electronic organs. One amplifier manufacturer reduced his selling price by two-thirds and found that his sales quadrupled. Even the voracious appetite of computers for solid-state devices is being satisfied with the technique of plastic encapsulation.

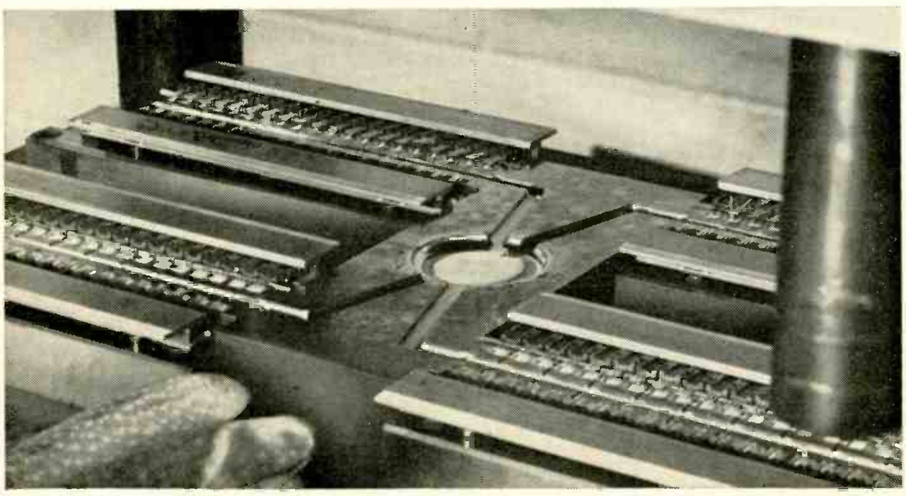
Plastics engineers climbed a long hill before airtight plastic packages became a reality. After 3 years of experience with the technique, engineer George Berryman of Texas Instruments says that "we have found plastic units as reliable as their counterparts in metal cans."

The plastics involved are derivatives of epoxy, that familiar hardware-store glue that provides rock-hard bonding between almost any two substances.

The big problem in transistor manufacture was getting a package that could completely seal off air. This sounds easy, but for chemical reasons it's difficult to form a tight bond between plastic and metal. This bond is necessary where the transistor leads enter the case. It is often said that the semiconductor art has two phases—growing the chip, then packaging it so it will operate. Some solid-state manufacturers send chips overseas, there to be packaged in areas of low-cost labor and then return to the U.S.

Plastic-encapsulated semiconductors are manufactured by either of two processes: the liquid or cast-molding system, or the transfer-molding system. The liquid system uses a "header" of ceramic and plastic to hold the leads. This header is formed from powdered glass and ceramic which is first compressed. A charge of ceramic powder follows a charge of glass, followed by a charge of ceramic in a press die. The powder is then compressed until the chemical binder sticks the whole mass together in a solid form.

The presses used for liquid or cast molding are multiple rotary affairs. The forms are "fired" after lead insertion to form a solid mass. The header, together with the leads fused to it and with the chip connected, is covered with liquid plastic, usually in a mold, then baked. The process is messy. Because the resin must be mixed with a hardener just before use, only small batches at a time are mixed, and proportions are carefully controlled.



This mold is used for compressing the transistor into a rock-hard plastic capsule.

Transfer molding is initially more expensive process, but for volume production it offers more advantages. The process uses a dry-mix compound which is transferred to a hot die by heat and pressure. In the process the mixture goes from a solid to a liquid and then back to a solid state. When finished, the chip is surrounded with only one substance—the plastic—and the leads and bonding wires are embedded to form a highly reliable unit.

When a completely new product is developed, some assurance of its reliability must be established. One way to check reliability is simply to sell the product and wait for the customers to scream. This is certainly no way to keep customers or to introduce new products. The safe method is a laboratory test program. Plastic semiconductors have been heated, cooled, pounded, dropped, and given all sorts of rough treatment. Areas of reliability testing are resistance to moisture and the ability to withstand thermal and physical shock. One other consideration is possible damage to the chip by the plastic itself.

Moisture resistance is tested by using what's called a "Joy bomb." A semiconductor is sealed into the "bomb" along with detergent solution. Hydrostatic pressure then forces moisture through any leaks. The new plastics pass this test with flying colors.

Humidity resistance is tested in a "bowser box"—a test chamber in which temperature, humidity and pressure may be precisely controlled. A common ritual for semiconductor testing is 1,000 hours or longer at 90% relative humidity and +45°C.

In many circuits it is important for a transistor to maintain its parameters within certain limits over long periods of operation. The graphs show a "scatter" plot of I_{CBO} and h_{FE} for one transistor after 1,000 hours of back bias at elevated temperatures and high humidity. The 45° lines represent no change from initial readings. Note the close grouping around this line, showing excellent stability. One company—Texas Instruments—has gathered reliability data from 2 million hours of test operation. It appears that plastic semiconductors are here to stay and, what's more important, at low prices.

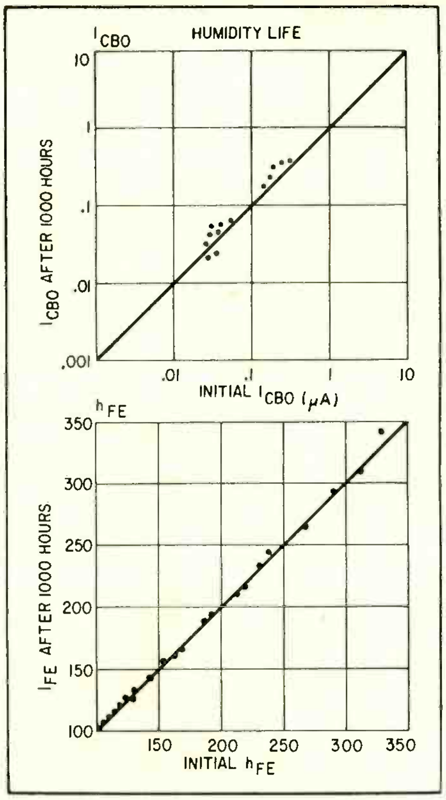
As an example of the low cost of plastic transistors, the small-quantity retail price of the 2N4419 is in the neighborhood of 50¢. This device is one of a line of npn/pnp high-speed low-level switches.

Another good example, now available in quantities of 1–99 at $1.50 each, is the TIP24. Just for comparison, when silicon transistors were first made, around 1960, they sold for $15 or more.

The TIP24 is a 2-amp epitaxial-planar silicon power transistor. It could be a boon for audio. A pair of TIP24's will easily deliver 20 watts. The devices will sell in pairs matched within 20% (I_C = 1.5 amp) assuring minimum distortion in class-B operation. A mounting tab serves as the collector lead of this double-ended low-profile package. This feature allows mounting with only one chassis hole and a sheet-metal screw. In production, it is possible to form the leads and tab for special mounting requirements. Good beta linearity and low saturation voltage is claimed for this transistor, when operated on a 70-volt supply and delivering 10 watts, with 167°F case temperature. With both high voltage and high current, good speaker matching is claimed.

Another low-cost transistor, usable as an oscillator, a multivibrator, a waveform generator or an SCR trigger, is the TIS43. This one will withstand an acceleration of 60,000 times the force of gravity!

Both silicon and germanium transistors are being encapsulated in plastic. Silicon types are valuable because of their reliability. Their high-temperature characteristics are valuable in places like auto radios and solid-state ignition systems where temperatures soar on hot summer days. Germanium can still turn in the best record for performance, however, and for lowest cost it is still the leader.



The effect of humidity on I_{CBO} and h_{FE} in a group of plastic transistors. Straight-line before-and-after plots show stability.

Plastic economy packages are available in both silicon and germanium transistors, field-effect transistors, unijunction transistors, power transistors, silicon rectifiers and integrated circuits. Plastic transistors can be mounted flush on PC boards, reducing the possibility of shorts from excess solder and other production mistakes. One-piece construction leads to increased reliability.

A new plastic IC family of 11 digital circuits (designated 15830N) includes multiple gates, buffers, expanders, binary elements and a one-shot multivibrator. Plastic encapsulation reduces the price of these circuits 25%. Shock and vibration resistance and heat dissipation of these plastic IC's are excellent. The leads are in two rows, spaced 0.3-inch apart and the units are designed for high-speed automatic insertion in PC boards or chassis.

In production quantities the TIXM-12 costs only $1. This is a germanium planar field-effect transistor for vhf mixers and amplifiers. It has low cross-modulation distortion, with a noise factor of 2 dB at 10 MHz.

National Electronics, Inc. (a subsidiary of Varian) is now producing a new low-cost readout driver using plastic transistors. Because the price has been reduced, many industrial users will now be able to use readouts on their production lines. Formerly such devices were considered luxuries by many small industrial plants.

Engineers are saying that there are exciting possibilities in low-cost field-effect transistors. The FET has, of course, a number of advantages over both vacuum tubes and junction transistors. It's high impedance makes it useful in many circuits where ordinary low-Z transistors couldn't be used. Furthermore, the output impedances of the source and drain circuits are roughly the same, which is not true of tube plate and cathode circuits.

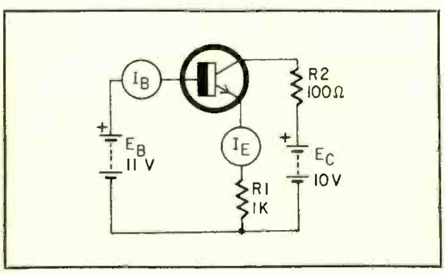
Plastic encapsulation of FET's increases their reliability and lowers their cost. These are two reasons for predicting that FET's will be used more and more in the next few years. Epoxy capsules seem a major step forward in solid-state technology. END

WHAT'S YOUR EQ?

Conducted by E. D. CLARK

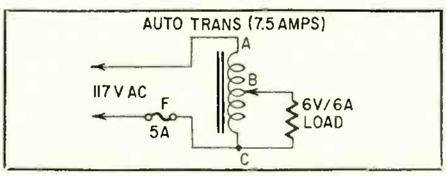
Transistor Current

In the circuit illustrated, forward bias (base–emitter and base–collector)



is 0.5 volt. Is I_B (1) greater than I_E, (2) smaller than I_E, or (3) equal to I_E?
—*Allan C. Schoening*

Current Mystery



In the above circuit, the fuse does not blow. Why not?—*Clarence L. Chinn*

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 puzzles are on page 91.

50 Years Ago

In Gernsback Publications
From March, 1917
Electrical Experimenter

- Using Gas Balloons to Support Wireless Antenna
- A Batteryless Electrolytic Detector by L. Mott-Smith
- Controlling Toys by Radio
- The Quenched Spark Gap by Chas. S. Ballantine
- New Undamped Wave Tuner Has Adjustable Disc Core
- Is Radio Transmission Due to Magnetism? by J. S. Clemens
- Spark Gaps in Running Liquids
- A Rotary Receiver Tuner by Oliver M. Black
- Tri-City Radio Laboratory
- Radio Condenser Hints by Walter D. Scholl

An Experimenter's Transistor Test Set

This easy-to-build and useful tester doubles as a breadboard for experimental circuits

By DONALD R. HICKE*

THOSE WHO WORK WITH TRANSISTORS often need a good transistor test set. If you look through the electronics magazines for the past two or three years you will find several testers described. Some perform simple, go/no-go tests to determine whether the transistor is dead or alive. Others are exotic affairs that could have come only from a professional laboratory and which require an elaborate procedure to test a single transistor. I needed a simple test set for my bench but wasn't satisfied with any of the ones described in published articles.

My biggest objection is that the ordinary tester consists of two batteries and a fixed resistor to supply the base current, and a milliammeter marked in units of *beta* to measure the collector current. Needless to say, this method is not very accurate. More important—it measures the gain of the transistor at only one point. The conditions under which the transistor will actually be used in a circuit may be something else.

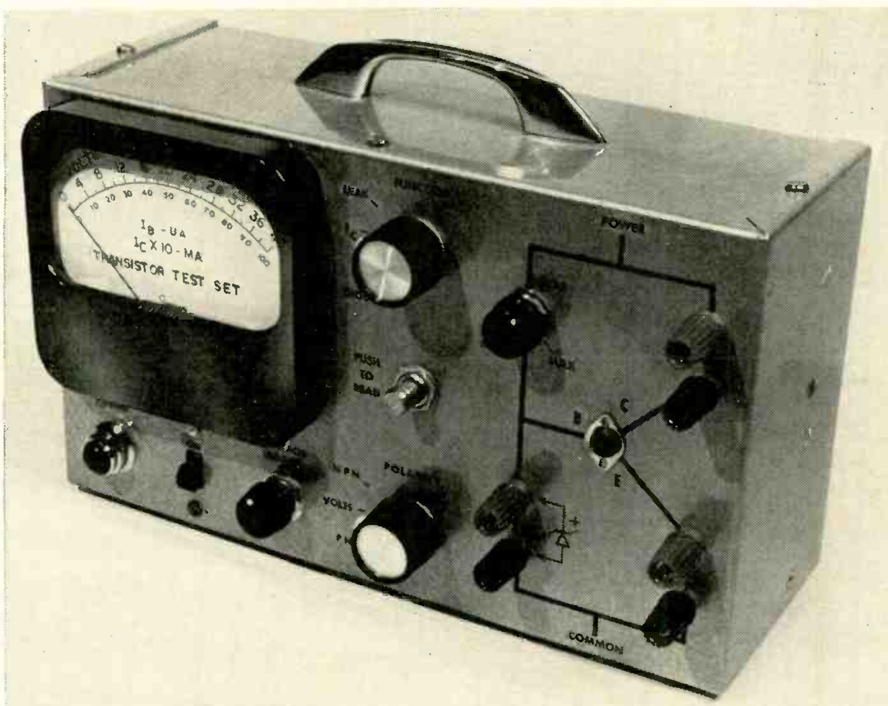
I wanted a test set in which the supply voltage and base current could be set to desired values, and the resulting collector current read on a meter. It looked like the only way to get it was to design and build my own. Since it was impractical to include a battery for every supply voltage that might be encountered, I decided that I needed an adjustable, regulated power supply to cover the range of at least 9 through 22½ volts. Of course a meter and some switches were required to get the power-supply voltage to the transistor and to measure the current flowing through it. Then it seemed a shame to confine the power supply to one little test set, so I added binding-post terminals for external base, emitter and collector resistors. The result was a complete general-purpose transistor/diode test set and breadboard.

How it works

Fig. 1-a shows the circuit used to measure leakage current. Shunt resistor R_S reduces the sensitivity of the meter from 100 μA to 10 mA. It protects the meter from damaging currents in case the wrong power-supply polarity is chosen for the type of transistor being tested. Limiting resistor R_L protects the power supply under this same condition by restricting the total amount of current that may be drawn. R_S is removed from the circuit when the PUSH-TO-READ switch is depressed. If a meter other than the one specified is used, the proper value for the shunt resistor is $R_S = (R_M \times I_M)/(I_T - I_M)$, where R_M is the meter resistance, I_T is 10 mA and I_M is 100 μA. This simplifies to $R_S = .0101\ R_M$. In other words, when you buy your meter to build this test set, simply multiply its resistance by .0101 to get the value of R_S. You will probably have to parallel two resistors to get the exact value.

Base current is applied and measured with the circuit shown in Fig. 1-b. The 2-meg pot in series with the base-emitter junction of the transistor is adjusted to obtain the desired base current. The PUSH-TO-READ switch must be depressed to remove the meter shunt when taking a reading. Unlike most other test sets of this type, no interpretations or approximations are necessary because the meter shows the base current directly in μA.

Collector current is measured by switching to the circuit of Fig. 1-c. This method has an advantage compared to others which have been previously published. Resistor R_M, equal in value to the internal resistance of the meter, is switched into the base circuit when the meter itself is switched out. This eliminates errors which would otherwise result from the change of resistance in the bias circuit. In addition the shunt is arranged so that the meter circuit is opened in case the PUSH-TO-READ switch is inadvertently depressed. This prevents



The black tape lines on front panel make it easy to connect semiconductors for test.

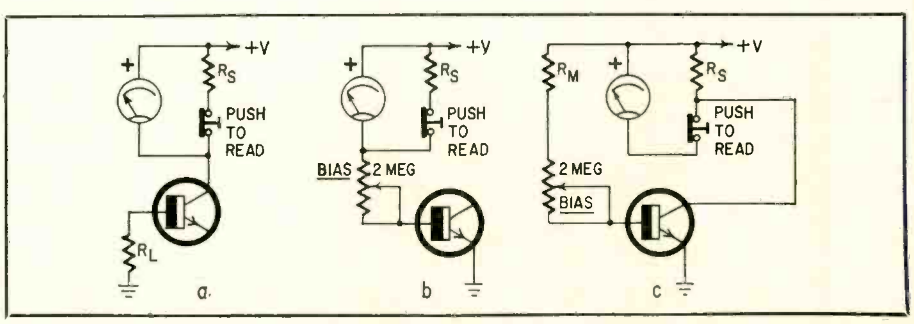
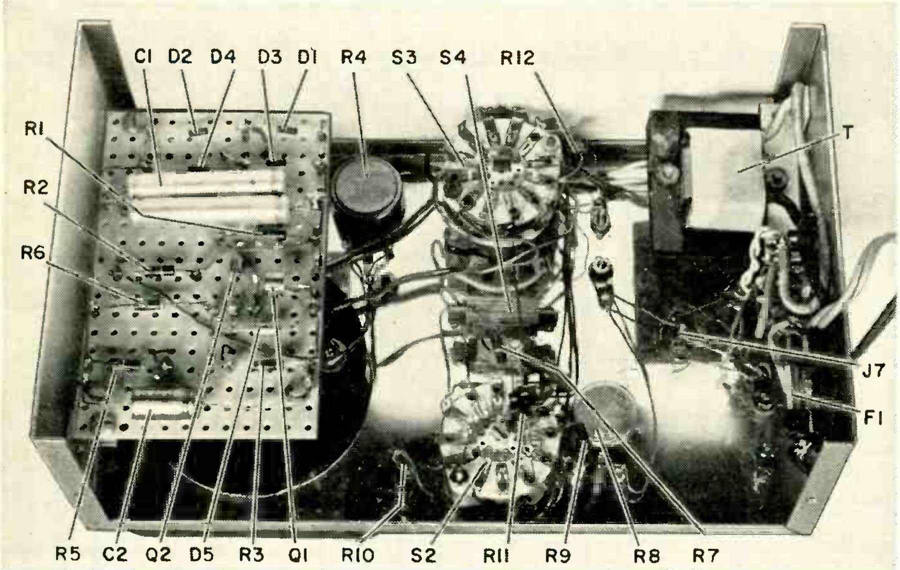


Fig. 1—Three basic circuits: a—leakage, b—base, and c—collector current measurement.

*Brown Engineering Co., Huntsville, Ala.



Parts placement. Punched board is mounted on side of chassis just above meter.

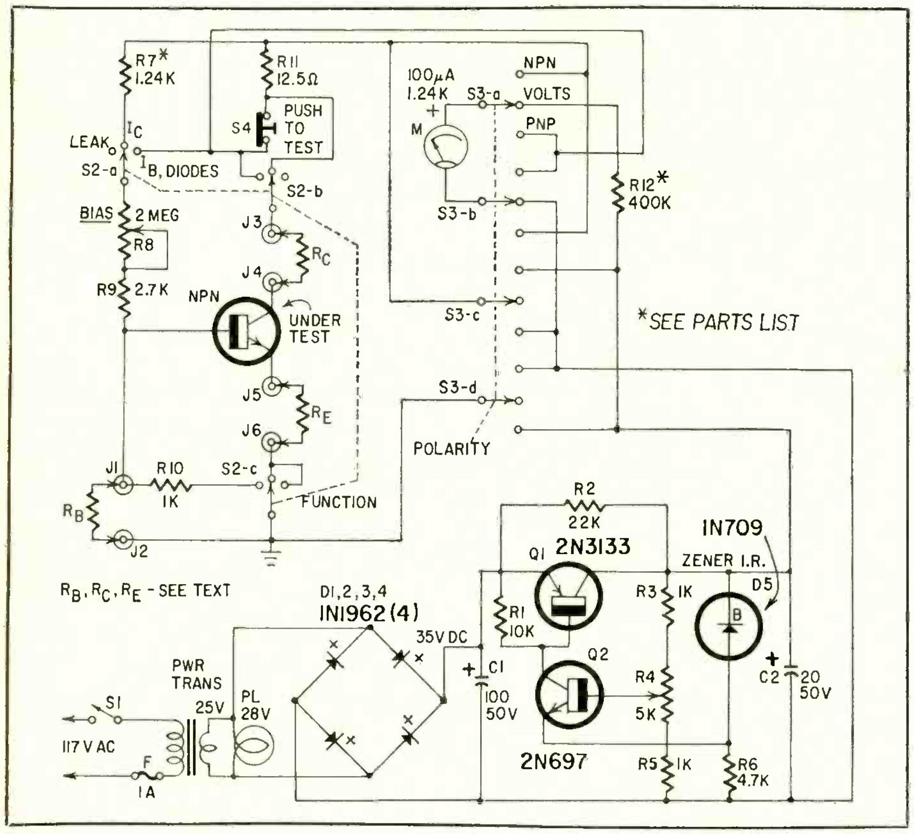


Fig. 2—Wiring diagram shows use of regulated power supply to stabilize measurements.

R1—10K, ½ watt
R2—22K, ½ watt
R3, R5, R10—1K, ½ watt
R4—pot, 5K
R6—4.7K, ½ watt
R7—1,240 ohms, ½ watt, 1% (Aerovox CEC T-0 or equivalent)
R8—pot, 2 megs
R9—2.7K, ½ watt
R11—12.5 ohms, ½ watt, 1% (Aerovox CPSX½ or equivalent)
R12—400K, ½ watt, 1% (Aerovox CPSX½ or equivalent)
C1—100 µF, 50 volts, electrolytic
C2—20 µF, 50 volts, electrolytic
D1, D2, D3, D4—100 volts, 600 mA (G-E 1N1962)
D5—Zener, 6.2 volts, 400 mW, 1N709 or equivalent
Q1—pnp (Motorola 2N3133 or equivalent)
Q2—npn (G-E 2N697 or equivalent)
T1—filament transformer, 25 volts, 1 amp (Knight 54A1421 or equivalent)
M—100-µA 1,240-ohm meter (Knight 52A7202 or equivalent)
S1—spst slide switch (Continental Wirt G323 or equivalent)
S2—3-pole 3-position rotary switch (Centralab 1007 or equivalent)
S3—4-pole 3-position rotary switch (Centralab 1013 or equivalent)
S4—normally closed pushbutton switch (Grayhill 4002 or equivalent)
PL—28-volt lamp
F1—1-amp fuse
J1, J3, J5—red 5-way binding posts
J2, J4, J6—black 5-way binding posts
J7—transistor socket (Elco 05-3301 or equivalent)
Miscellaneous: Lamp socket, fuse holder, 10 x 6 x 3½-in. cabinet, handle.

any possibility of burning out the sensitive meter through improper operation of the test-set controls.

The schematic of the test set is shown in Fig. 2. The power supply is relatively standard. It uses an inexpensive 25-volt filament transformer and a full-wave bridge rectifier to supply dc to the regulator. The output across R6 is always 6 volts less than the regulator output because of the constant drop across Zener diode D5.

The base–emitter current in Q2 therefore depends upon the power-supply output voltage and the setting of pot R4. This current is amplified and taken through transistor Q1, which is the series regulating element, to hold the output constant with variations in load. The output can be varied from 7 to 33 volts. and regulates up to 10 mA over the range of 8 to 30 volts. If the output is accidentally shorted (from experience, I'd say this happens pretty often), Q2 sees zero volts at both its base and emitter. It ceases to conduct, which cuts off Q1 and no harm is done. Resistor R2 is needed to restore the power supply to operation after the short is removed. Capacitor C2 must be relatively small, say 20 µF or so, so that it cannot supply large currents when shorted.

Transistors other than the ones listed may be used, provided certain conditions are met: Q1 must be rated at least 40 volts collector-to-base (BV_{CBO} on most data sheets) and 600 mW dissipation (P_D). Suitable devices include the Motorola 2N1132 and 2N3133 silicon transistors, or the RCA 2N1183 germanium transistor which costs a lot less but is larger in size. Transistor Q2 may be almost any small-signal type with a collector-to-emitter (V_{CEO}) rating of 40 volts.

The power-supply output voltage is monitored on a 0–40-volt scale on the meter by connecting resistor R12 in series with it. A value of 400,000 ohms is correct for almost any meter you might use, because the meter's resistance will be small in comparison.

Comparing Fig. 2 to the simplified circuits in Fig. 1, note the following: R7 is meter-substitution resistor R_M; R10 is current-limiting resistor R_L and R11 is meter-shunt resistor R_S. The resistors labeled R_B, R_E and R_C are connected externally as needed. Also note that, because of the reversal of power-supply polarity when changing from an npn to a pnp, both sides of the power supply must float above ground. This means that all capacitor and semiconductor leads must be insulated from the chassis.

Construction

The size of the test set is determined mainly by two things: the size of the meter used and the space required for the circuits connecting the test terminals. I used a 6 x 10 x 3½-inch metal cabinet and had no trouble fitting everything inside.

The power-supply regulator is wired on a piece of punched circuit board which fastens to one side of the cabinet with small brackets. The transformer and fuse are on the other side. All other components are mounted on the front panel.

The binding-post terminals and the transistor socket are arranged in the form of a common-emitter amplifier circuit and symbolically connected with narrow strips of black tape to simulate the internal connections.

The original meter scale is erased and two new scales added with India ink to read 0–40 for voltage and 0–100 for current. You have to divide by 10 mentally to read collector current to 10 mA, but this is no problem.

The test set shown in the photographs was admittedly built mostly with junkbox parts, especially the meter, rotary switches and power transformer. The components recommended in the parts list, however, are electrically equivalent and in most cases superior to what I used.

Operation

Using the test set is as simple as 1, 2, 3. In fact, there are only three steps:

1. Check leakage.
2. Set base-bias current.
3. Read collector current.

To check leakage, first connect a jumper across the R_C terminals and set the function switch to the LEAK position. Then turn the polarity switch to NPN or PNP as appropriate and depress S4, the PUSH-TO-READ switch. Read the collector-to-base leakage current directly on the 0–100-μA scale. When performing this test be careful not to exceed the BV_{CBO} rating of the transistor that's being tested.

To set base-bias current, complete the emitter circuit by connecting a jumper across the R_E terminals. Turn the function switch to the I_B position and depress S4. Adjust the bias pot until you read the desired base current on the 0–100-μA scale of the meter.

To read collector current, make sure that both the R_C and R_E terminals are jumpered and then turn the function switch to the I_C position. Read collector current in mA by dividing the 0-to-100 scale reading by 10.

Applications

This transistor test set has several useful applications. One of the most obvious is to determine the polarity of an unmarked or unfamiliar transistor. To do this, plug the orphan into the test set and measure leakage. If the meter shows almost full-scale deflection, the transistor is either shorted or is the opposite polarity from that assumed. To tell which, simply turn the polarity switch to the other direction and watch the meter. If it still shows full scale, the transistor is shorted. It should be necessary to depress S4 to get a reading when the correct polarity is chosen. In other words, a full-scale leakage reading means that the collector–base junction is forward-biased or shorted.

Another important application of the test set is to determine how much base-bias current is needed to get a certain amount of collector current. Let's say you are building a circuit where you want 1 mA to flow in the transistor. Set up the test set to read collector current and adjust the bias pot until the meter indicates 1 mA. Then turn the function switch to the I_B position, depress the PUSH-TO-READ switch and read the required bias current directly on the meter. To determine the bias resistance under these conditions, turn the function switch back to I_C, the polarity switch to VOLTS, and remove the transistor from the socket. Then use an ohmmeter to measure the total resistance of R7, R8 and R9 between the J1 and J3 terminals (just follow the taped lines; that's what they were put there for).

The test set may also be used to check Zener diodes. Connect the diode and a voltmeter to the R_B terminals, following the decal for polarity. Set the voltage and bias controls to minimum, the function switch to DIODES (same position as I_B), and the polarity switch to NPN. Slowly increase the bias and then the voltage while watching the meters. The point at which the voltage ceases to increase is the Zener voltage of the diode, and the current reading at that point (don't touch S4) is the minimum Zener current. Continue to increase the voltage to see how well the diode regulates over a range of current.

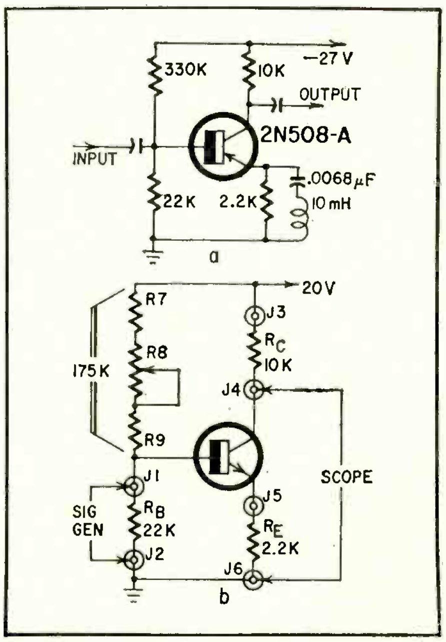


Fig. 3—How to use the test set to breadboard an amplifier. a—Original recommended circuit. b—Modified practical circuit found by experiments with tester.

The forward voltage drop of a regular diode can be checked in much the same way. Connect the diode backward —with the arrow pointing down—and set the bias control for the desired forward current (again, don't touch S4). Read the voltage drop on the voltmeter.

By far the most useful application of this test set, however, is as a breadboard for checking experimental amplifier circuits. Assume that you'd like to make the simple audio amplifier shown in Fig. 3-a from page 276 of the General Electric *Transistor Manual*, seventh edition. Suppose you have an npn 2N3565 instead of the pnp 2N508-A called for. Assume that supply voltage is 20 instead of 27. Simply adjust the test-set power supply to 20 volts; connect the base, emitter and collector resistors to the test terminals and plug in the transistor. Connect a signal generator to the base at terminal J1 and a scope to the collector at J3. Set the function switch to I_C and the polarity switch to NPN. Turn on the signal generator and adjust the bias pot for symmetrical clipping of the output-voltage waveform. Read the value of the needed bias resistor with an ohmmeter, as explained above.

In the example shown in Fig. 3-b, symmetrical clipping was obtained with the bias resistance set at 175K, which resulted in 12 volts at the collector. The output was 15 volts peak-to-peak with 3 volts input. The ac voltage gain is markedly improved by adding a bypass capacitor across R_E. Of course the optimum dc bias point and the maximum undistorted ac output voltage remain the same.

Improvements

Several refinements of this test set can extend its usefulness. The addition of a 1-kHz oscillator would simplify ac voltage-gain measurements. I didn't attempt this in the original model because I have access to an external signal generator.

Another improvement would be to add a second transistor test socket with the corresponding resistor jacks and internal connections to the meter. This would allow the popular two-transistor preamplifier circuits to be breadboarded with ease.

Finally, a second current range of, say, 40 mA would be very useful for checking many transistors and diodes. It would, however, require changes to the power supply and, as a suggestion, an extra position on the function switch called HIGH I_C, or something to that effect. END

Walkie-Talkie Power Booster

Build this outboard linear amp, which can be used with any 100-mW transceiver, and increases transmitting power and range of your rig

By ARTHUR T. CRANE, KHA9543

HAVE YOU BEEN ADMIRING THE RASH of high-powered 1-watt walkie-talkies that have hit the market? Ever thought to yourself, "If only my 100-milliwatter had more power?"

Build this compact piggyback linear amplifier and realize your desire. This transistorized attachment will boost the output power of any 100-mW walkie-talkie by a factor of 25. And 2 watts of undistorted squawk-power is obtained with only one transistor. The cost of parts is less than $30—far less than the cost of a new 1-watter. You also get the bonus of a built-in battery recharger. Many commercial units feature this only as an optional, extra-cost accessory.

Three watts PEP (peak envelope power) is approximately 2 watts average rf output. Look at what 2 watts will do for your transmitting range. A 100-mW transceiver has about 80 mW rf output. With 85% modulation and a good hot receiver such a rig will provide communication up to 2 miles under favorable conditions. The rule of thumb is this: The transmitting range increases as the square root of the output power. Clip on the linear and your output power increases 25 times. The square root of 25 is 5. That means five times greater range, or about two-thirds the range of a mobile CB unit running the legal limit of 4 watts rf output (5 watts dc input).

Strap linear to transceiver back so both push-to-talk switches are on the same side.

This amplifier simply clips onto your walkie-talkie. No butchering is necessary. You can still use 100 mW for close-range communication. For greater range, switch over to 2 watts of power. However, don't forget to use your proper CB call sign and legal operating procedures—*whether you run high power or low*—or you invite an FCC citation. If you don't have a CB license at present, you must get one.

Linear amplification must be used on any signal that carries modulation. This eliminates spurious output (splatter) near the operating channel. This amplifier operates class-B linear, in preference to class A, because of the higher efficiencies possible. The class-A linear can theoretically be only 50% efficient. Class-B linear can theoretically approach 78.8% efficiency.

The 80-mW exciter signal enters the linear through C3 (see Fig. 1). This capacitor must be mounted on the alligator clip at the end of the coax. The purpose of C3 is to match the 50-ohm coax to the walkie-talkie output stage. The base circuit of Q1 is tuned by the parallel network L1–C1. C2 determines the level of rf drive applied to the base. The collector output circuit is somewhat unconventional, but loads well. The short 55-inch whip presents a highly capacitive reactance to the collector circuit. This is tuned out by L2. Collector tuning is accomplished by C4; antenna loading by C5.

The battery recharging circuit economically extends battery life. While zinc-carbon and manganese-alkaline batteries cannot actually be *recharged* (they are dry cells), they can be "rejuvenated" somewhat—if they are caught before they run down too far. Manganese-alkaline cells can be rejuvenated more times than the ordinary zinc-carbon variety. A rejuvenated battery will deliver about one-half the energy per charge of a new one. Thus an overnight recharge can bounce the batteries back for more service dozens of times. A word of caution, however: start with a fresh set of batteries. Old batteries that have deteriorated through chemical action cannot be satisfactorily rejuvenated.

Constant-current charging is employed. Diodes D1 through D4 constitute a full-wave bridge rectifier circuit. The 60-Hz reactance of C10 limits the charging current to 35 mA. Diode D5 blocks the collector supply from discharging through bias network R1 and R2. C6 and C9 isolate the chassis from the charging circuit. Since one side of the rectifier bridge is common with the line, C6 and C9 eliminate a potential shock hazard. No attempt is made to

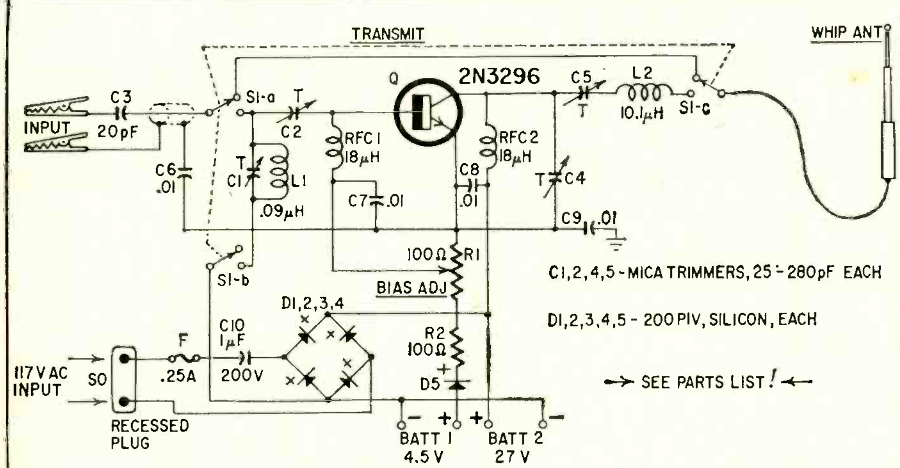


Fig. 1—Complete schematic of the linear amplifier. Ac plug is TV chassis type.

Parts List

- C1, C2, C4, C5—mica trimmer, 25–280 pF, (Arco-Elmenco 64 or equivalent)
- C3—20 pF mica
- C6, C7, C8, C9—.01 μF disc ceramic
- C10—1 μF, 200 volts, Mylar
- D1, D2, D3, D4, D5—200 piv silicon
- F—1/4 amp fuse
- L1—.09 μH coil consisting of 4 turns of #18 wire on a form 3/8 inch long and 1/4 inch in diameter
- L2—10.1 μH coil consisting of 30 turns of #18 wire on a form 1 5/16 inches long and 1/4 inch in diameter
- Q1—Motorola 2N3296 or equivalent
- R1—linear pot, 100 ohms, 1/2 watt, (Bourns 3067-S or equivalent)
- R2—100 ohms, 1/2 watt
- RFC1, RFC2—18 μH, (J. W. Miller 9310-42 or equivalent)
- SO—recessed plug, (Cinch-Jones 2RP or equivalent)
- S1—3pdt pushbutton type, (Switchcraft FF-1009 or equivalent modified as described in text)
- ANT—55-inch replacement whip for walkie-talkie, (Dunwell A-2 or equivalent)
- Miscellaneous: Case, 5 1/4 x 3 x 1 1/2 inches, (LMB 531 EL or equivalent); 10 inches of RG-58/U; 2 alligator clips; 1 5-point terminal board; 1 2-point terminal board; TV-type ac cheater cord; nuts and bolts; 21 manganese-alkaline cells, (Eveready E92 or equivalent).

See July p 4

recharge the three bias cells, since they will outlive the rejuvenated collector-supply batteries anyway.

Construction is simple and straightforward. A standard metal utility box is used as the housing to give the finished unit a professional appearance with a minimum of effort. First, lay out and drill all the holes in the housing, following Fig. 2. Next, fabricate the battery box from .030-inch sheet aluminum. Fig. 3 is the pattern.

Push-to-talk switch S1 must be disassembled and modified to conserve space. Take the switch stack completely apart. Reassemble it as shown in the photo. The bottom section (S1-b) should be reassembled as it was, with one exception: Remove the normally closed (N.C.) blade. The next deck supports both S1-a and S1-c and each blade is supported by only one mounting hole. The overhanging unused "hole" should be clipped off with diagonal cutters. Shape the fiber blade actuators slightly with a file and mount them in Y-fashion, as shown. It will, of course, be necessary to trim off the cylindrical plastic screw insulators and switchstack mounting screws to complete the modification properly.

Install the rubber grommets, and assemble all the bolt-together hardware. Don't install the antenna until after the wiring is completed. Insulate the battery compartment by lining it with electrical tape.

Proceed with the wiring, being careful to avoid getting the transistor and diodes too hot. The input and output coils (L1 and L2) should be mounted so they're off the chassis and at right angles to each other, minimizing feedback. All rf component leads should be kept as short as possible. Install the antenna and you've completed the amplifier and charger wiring.

Special care must be exercised in assembling the rechargeable battery pack. The batteries are soldered together to conserve space and reduce cost, even though battery makers don't recommend soldered connections to their batteries.

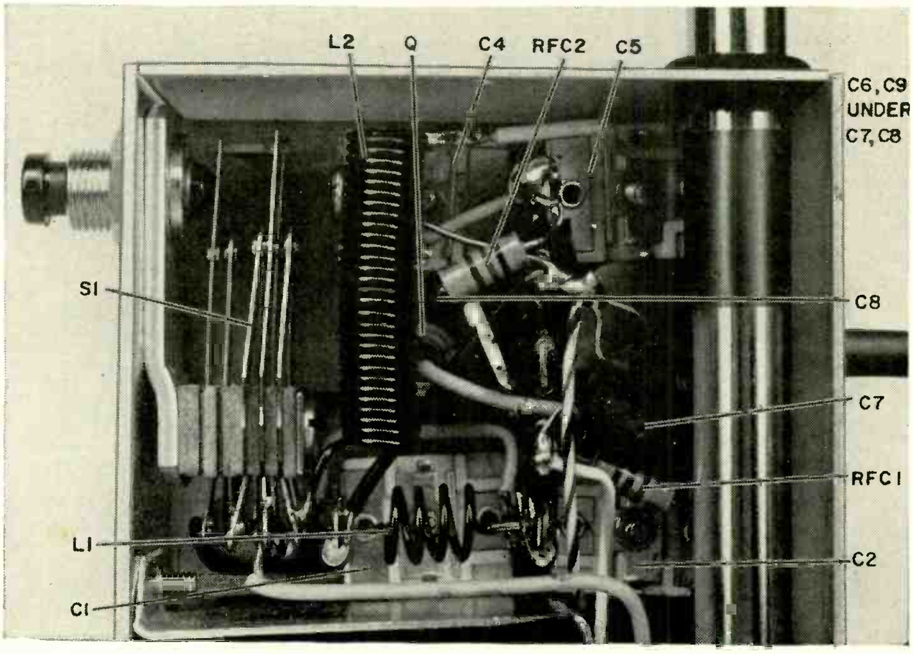
The center electrode of a manganese-alkaline cell (minus post) is the most difficult to solder to. Excessive heat softens the plastic seal, and at the same time generates steam within the cell, destroying the seal. The cell will then short itself out, and may possibly rupture from internal pressure buildup. Such ruptures are not usually violent, but will allow corrosive potassium hydroxide to attack the amplifier. I found it best to rough up the battery posts with sandpaper first. Then tin a small spot (approximately ⅛ inch in diameter) in the center of each post. Use a hot iron and work fast (no longer than 1 second). Pretin the wires before attempting to complete the connections. The batteries can then be easily "tacked" together with less danger of damaging the cells.

Install the batteries in the battery compartment and complete all connections with the exception of the +27-volt lead. Bring the +27-volt battery lead and the B+ lead from the amplifier temporarily outside the bottom of the case, for tuneup measurements. Insert a 0–10-mA meter between these leads ("+" lead of meter to +27-volt battery lead).

The transistor must now be properly biased so that it operates within its class-B linear range. Short the alligator clips at the end of the input coax leads to eliminate any possible input signal. Initially set the wiper of R1 to the ground-bus end. Depress S1 and adjust R1 for a meter reading of 4 mA. That's all there is to the bias adjustment.

Now the linear is ready to be tuned up for on-the-air operation. Change ranges on the milliammeter so that it will read up to 250 mA. Collapse the walkie-talkie whip and to it clip the input coax from the linear. The linear whip must, naturally, be fully extended. Tuneup is best done with an absorption-type wavemeter (a grid-dip oscillator in the "diode" position). The S-meter on your CB rig will work just as well if the CB antenna is removed and a one-turn pickup link substituted. This is necessary to avoid blocking your receiver and pegging the S-meter.

continued on page 66



Here are details of switch S1 after modification, and placement of some components.

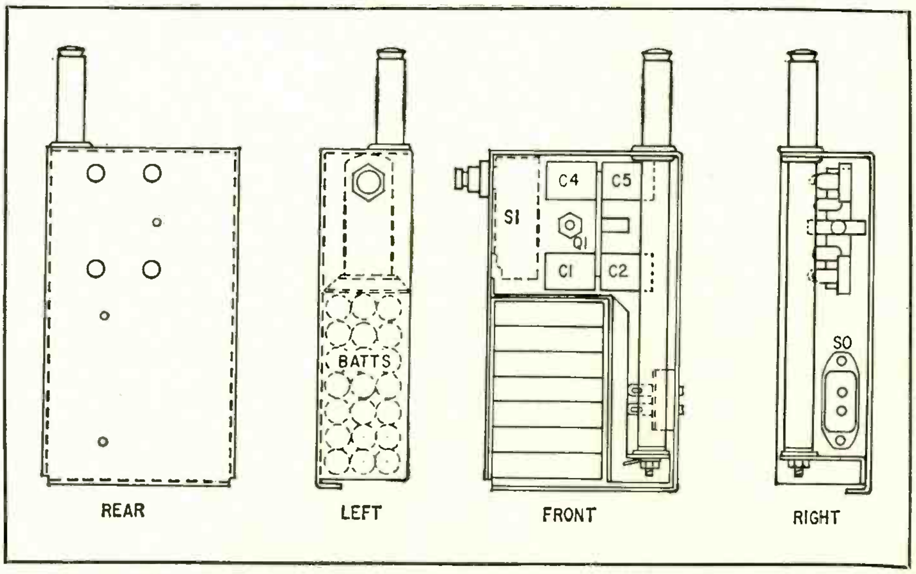


Fig. 2—This shows layout of components and mounting holes in the amplifier cabinet.

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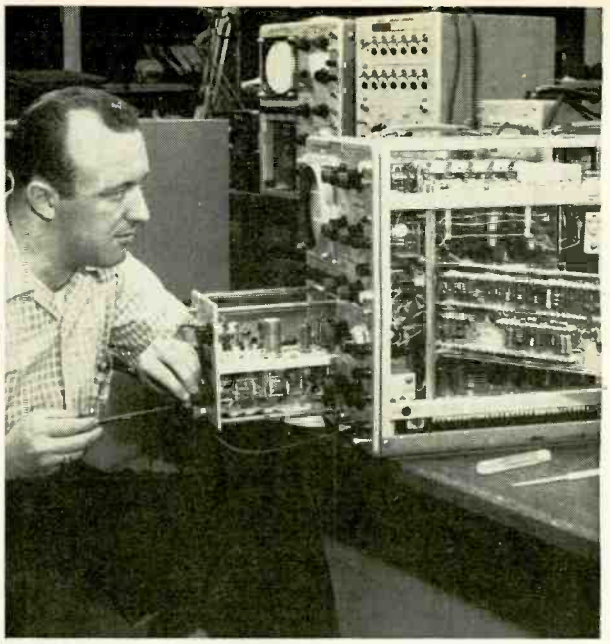

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- Automatic Controls
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- Industrial Electronics
- Nuclear Instrumentation
- Solid State Electronics
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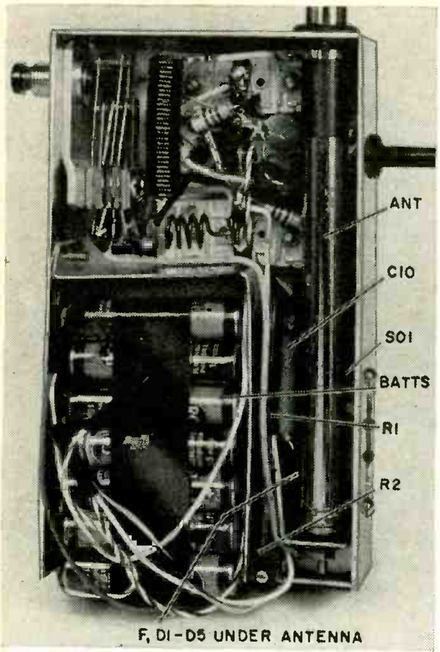
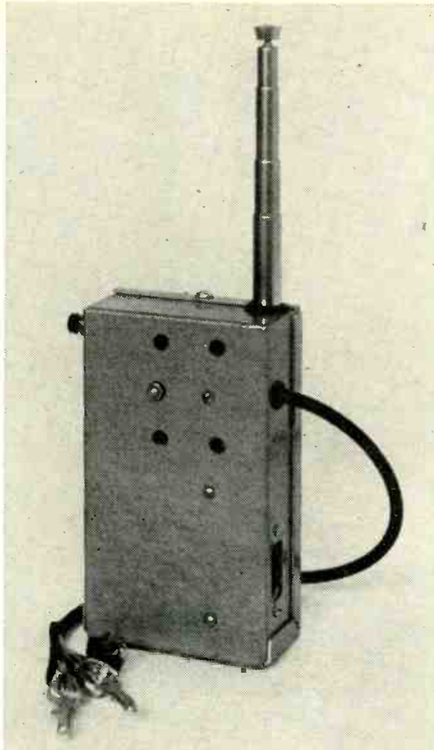


Arrangement of batteries in compartment. Use plastic tape as retaining strap and it will be easier to solder wire connections to the cells. Taped wire splices are necessary because a milliammeter must be inserted at this point for bias setting.



The finished amplifier. Chassis-mounted ac plug is used to rejuvenate batteries.

Position the whip on the linear close to the wavemeter coil or one-turn pick-up link. Depress both transmit buttons (S1 on the linear and its equivalent on the walkie-talkie. Now adjust C4 and C5 for maximum rf power indication consistent with minimum collector-current indication on the 250-mA meter. Next adjust C1 and C2 to bring the collector current to 150 mA. Repeat the process at least once, since all adjustments interact somewhat. Be wary of very large increases of indicated rf power output resulting from small adjustment changes, as this indicates that the linear has broken into oscillation and is spuriously radiating an uncontrolled signal. Tuneup is now completed. Remove the milliammeter, solder the wires permanently together, and install the chassis in the case.

After you've completed the linear, you should have it checked to see if it meets the requirements of Part 95 of FCC Regulations. Since your walkie-talkie will now be used as a licensed CB transmitter, oscillator frequency must be stable to within .005%. Rf output from the linear must not contain modulation over 100%, and spurious or off-channel radiation must be suppressed to certain limits. Anyone who's skilled in making such measurements, who holds an FCC commercial radiotelephone second-class (or better) license, and who has access to the necessary equipment, may check your rig. Once he's made the tests, the licensed technician should furnish you with a written certificate, stating that your transceiver complies with Part 95 of FCC Rules. If you already have a CB license, keep the certificate with it; the FCC may ask to see it.

If you have no CB license, you'll have to get one. You can write to the Federal Communications Commission, Washington, D.C. 20555, and ask for Form 505. Fill out this application and attach to it the certificate on the linear. On Form 505, list the make and model of your transceiver as "composite crystal-controlled." You might also list the make and model of the 100-mW transceiver.

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3. Crane, Arthur T., "Low Voltage Power Supply," *Electronic Design*, April 12, 1965.
4. Yeagle, F. D., "How Much Can You Get Out of a Recharged Cell?" *Product Engineering*, March 28, 1966.

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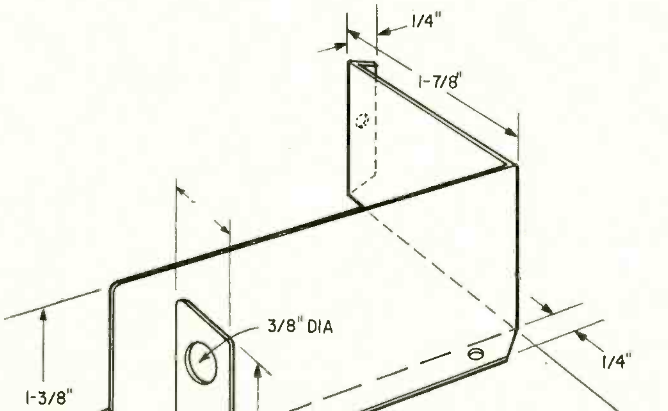


Fig. 3—Follow pattern and make battery retaining bracket of .03-inch aluminum.

FCC Issues Warning

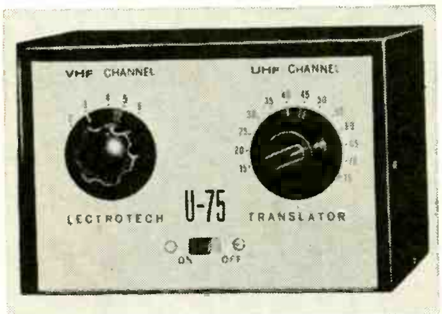
Just before Christmas 1966, the FCC reminded persons buying walkie-talkies of rules governing their use. Only transceivers with 100 mW or less of dc input to the final rf amplifier may be used license-free. Such units may be used to communicate only with other license-free transceivers. If there is communication with licensed CB stations, the 100-mW unit must also be licensed as a CB station.

When buying a transceiver, check the certificate (usually on the back or inside of the case). If certified under Part 15, the unit may be used license-free; if under Part 95, a CB license is required.

EQUIPMENT REPORT

Lectrotech U-75 UHF Translator

Circle 25 on reader's service card



HERE IS A SOLID-STATE UHF TRANSLATOR cut just about to the bare essentials. It does a good job, even a better job than some more elaborate ones—under certain conditions.

This translator does not use any vhf amplification but does have a tunable vhf input that permits a good match to the translator section. No amplification means the input signal must be quite high (Lectrotech suggests it should be at least 2,500 μV) for a good clean output. Since there is no vhf oscillator in this translator, the uhf dial calibration is valid only if the input is at 69 MHz. This means that if the input is on channel 2, 3, or 4 the uhf calibration will be slightly high, while on channel 5 or 6 it will be slightly low. You will have no problem if you realize it's normal.

The lack of a vhf oscillator is an asset since it eliminates a source of beats that could be a problem—especially when you interconnect translators and vhf signal generators to align uhf television receivers.

I connected the U-75 to a uhf TV set and to an outside antenna. The pictures could have been better; but, considering that where I live the vhf input signal is usually below 500 μV and never reaches 2,500 μV, the results weren't surprising.

I left the uhf side connected but hooked the vhf input to a color-bar generator with output on channel 3. I got a good dot/bar and color-bar pattern on uhf. The adjustment of the vhf input control was slightly critical, though not intolerably so.

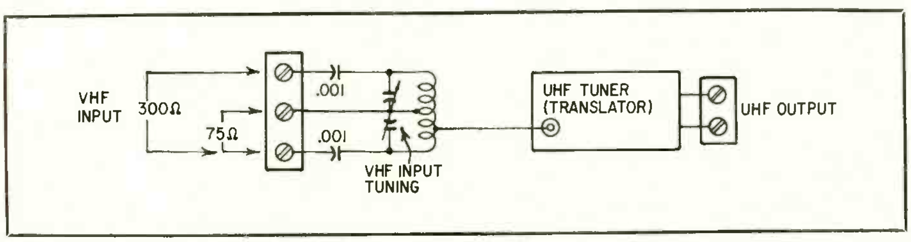
The diagram is a schematic of the vhf input circuit and a block diagram of the translator section. Note that vhf inputs for both 75 and 300 ohms are provided. This permits using either coaxial cable or twin lead. Of course the 75-ohm input is best for most signal generators.

A planetary tuning system on the uhf translator section moves the dial rapidly after a quarter-turn of the small knob. During the first quarter-turn, the tuning speed is much lower, for easy fine tuning.

The translator should be a useful piece of gear for any technician in a uhf area—especially so if he also happens to live where vhf signals are strong. But I think it's even more desirable for use with test equipment since beats are absent even with a strong signal input. One thing that may be a little critical with some uhf tuners is the length of wire between the translator and the set. Test this by grabbing the twin lead and noting whether there is a drastic change in picture output. If there is, shorten or lengthen the lead and try again. Even a slight change in length will usually cure the trouble, particularly on one specific channel.

The U-75 operates on a self-contained 9-volt snap-on battery.—*Wayne Lemons*

Price: $39.50



TWO MYSTERIES OF SCIENCE . . .

lightning phenomena and UFO's will both be explored in a comprehensive article by our science editor. If you want to be prepared for strange things you may see in the sky this summer, read "Lightning, Plasmas, and Balls of Fire" in

April RADIO-ELECTRONICS

67

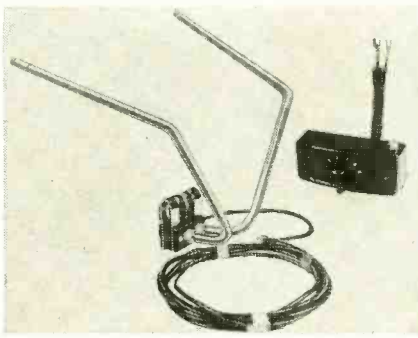
Auto TV Antenna

Circle 28 on reader's service card

SPREADING ITS DIPOLES IN THE GRACEful appearance of lengthy horns on a gazelle, JFD's new model ATV111 television antenna clamps on the window glass of an auto. The "horns"—the chrome-plated dipoles—extend neatly above the car top.

Inside, the 72-ohm coaxial lead plugs into a small plastic "black box" that fastens to the television receiver. Besides matching the coaxial lead-in to the 300-ohm antenna input of the set, the black box has a six-position switch that helps eliminate directional ghosts.

I tried the ATV111 in a moving car and as an indoor antenna clamped to the rear cover of a color set. It's easy to clip over the door glass or to any thin flat object. I ended up clipping it on a piece of Masonite screwed to my workbench.



As an indoor rabbit ears, it worked fine on all black-and-white channels. Even drew acceptable uhf pictures. It pulled good color on the low channels, but color was weak on the higher channels. I checked at the receiver's video detector with a scope; the burst was just too weak on the high bands even though signal strength measured fairly good.

On a b-w portable in the car, the ATV111 ran circles around the set's built-in antenna. On the highway it was great, though it had a tough time coping with ghosts in the concrete canyons of Manhattan. The switch took care of curves and turns on the road.

With 12-volt transistorized portables becoming so popular in cars and on boats, the ATV111 will probably be popular, too. A back seat full of small children on a long trip has always been a problem for motoring parents. This antenna and a portable TV will keep the kids busy.—*Larry Allen*

Price: $19.95

Mercury 1800 Vom

Circle 30 on reader's service card

THE VOLTOHMMETER IS GOING TO BE even more popular in the future than it is now. Although I used to use mine mostly as a portable tester to be carried in my truck for use in homes, cars, etc., it's going to be more and more of a bench instrument. Provided with proper ranges, the vom can be a great time-saver in the shop, for big color sets and all kinds of transistor work.

The Mercury 1800 is one of the new breed of vom's. It has all the standard ranges, with new ones added at top and bottom. The lowest dc range is 0.25 volt, full scale, followed by an 0–1-volt range. These are our bias-reading scales for transistor equipment. With the fully isolated vom, we can take voltage readings between base and emitter, without having to worry about possible "hot" grounds.

At the top, an 0–5,000-volt range has been added. This is just right for focus voltages on color tubes. Their voltages run from 3,500 to 5,000—the average seems to be around 4,500 volts, which is the bogie value for most color CRT's.

The Mercury 1800 has a full-wave bridge meter rectifier for ac voltage ranges: 0–2.5, 0–10, 0–50, 0–250, 0–1,000 and 0—5,000, at 5,000 ohms per volt. Don't forget you can use this vom on the ac scale for making gain checks, signal-tracing tests in transistor radios and stereo amplifiers, with an audio signal generator as a source of constant signal.

The ohms scales go up to a 20 megs full scale. The lowest ranges are powered by a 1.5-volt battery, making the vom safe for any transistor or diode. The R × 10K range uses only a 6-volt battery, and even small transistors will handle that. The high ohms scale is useful for finding diodes with a nice high front-to-back resistance ratio, and so on.

The 1800 has a dc range from 10 amps, handy for modern car radios, down to 50 μA. The 10-amp range is good for finding off-bias conditions in car radios, as well as in high-powered stereo amplifiers with transistor outputs. The microamp scale is useful for a lot of things—reading test currents in two-way radios, grid currents, and any other test which requires high current sensitivity. (With a diode, it makes a handy little field-strength meter for tuning up peanut-size CB handie-talkies!)

The 0–1-mA scale is fine for reading high-voltage regulator cathode-current ranges in color sets. The 0–10- and 0–100-mA ranges suit any kind of transistor radio, and the 0–500-mA scale reads horizontal output tube cathode currents in any TV, b-w or color.

This meter has one thing, rarely found in vom's, that I like: calibration adjustments! Inside the case, at one end of the parts board, there are three pots: one for low ac volts ranges, another for high ac volts, and the third for dc.

The 1800 is rated at 2% accuracy on dc voltage and current ranges, and reads true rms on ac voltages. All dc scales are at 20,000 ohms per volt, with ac at 5,000 ohms per volt.

A dB scale with four ranges is provided for output measurements. The zero-dB point on the lowest range equals 0.775 volt across a 500-ohm load. This function is handy for checking channel separation in stereo equipment. By setting one channel output at any desired dB level, you can read the output of the other channel, and so on. The dB scale is read directly, adding a certain amount each time you go to a higher scale. The 250-volt scale, for example, adds 40 dB to the scale reading.

The instrument is surprisingly light. PC board construction is used, and the case is made of what looks like a more flexible, tougher plastic than the old ones. (I didn't quite dare drop it to see, but it does look as if it would stand a pretty good jolt without cracking.) A leather handle on top makes the 1800 easy to carry, and can be tucked under for use as a rest on a bench.

The meter is big enough to see from a good distance; it has a 5-inch rectangular face. For what it will do, and by comparison with meters I have used, the Mercury 1800 is a lot of meter for the money.—*Jack Darr*

Price: Kit, $26.95.
Wired, $34.95.

END

Quick-Checker for Controlled Rectifiers

A project for testing SCR's, Triacs, GTO's, etc. **By DON ANGLIN**

ALTHOUGH AN OHMMETER CAN BE USED to check the condition of most semiconductors, a silicon controlled rectifier can't be checked by making resistance readings. The SCR (triode thyristor) is a three-junction (pnpn) device. Not all the junctions are available externally for testing, and an SCR will not conduct in the forward direction unless the breakover voltage is exceeded or a proper gate voltage is applied.

In testing, our primary objective is to find out whether the SCR will do its job. Will a small current fed to the gate properly control a large current in the anode circuit? If it will, the SCR is good. The checker will not furnish enough current to damage the most delicate controlled switch, yet it tests SCR's with anode current ratings up to 110 amps. It will check GTO's, Transwitches and Trigistors for turn-on sensitivity.

An economical way to check an SCR is to connect it in a standard lamp dimmer circuit (making sure not to exceed maximum voltage and current specs). If the SCR controls the lamp brilliance, it is good. If the lamp glows brightly at all times, the SCR is shorted. If the lamp cannot be turned on at all, the SCR is open or has low gate sensitivity.

The basic lamp dimmer circuit used is shown in Fig. 1. This simple gating circuit will furnish conduction angles only from 90° to 170°. A more elaborate circuit, which could control from 0° to 180° is not necessary for our purpose. There will be current through the load only when the SCR is "on," since the lamp is in series with the anode. Diode D admits only positive half-cycles to the voltage divider R1–R2 so that the gate–cathode junction will not be damaged by reverse bias. Resistor R1 limits the maximum forward gate current to a safe value. R2 controls the forward bias applied to the gate. Waveforms at the gate, at the anode and across the load are shown in Fig. 2.

For the waveforms in Fig. 2-a, R2 is set so there is not enough gate voltage during any part of the cycle to fire the SCR. Therefore, there is no current through the load and the voltage from the transformer appears on the anode during the full cycle.

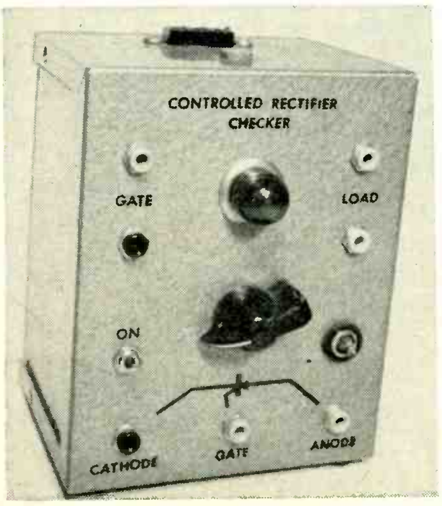
For Fig. 2-b, R2 is advanced so that the SCR just fires (minimum conduction angle). The applied voltage is present on the anode until the SCR fires (point A). Then the anode voltage drops to practically zero, and the applied voltage is across the load until the current through the load falls below the holding current of the SCR and allows it to turn off (point B).

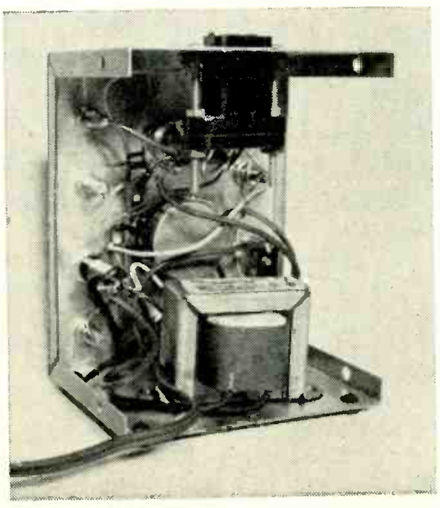
For Fig. 2-c, R2 is at maximum, the SCR turns on about 10° after the anode goes positive, and conducts during most of the positive half-cycle. Note that the applied gate voltage never goes appreciably over the gate firing value because, once the SCR has fired, the gate-cathode is a forward-biased pn junction with a nonlinear voltage–current characteristic.

The complete Controlled-Rectifier Checker is shown in Fig. 3. It is a half-wave lamp dimmer operating from a filament transformer. Since only 6.3 volts is applied to the SCR being tested, and the maximum average current is less than 100 mA, low-voltage, low-current SCR's and controlled switches may be tested safely. D, R1 and R2 furnish a variable gate signal to the SCR being tested, and the load lamp (I1) will be out when R2 is fully counterclockwise unless the SCR is shorted. As R2 is rotated clockwise, the gate drive is increased until the SCR fires and the lamp glows. Low-current SCR's require only a small gate current to fire, and the load lamp will glow when R2 is rotated about 30%. Larger (35- to 110-amp) SCR's will not fire until R2 is at 70% to 80%. As R2 is increased, the conduction angle of the SCR increases, and the lamp gets brighter. R2 can be calibrated and used to compare gate sensitivities of different SCR's.

S2 is used only for checking bidirectional triode thyristors, such as the Triac. When S2 is open, D allows only positive pulses on the gate, protecting the conventional unidirectional thyristor from being reverse-biased. The bidirectional thyristor is a five-layer (npnpn) device, and will conduct on both halves of the ac cycle provided it is gated on during positive and negative half-cycles. Closing S2 shorts out D and furnishes a bidirectional gate signal for checking the Triac. Do not press S2 when testing conventional SCR's.

The checker is built in a 3 x 5 x 4-inch two-piece aluminum box. Parts layout is not critical. Transistor socket (SO) is used for small SCR's and CS's. The anode, cathode and gate terminals are also brought out to tip jacks (J1, J2 and J3) so that clip leads can be used for checking larger controlled rectifiers. A deep-well transistor test socket (such as Pomona TS-187) is handy for SCR's with long leads and can be wired in





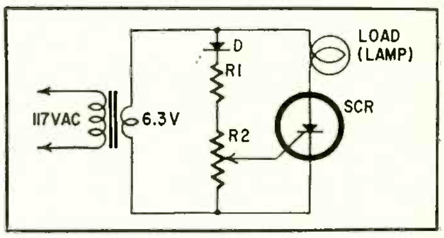


Fig. 1—Basic idea behind the checker: a simplified lamp-dimmer circuit. R1 is necessary to limit forward gate current.

Photos show (left) the completed tester in case, with symbol lines on panel to show connections to input jacks, and (right) parts mounting within the chassis.

A THYRISTOR BY ANY OTHER NAME . . .

The terminology manufacturers use to describe their thyristors is sometimes confusing. Basically, the four-layer thyristors can be grouped into two categories. First are the triode thyristors which can be turned on by a gate signal, after which the gate no longer controls the anode current. These are the semiconductor equivalent to the thyratron tube, and are generally called *controlled switches* if they are low-power devices, *silicon controlled rectifiers* if they can control large currents. The second group can be turned on *and off* by gate signals. Low power devices in this group are typified by Transitron's Transwitch and the Trigistor by Solid state Products, although some manufacturers use the terms *gate-turnoff switch* or *gate-controlled switch* (GCS). The high-current SCR's which can be turned off at the gate are generally called *gate-turnoff controlled rectifiers,* abbreviated GTO.

Tetrode thyristors are similar to conventional triode thyristors except that all four layers of the semiconductor are brought out to external leads, and the fourth lead is another control electrode. Examples are the *silicon controlled switch* (SCS) by General Electric and the Binistor by Transitron.

Another device you may encounter is the Dynaquad made by Tung-Sol. It is a low-power germanium npnp device which can be turned on and off at the gate. Signal polarities required are opposite to those for pnpn silicon devices. It must have a negative voltage on the collector and a negative signal on the gate for proper operation. **Do not use this tester to check the Dynaquad. The gate signal has wrong polarity.**

parallel with SO. Thyristor basing diagrams are shown in Fig. 4.

The gate signal has been brought out to J4 and J5, and the voltage across the load is available at J6 and J7, so that an oscilloscope can be used to monitor the control action of the SCR being tested. Fig. 5-a shows the waveform across the load at the minimum conduction angle, and Fig. 5-b shows maximum conduction angle. Fig. 6-a shows the waveform across the SCR (J5 to J7). Fig. 6-b shows the gate waveform at minimum firing angle. Note the abrupt voltage change when the SCR fires. (Transients like this can cause radio interference if allowed to get back into the ac line. Therefore they must be suppressed.) END

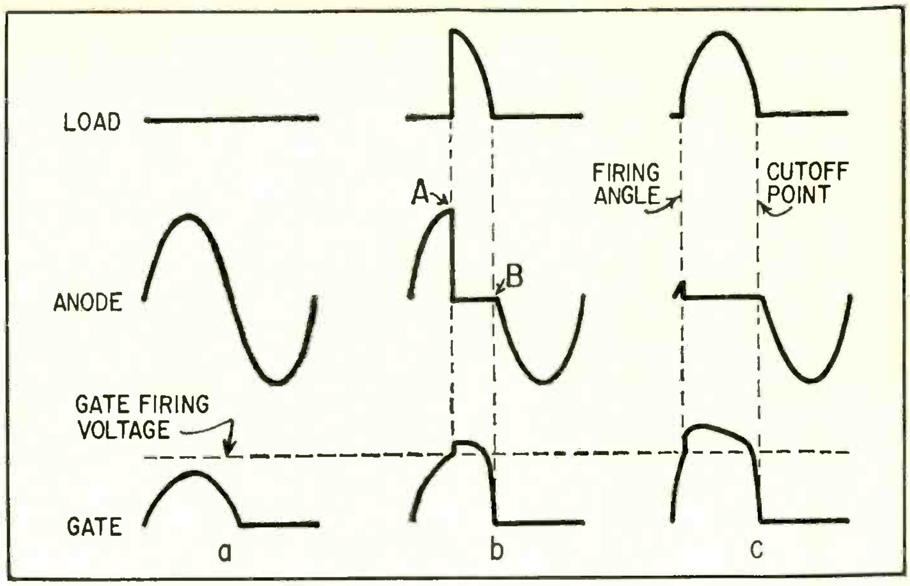


Fig. 2—These waveforms show what occurs inside the checker for three settings of R2.

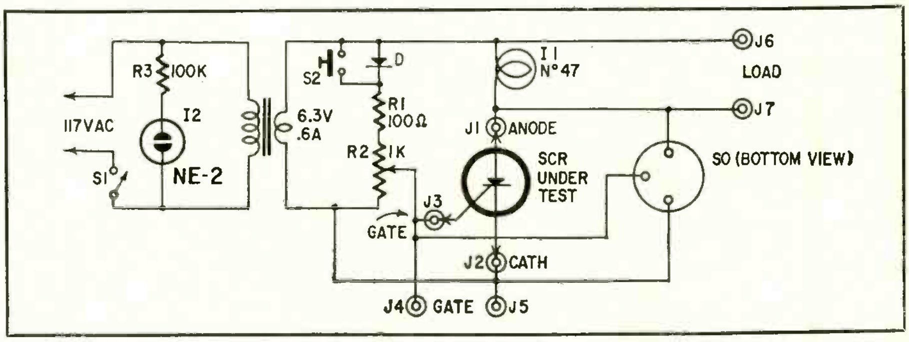


Fig. 3—Complete schematic of the checker. Gate signal at J4-J5 is for scope display.

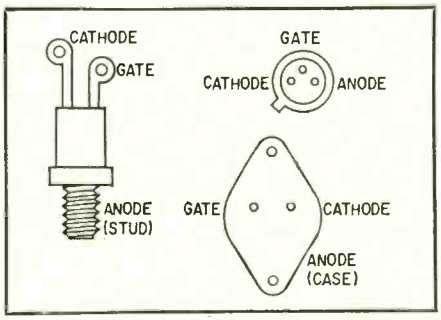


Fig. 4—Three thyristor-terminal layouts.

D—silicon rectifier, 50 volts, 750 mA or better (1N536 or equivalent)
I1—No. 47 pilot lamp (6.3 volts, 0.15 ampere)
I2—neon lamp (NE-2 or similar)
J1–J7—tip or banana jacks
R1—100 ohms, ½ watt
R2—pot, 1k, linear taper
R3—100k, ½ watt
S1—spst toggle switch
S2—spst pushbutton, normally open
SO—transistor socket (Elco 05-3301)
T—filament transformer, 6.3 volts, 0.6 amp (Stancor P6465 or equivalent)
Two-section aluminum cabinet, 3 x 4 x 5 inches
Miscellaneous hardware

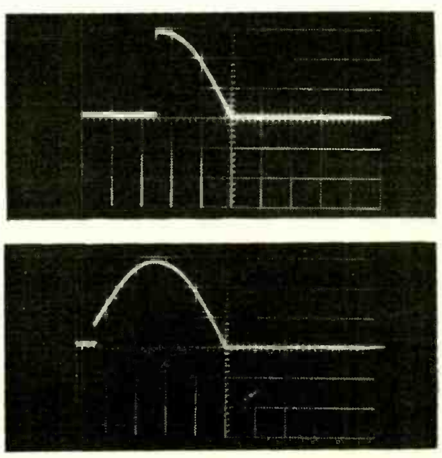


Fig. 5—Waveform across load at minimum (a) and maximum (b) conduction angles.

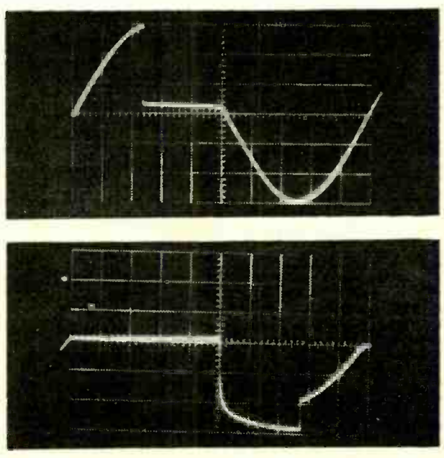


Fig. 6—Waveform across the SCR (a) and at gate (b) at minimum firing angle.

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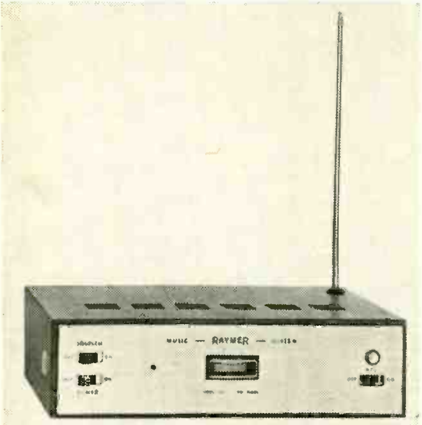
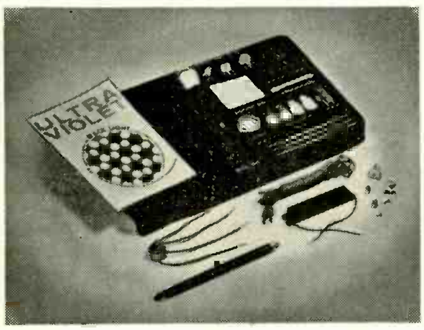
More information on new products is available free from the manufacturers of items identified by a Reader's Service number. Turn to the Reader's Service Card facing page 72 and circle the numbers of the new products on which you would like further information. Detach and mail the postage-paid card.



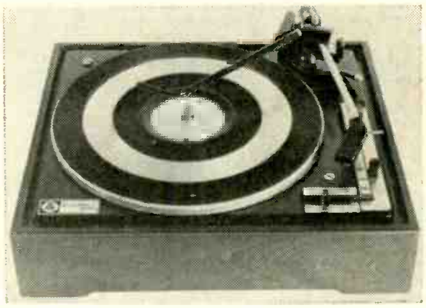
SEMIFIXED 1-FREQUENCY FM TUNER, *model 651,* for use with wireless microphones and wireless musical instruments employing 88–108 MHz. Tunable. Positive squelching automatically silences audio when transmitter is turned off or signal-to-noise ratio falls below usable level. Reproduces 20–20,000 Hz. Separate output jacks. Plug-in vertical antenna, connections for external antennas of 72 and 300 ohms. One 6CH8A tube, three 6AU6 tubes, silicon transistor, silicon diode, silicon power rectifier, three germanium diodes. Tan metal cabinet. Also available in standard rack panel. 9½ x 7 x 12$^{15}/_{16}$ in. $85.—**Truetone Electronics, Inc.**

Circle 46 on reader's service card



"BLACK LIGHT" KIT, *stock No. 70,256,* for variety of ages and interests. Contains 6W filter-type black-light bulb, starter, switch, electrical connections, power cord and complete instructions. Invisible water paints and ink, 3 brushes, pen, tracer powder, fluorescent crayon and flourescent minerals. Book of 40 experiments. $14.50.—**Edmund Scientific Co.**

Circle 47 on reader's service card

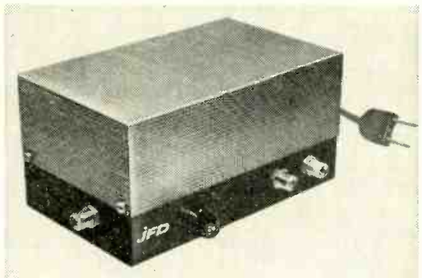


AUTOMATIC TURNTABLE, the *MacDonald 500.* Stylus pressure controlled by micrometer-like settings, 1/3 gm adjustment 0–6 gm. Pickup arm supported by horizontal ball-bearing pivots. Specially designed mechanism protects arm against accidental overload. Mono or stereo cartridges. Arm locks automatically when machine turns off. Finger-lift for single-record play. Automatic shutoff and repeat. Cuing lever permits pickup arm to be raised or lowered in any spot without record or stylus damage. 7-, 10-,

75

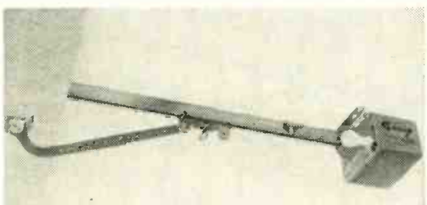
12-in. records at 15, 33, 45, 78 rpm. Dynamically balanced, hum-shielded, 4-pole ac motor. 11-in. turntable.—BSR (USA) Ltd.

Circle 48 on reader's service card



TV/FM ANTENNA DISTRIBUTION AMPS, *model HBV2* for 300-ohm; *model HBV-75* for 75-ohm; up to 4 sets. Up to 7 dB to each set. Etched-copper circuit boards with poly-U sealant. Two frame-grid, low-noise tubes for vhf. Perforated gold housing, black base, bracket for vertical or horizontal mounting. Protective felt pads. Operation on 117 Vac at 20W. *Model HBV2*, $29.95; *model HBV2-75*, $34.95.—**JFD Electronics Co.**

Circle 49 on reader's service card

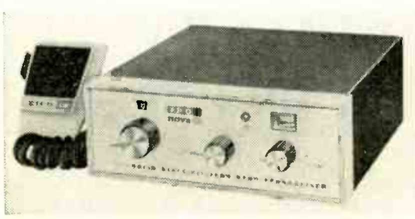


RADIO-CONTROLLED GARAGE-DOOR OPENER, the *Genie model 401*. One-piece cover removable with single screw. Front-mounted circuit components. Built-in time delay for garage light. Pushbutton or pocket-sized remote-control radio transmitter actuates unit. *Model AR-15* radio receiver with nuvistor tubes automatically activates motor on *Genie 401*.—**The Alliance Manufacturing Co.**

Circle 50 on reader's service card

ANTI-STATIC RECORD SPRAY, *Kleer-Tone No. 1632-6S*. Safe for all records including old shellacs. Nonflammable. Cleans and lubricates with silicone film, prevents static buildup. Spray-cleans needles and cartridges.—**Colman Electronic Products**

Circle 51 on reader's service card

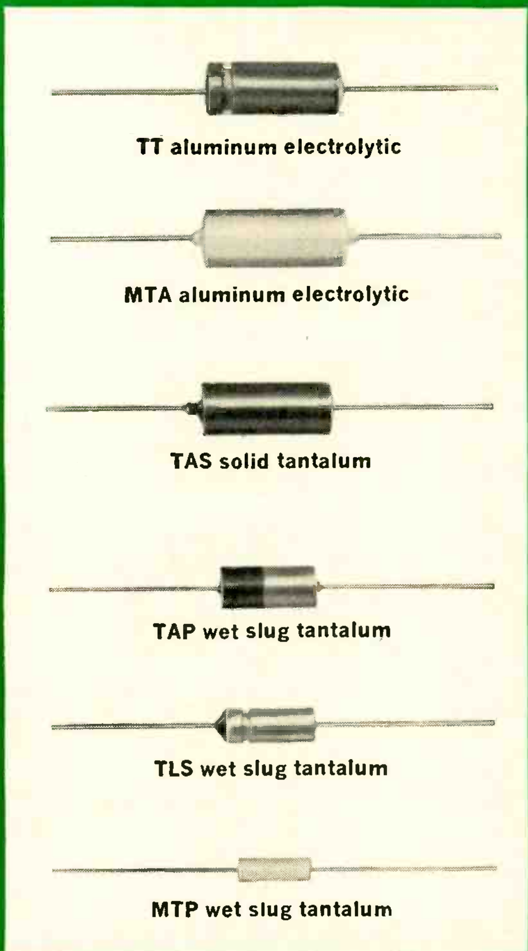


23-CHANNEL 5W CB TRANSCEIVER, *model 7923, the Nova-23*. Dual-

MALLORY Tips for Technicians

Which miniature electrolytics for transistorized AM-FM radios?

COMPARATIVE SIZES OF CAPACITORS ALL RATED 10 MFD., @ 25 WVDC
(shown actual size)



The new portable AM-FM radios are so compact you wonder how they get all those components into that little box. You wonder even more when you have to replace some of the parts.

Electrolytic capacitors, for example. The original electrolytic usually turns out to be a tiny thing jammed in among a dozen other midget gidgets. Getting it out is a trick in itself. Getting a suitable replacement is even tougher! And unfortunately, you're apt to need replacements, because many of these tiny capacitors just aren't much good. They don't meet the quality specs of good domestic capacitor makers. But high quality domestic capacitors are often just a bit too big to fit in the space available.

What's the answer? Search the town for another "little-bitty" original capacitor? Tell your customer you can't finish the job?

Don't give up. We have a few suggestions.

First, try a Mallory TT aluminum electrolytic. This is a real quality capacitor, rated 85°C, and it's pretty doggone small. Or a Mallory MTA, a revolutionary molded case aluminum electrolytic with excellent quality at low-low price.

If neither of these will fit, try a Mallory tantalum capacitor. The TAS solid tantalum is about the same size as the TT, but it's rated 125°C. Need still smaller size? Take a look at the Mallory "wet slug" tantalum types TAP and TLS—and the super-miniature MTP, which gives you the most microfarads in the smallest size of anything on the market. The pictures at the left show you comparative sizes, all for a 10 mfd, 25 WVDC rating.

Sure, you'll pay a little more for the tantalum capacitor. But not as much as you might think. The TAP only costs 42c more than the TT, in the rating shown. And you get the utmost in reliability.

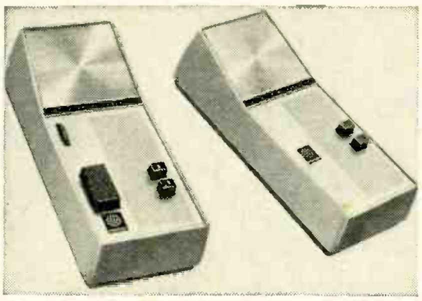
We certainly don't expect you to use a tantalum capacitor to replace every aluminum electrolytic. But they come in mighty handy sometimes. And you can get them when you need them from your Mallory Distributor. Ask him for our latest catalog, or write to Mallory Distributor Products Company, a division of P. R. Mallory & Co. Inc., Indianapolis, Indiana 46206.

DON'T FORGET TO ASK 'EM—*"What else needs fixing?"*

Circle 111 on reader's service card

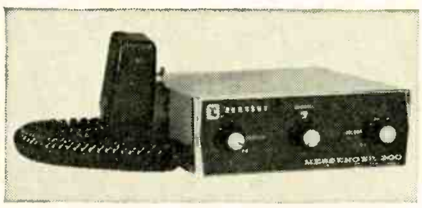
crystal lattice filter. Frequency synthesizer. Sensitivity less than 0.5μV for 10 db S/N ratio; squelch adjustable to 1 μV. Automatic noise limiter. 100% modulation of driver and rf power amplifier; noise-cancelling microphone. Rf output 3.2 W. Push-to-talk operation. Converts to 3.5W PA system. 12-Vdc negative- or positive-ground power supply. Optional 117-Vac power supply (model 791). Military-type modular PC construction. 8 x 3 x 8¼ in., 7 lb. Wired only, $189.95.—**EICO Electronic Instrument Co., Inc.**

Circle 52 on reader's service card



2-STATION INTERCOM, *model FIC-3*. Output 2W. Heavy-duty transistorized circuitry, pushbutton operation. *FI-3* master unit and *FIC* indoor remote station with 50 ft of 3-conductor cable. A second remote station, either indoor or outdoor, may be added. Sealed, self-cleaning French Isostat switches, silvered contacts. Power supply is separate. Can be powered by external battery. Indoor remote station has "beep" signal to call master unit and a "privacy" button. In private operation, remotes cannot be monitored. For desk or wall. *Model FID* outdoor remote station and other accessories optional.—**Fanon Electronic Industries, Inc.**

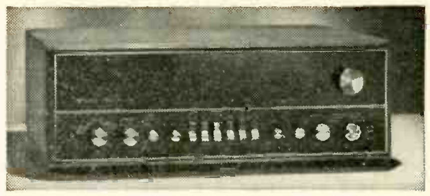
Circle 53 on reader's service card



CB TRANSCEIVER, the *Messenger 300*. 12-channel, solid-state. Precision crystal filter in receiver reduces adjacent-channel interference. Multistage noise-limiting circuit; speech compression in transmitter; plug for *Tone Alert* selective-calling system. 12-Vdc operation. Mobile mounting bracket. Push-to-talk microphone and crystals for 1 channel. Two accessory power supplies enable unit to be used as base station or portable unit. $189.95.—**E. F. Johnson Co.**

Circle 54 on reader's service card

SOLID-STATE HI-FI RECEIVERS, the *Nocturne Two Hundred, Two Ten*, and *Seven Twenty* (shown). New MOS FET front ends. Tuning scale, meter and



stereo indicator all light up when receiver is on, disappear behind panels when off. *Two Hundred* is an FM stereo receiver, 50 watts IHF; *Two Ten* an FM stereo/AM 50-watt receiver; *Seven Twenty* an 80-watt FM stereo receiver. *Seven Twenty's* usable FM sensitivity, 1.8 μv. Frequency response: 5–60,000 Hz at 1 watt, 8–40,000 Hz at full power. Push-button on-off, tape monitor, tone-control defeat, scratch, rumble, interchannel muting and contour switches, headphone jack; 2-system stereo-speaker selector. *Two Hundred, Two Ten* have switches for stereo in 2 rooms separately or simultaneously. All-transistor.—**Harman-Kardon, Inc.**

Circle 55 on reader's service card

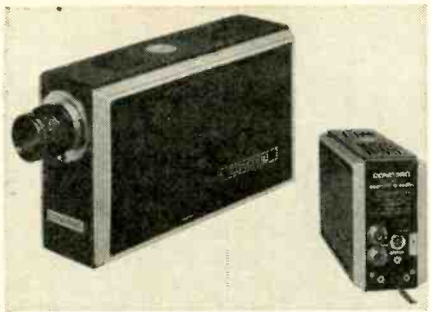
SOUND COLUMN, *No. 3113*. Range 50–18,000 Hz. 3 woofers, 1 tweeter in line arrangement. Power capacity 50 watts. Sound spread over wide area, both vertical and horizontal; gives constant audio level. Adjustable impedances with built-in transformer 16–500 ohms.—**Audio Div., American Geloso Electronics, Inc.**

Circle 56 on reader's service card

BREADBOARDING, IC KITS, cover *Series 74* TTL, *Series 73* DTL digital logic circuits, *Series 72* operational amplifiers. Include variety of basic IC's as well as breadboarding sockets. Sample diagrams for converter, counter, adder, amplifier applications; device data; catalog of more than 125 digital and linear circuits. Two of kits contain 7 and 8 IC's each, 4–6 breadboard sockets. Third kit, 4 amplifier circuits, 2 sockets.—**Texas Instruments Inc., Semiconductor-Components Div.**

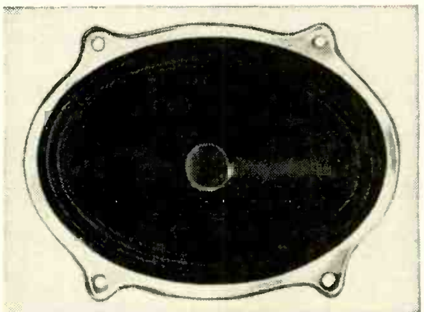
Circle 57 on reader's service card

HEAVY-DUTY CCTV CAMERA, *model MCT-15*. High-sensitivity vidicon tube; simultaneous rf, video output. Solid-state. Automatic adjustment to changing light conditions. Equipped with f1.8 lens. Picture resolution 550 lines. Tube life expectancy 3,000 hr or more. Intercom jack for 2-way audio communication. Circuitry automatically adjusts to changes in line voltage. Scanning frequency: horizontal, 15,750 Hz; vertical, 60 Hz. Scanning sys-



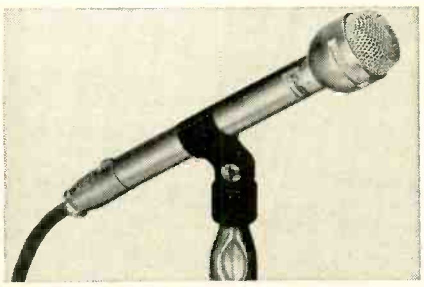
tem: random interlace; synchronizing system: synchronous to ac power line. Video bandwidth: 6 MHz. Rf carrier frequency: 76–88 MHz (tunable to channels 5, 6). Output impedance: 75 ohms; output voltage: rf, 30 mV; video, 1.4V. Power requirements: 105–130V, 60 Hz, 5 watts. 3 x 5 x 9½ in. 6 lb.—**Concord Electronics Corp.**

Circle 58 on reader's service card



AUTO REPLACEMENT SPEAKERS, new series in 5 x 7-in. and 6 x 9-in. sizes. *Model 57CMS-7*, 1.47-oz magnet, 5W; *model 57EVS-7*, 2.15-oz magnet, 6W; *model 69EVS-7*, 2.15-oz magnet, 8W; *model 69FOS-7*, 3.16-oz. magnet, 8W; *Model 69F3S-7*, 4-oz ceramic magnet, 8W. All 5 models have 8-ohm voice coils.—**Oxford Transducer Co.**

Circle 59 on reader's service card



SUPERCARDIOID MICROPHONE, the *RE15*, for professional applications. Frequency response virtually independent of angular location of sound source. Sound rejection up to 26 dB at 150° off axis. Internal mechanical-nesting construction, *Acoustalloy* diaphragm. Frequency response 60–15,000 Hz; output level –55 dB. "Bass tilt" switch. High-quality broadcast-type cable, *model 310* stand clamp. Steel case, satin-nickel finish. $153—**Electro-Voice, Inc.**

Circle 60 on reader's service card

COLOR TEST ADAPTER, *model 2712*, for measuring cathode current of 6JS6 and 6JM6 horizontal output tubes. Alligator test leads run from interrupted

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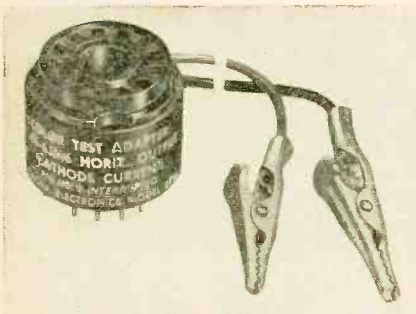


pin 2 of adapter. Unit installs between tube and tube socket. $3.95.—**Pomona Electronics Co., Inc.**

Circle 61 on reader's service card

CB MOBILE ANTENNA, the *MACH III*. Spiral, printed-circuit coil, water proofed, shock-suspended. Wing-shaped ornamental base made of tough plastic of type used in auto racing bodies; black satin finish, silver trim. Mounted with or without shock spring. Dc-grounded, essentially flat at center frequency, SWR 1.3:1 across band. 32-in. stainless-steel whip may be bent in circle without setting. Base adjustment for tuning.—**The Antenna Specialists Co.** END

Circle 62 on reader's service card

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

ELECTRONIC TEST ACCESSORIES CATALOG, *General Catalog 11-66*. 31 pages, looseleaf-punched. Alphabetical–numerical index. Illustrations, diagrams, specs, applications.—**Pomona Electronics Co., Inc.**

Circle 63 on reader's service card

2-WAY RADIO BROCHURE, *Instant Communications for Your Men on Foot*. Information on *HT series Handie-Talkie* 2-way radios. Description, illustrations, applications, accessories.—**Motorola C & E, Inc.**

Circle 64 on reader's service card

DATA SHEET ON HAND-SIZE VOM, *No. 71066-R*. 2 pages, looseleaf-punched. Describes battery-operated *model 666-R* vom. Photos, specifications.—**Triplett Electrical Instrument Co.**

Circle 65 on reader's service card

DYNAMIC MICROPHONE FREQUENCY-RANGE CHARTS, *How the Sonotone Microphone Covers the Range of Audible Sound*. 2-color charts illustrate frequency ranges of 3 latest dynamic microphones. 3-hole-punched. 11 x 16¼ in.—**Sonotone Corp.**

Circle 66 on reader's service card

TOOL CATALOG, *No. 266, Tools for Electronic Assembly and Precision Mechanics*, 58 pages, handbook size. Describes over 1,500 items. Special solder section. 4 pages of technical information on tool selection.—**Jensen Tools and Alloys**

Circle 67 on reader's service card

SEMICONDUCTOR DIODE TABULATION, 18th edition of *Semiconductor Diode and SCR Characteristics Tabulation*. Contains complete product line of 142 manufacturers. Technical information on approximately 50,000 electronic devices. Type numbers and major characteristics.—**D.A.T.A., Inc.**

Circle 68 on reader's service card

1967 TEST EQUIPMENT CATALOG, 16 pages. Illustrates complete line of test and repair instruments. Tube testers, solid-state color generator, vtvm, vom, component substitutor, CRT tester–activator, in-circuit capacitor tester, signal generator. Includes wire-it-yourself kits.—**Mercury Electronics Corp.**

Circle 69 on reader's service card

COLOR RECEPTION AID, 16-page booklet to help boost antenna rotor sales. Explains non-technically how color TV and FM reception can be boosted with a rotator. Excellent handout piece.—**Cornell-Dubilier**

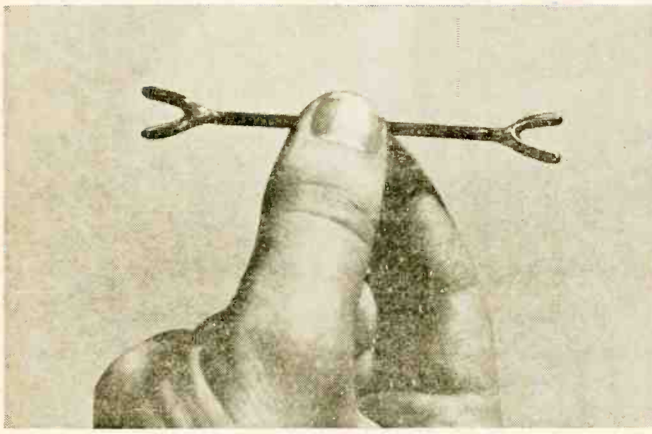
Circle 70 on reader's service card

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

FET REFERENCE GUIDE, the *FET Fact File*, 250 pages in file folder. Complete, up-to-date FET reference material. Application notes, circuit ideas, performance data and design curves, reliability data, detailed specifications. $5.—**Texas Instruments Inc., P.O. Box 5012, Dallas 22, Texas**

END

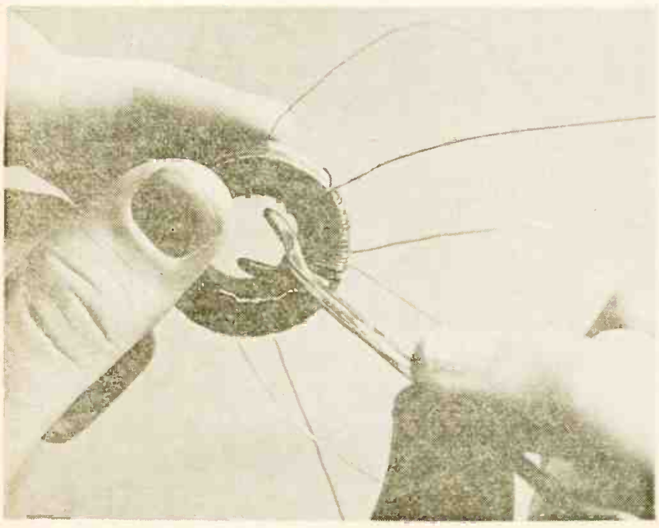
A SIMPLE WINDING AID FOR TOROIDS



HAVE YOU EVER TRIED HAND-WINDING A TOROID BY REPEATEDly pulling long lengths of wire through the center hole of the toroid's core? If you have, you will certainly appreciate the double-ended "witching stick" shown above. It is a simple shuttle which will vastly simplify the laborious process of hand-winding toroidal transformers and inductors.

You can make the shuttle from a steel coat hanger. Cut the shuttle's three pieces to size, scrape off the paint, bend the pieces as shown, and solder. The soldering can be simplified by carefully pinning the pieces to a length of wood covered with aluminum foil. Make your shuttle to fit the size of toroid core you are using. The device in the photo has an overall length of 3¼ inches with forks about ⅜ inch wide. It was designed for cores with an inside diameter of $^{11}/_{16}$ inch. After soldering the pieces, use a small file and emery paper to smooth all sharp edges . . . and it's finished!

To use the winding aid, merely wrap the necessary length of wire about the tines and pass the whole shuttle assembly



about the core as shown in the second photo. Bifilar-wound coils can also be made by simultaneously winding two lengths of wire on the shuttle. With this device, neater coils can be made in less time with less chance of wire kinks, snags and snarls.—*Donald Null* END

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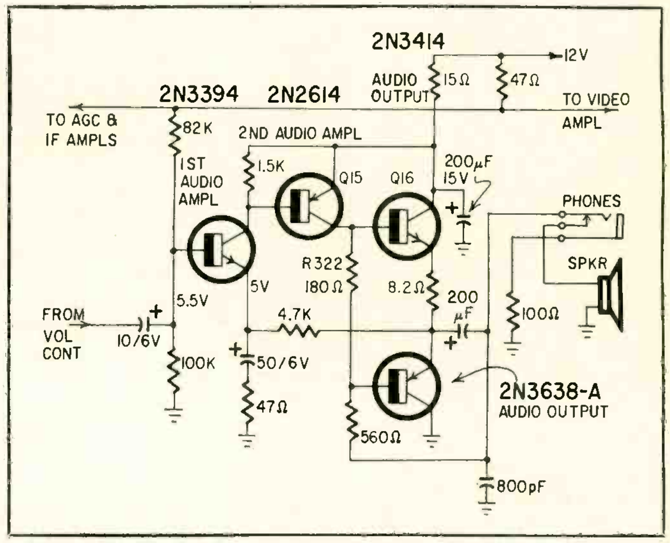
TECHNOTES

G-E TB CHASSIS—AUDIO DISTORTION



Audio distortion, resembling a raspy speaker, may be caused by crossover distortion in Q15 and Q16 due to component tolerance buildup. To correct this trouble, replace R322 (180 ohms, 10%) with a 220-ohm 10% ½-watt resistor. If a 10% resistor is not available, select the proper value with an accurate ohmmeter. Do not exceed 240 ohms or the output transistor ratings will be exceeded.

—*G-E Service Talk*

VERTICAL TROUBLES—ADMIRAL C2227X

The set came in with poor vertical linearity. The picture was compressed at the bottom. The linearity control worked okay but the height control did not. Similar troubles on other sets led me to the grid circuit of the vertical output tube.

The coupling capacitor checked okay on my in-circuit capacitor checker so I directed my attention to the capacitor in series with a resistor between the grid and ground. The capacitor checked out good, so I disconnected one end so I could get at one end of the resistor with my ohmmeter. After checking the resistor I, as a matter of course, touched the ohmmeter prods to the capacitor. The pointer climbed to 10 megohms and stopped. The capacitor was leaky.

After the capacitor was replaced, there was plenty of range in the height and linearity controls, and I was able to get a perfect circle on a test pattern.

This job taught me a lesson. In-circuit capacitor testers are useful but not infallible—particularly in high-impedance circuits. Now, I always lift one end of a capacitor before testing.—*Alvin Dargel*

G-E SB AND SC CHASSIS

Buzz, distortion and narrow sound-tuning range can be caused by a poorly crimped seam on the shield can for the sound i.f. interstage transformer (L301) or the quadrature coil (L302). A poor crimp can cause circuit detuning that varies with heat, age and looseness of the crimp.

Prior to sound alignment, and in all complaints involving these sound problems, run a bead of solder along the seam on the cans of L301 and L302. These shield-can seams are soldered in late production models.—*G-E Service Talk*

END

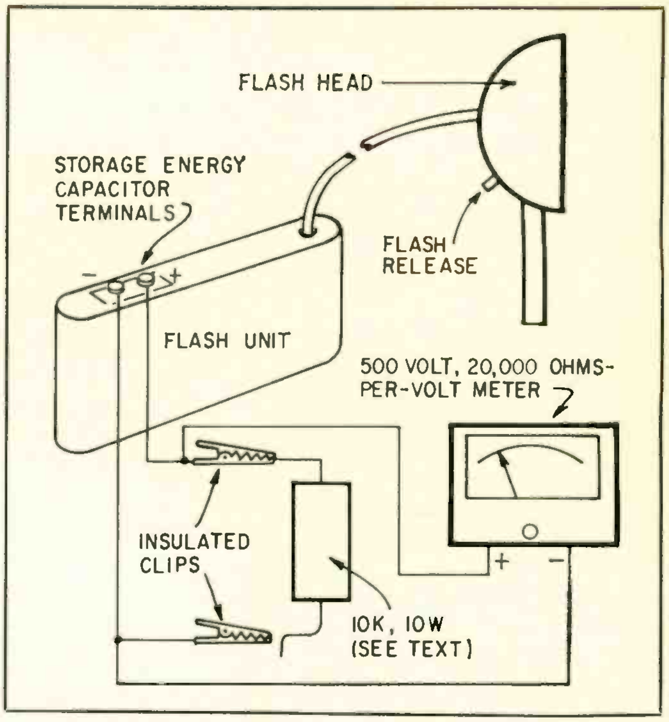
Measure Power of Electronic Flash

Have you ever wondered whether or not your electronic flash unit was delivering its rated light output? Here is a method by which you can determine its actual performance in watt-seconds (or joules), using only a 10,000-ohm 10-watt resistor and either an electronic voltmeter or a 20,000 ohms-per-volt meter with a 500-volt scale.

Before you start, remember that even the smallest electronic flash units operate at lethal voltages and unless you have had some experience with comparable equipment such as high-fidelity amplifiers and tuners, don't read any further. Many photographers, however, are also electronic equipment hobbyists and have had experience building amplifiers and tuners either from schematics or from kits, and it is to this group that the following information is directed.

The first step in determining the energy-storage capacity of your electronic flash unit is to measure the high-voltage energy-storage capacitors themselves. If you have a large flash unit with a detachable head, or with a two-terminal outlet for a second head, this step is relatively easy. If you have to open the case to get at the high-voltage capacitor terminals, it is not so convenient, but access can be had by using leads with insulated clips attached to each end. Before opening the case, make sure the storage capacitors are discharged. Turn on the unit until the ready light comes on. Turn it off, and immediately fire it. There will be some residual voltage left in the capacitors, but it should be 50 volts or less, and can be safely disposed of by shorting the terminals for a moment, using one of the clip leads. Never do this, of course, except *after* firing the unit as the full energy stored in even a small unit can fuse the clip lead and burn your fingers severely.

Now attach one clip lead to each of the two storage capacitor terminals, using a red lead for the positive terminal and black for the negative terminal. Connect a 500-volt voltmeter and resistor as shown in the diagram, leaving one terminal of the resistor open, with an insulated clip lead adjacent to the open end of the resistor. Turn the unit on and wait until the voltage stops rising. Record the observed voltage, say 450 volts. Now attach the clip lead to the open end of the 10K resistor and record the time in seconds required for the voltage to drop to 37 per cent of its initial



value (the voltage before the clip was attached to the resistor). You can now determine the capacitance of the energy-storage capacitors by the simple formula T = RC where T is the number of seconds required for the voltage to drop to $1/\epsilon$ (37 per cent) of its initial value, R is in ohms and C is in farads (not microfarads). If the voltage was 450 at the time the resistor was connected and it dropped to $1/\epsilon \times 450$ or 165 volts in 10 seconds, then the capacitance of your energy-storage capacitor is given by T = RC

$$C = T/R$$

$$C = \frac{10}{10{,}000} = 0.001 \text{ F} = 1{,}000 \mu\text{F}$$

Since you now know the voltage and capacitance of your energy-storage capacitors, you can calculate the rating of your unit in watt-seconds, or joules, by using the formula:

$$WS = \tfrac{1}{2} CE^2$$

where WS equals watt-seconds, C equals capacitance in farads, and E is the voltage on the capacitors. Since you already know that C equals 0.001 and E equals 450, you can write

$$WS = \tfrac{1}{2} \times (0.001)\,(450)^2 = 101.5 \text{ watt seconds}$$

This is the energy stored when the discharge is initiated for firing the lamp, but is not exactly the amount of energy utilized by the lamp as there is a small residual voltage (usually about 50 volts) after the lamp has been fired. However, since the energy in watt-seconds is proportional to the square of the voltage the error is small if you neglect the residual voltage. If you want to be precise, however, you could write the energy equation above in the following form:

$$WS = \tfrac{1}{2} C(E_0^2 - E_1^2)$$

where E_0 is the voltage across the capacitor terminals before firing the lamp and E_1 is the corresponding voltage after firing the lamp. In the example above you would find:

$$WS = \tfrac{1}{2}\,(0.001)\,(450^2 - 50^2) = 100.2 \text{ watt seconds.}$$

If your electronic flash unit gave the above results, you would be safe in calling it a 100 watt-second unit and in making your exposures accordingly. After completing your measurements, be sure to leave the 10,000-ohm resistor connected until the voltage in the capacitors reaches too low a value to read on the voltmeter before disconnecting your test leads and reassembling the unit.—*Nat Norman* END

IC GLOSSARY

(Relates directly to "Getting to Know IC's" on page 44)

Bistable—Describes circuit element with two stable operating states. For example, a flip-flop in which one transistor is saturated while the other is turned off. It changes state for each input pulse or trigger.

Common-mode gain—Ratio of output voltage to voltages applied to the inverting and noninverting inputs. Ideally, inputs must be equal in amplitude and phase.

Common-mode rejection—Ratio of full differential gain to common-mode gain of a differential amplifier.

Common-mode voltage gain—Ratio of signal voltage applied at the inputs (in parallel) to the signal voltage between the outputs.

Differential-input voltage range—The range of voltages that may be applied between input terminals without forcing the circuit to operate outside its specifications.

Differential voltage gain—Ratio of the change in output signal voltage at either terminal of a differential device to the change in signal voltage applied to either input terminal. All voltages measured to ground.

Fan-in—Number of inputs to a gate.

Fan-out—Number of loads that can be connected to the output of a gate.

Full adder—Circuit capable of accepting three binary input signals and producing both sum and carry output signals.

Gate—Logical device that produces a specific output for specified set of input conditions.

Half adder—Circuit that will accept two binary input signals and produce corresponding sum and carry outputs. So called because, above the first order, two half adders per order are required when adding two quantities.

Input admittance—Admittance between the input terminals with outputs shorted together.

Input common-mode rejection ratio—The ratio of change in input voltage to the corresponding change in output voltage, divided by the open-loop voltage gain. Also; the ratio of full differential voltage gain to common-mode voltage gain.

Input limiting voltage—Input signal voltage level which causes the output to drop 3 dB from its maximum level.

Input-voltage offset—The dc potential difference between the two inputs of a differential amplifier when the potential between the output terminals is zero.

Logical threshold voltage—The voltage level at the output of a logic device at which the following logic device switches states.

Offset—Measure of unbalance between halves of a symmetrical circuit. Generally caused by differences in transistor betas or in values of biasing resistors.

Open-loop bandwidth—Without feedback, the frequency limits at which the voltage gain of the device drops off 3 dB below the gain at some lower reference frequency.

Open-loop voltage gain—Ratio of the change in voltage between differential input terminals to the corresponding change in output voltage, with no feedback.

Open-loop differential voltage gain—See Differential voltage gain.

Output admittance—Admittance between output terminals with inputs shorted together.

Output saturation voltage—Lowest voltage level to which the collector of the output transistor can be reduced without degrading circuit performance.

Pull-down resistor—A resistor connected across the output of a device or circuit to hold the output equal to or less than the "O" input level of the following digital device. Also used to lower device's output impedance.

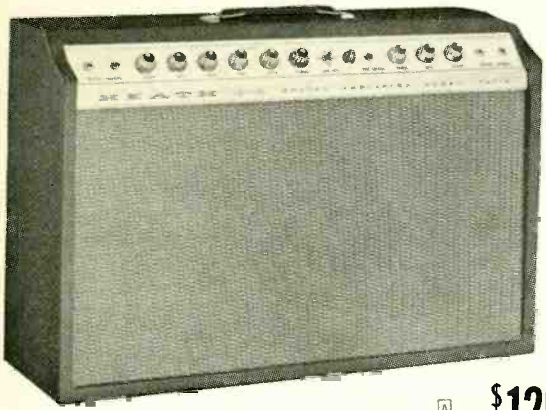
Response time—Time lapse between application of an input step function and the instant the output voltage crosses the logic-threshold voltage level.

Transadmittance—Ratio of output current to input voltage.

85

How To Have Fun While You Save...

NEW Harmony-By-Heathkit® Electric Guitars & Heathkit Guitar Amplifier



Kit [A] TA-16 $129^{95}

[B] Kit TG-46 $219^{95} (save $111.55)

[C] Kit TG-26 $99^{95} (save $47)

[D] Kit TG-36 $119^{95} (save $40.55)

[A] NEW Heathkit Transistor Guitar Amplifier — Compare It To Units Costing Several Times as Much

60 watts peak power; two channels — one for accompaniment, accordion, organ or mike — the other for special effects . . . with both variable reverb and tremolo; two 12" heavy-duty speakers; line bypass reversing switch for hum reduction; one easy-to-wire circuit with 13 transistors, 6 diodes; 28" W x 9" D x 19" H leather-textured black vinyl cabinet of ¾" stock; 120 v. or 240 v. AC operation; extruded aluminum front panel, 52 lbs.

Famous American Made Harmony-By-Heathkit® Guitars

All wood parts factory assembled, finished and polished . . . you just mount the trim, pickups and controls in predrilled holes and install the strings . . . finish in one evening.

These Valuable Accessories Included With Every Guitar Kit

Each guitar includes vinylized chipboard carrying case, cushioned red leather neck strap, connecting cord, Vu-Tuner® visual tuning aid, tuning record, instruction book and pick . . . worth $19.50 to $31.50 depending on model.

[B] Deluxe Guitar . . . 3 Pickups . . . Hollow Body Design

Double-cutaway for easy fingering of 16 frets; ultra-slim fingerboard — 24¼" scale; ultra-slim "uniform-feel" neck with adjustable Torque-Lok reinforcing rod; 3 pickups with individually adjustable pole-pieces under each string for emphasis and balance; 3 silent switches select 7 pickup combinations; 6 controls for pickup tone and volume; professional Bigsby vibrato tail-piece; curly maple arched body — 2" rim — shaded cherry red. 17 lbs.

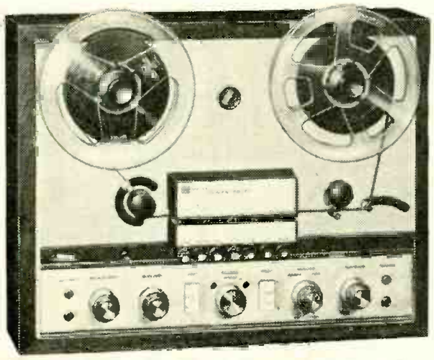
[C] Silhouette Solid-Body Guitar . . . 2 Pickups

Modified double cutaway leaves 15 frets clear of body; ultra-slim fingerboard — 24¼" scale; ultra-slim neck for "uniform-feel"; Torque-Lok adjustable reinforcing rod; 2 pickups with individually adjustable pole-pieces under each string; 4 controls for tone and volume; Harmony type 'W' vibrato tailpiece; hardwood solid body, 1½" rim, shaded cherry red. 13 lbs.

[D] "Rocket" Guitar . . . 2 Pickups . . . Hollow Body Design

Single cutaway style; ultra-slim fingerboard; ultra-slim neck, steel rod reinforced; 2 pickups with individually adjustable pole-pieces for each string; silent switch selects 3 combinations of pickups; 4 controls for tone and volume; Harmony type 'W' vibrato tailpiece; laminated maple arched body, 2" rim, shaded cherry red. 17 lbs.

NEW Heathkit® /Magnecord® 1020 4-Track Stereo Recorder Kit



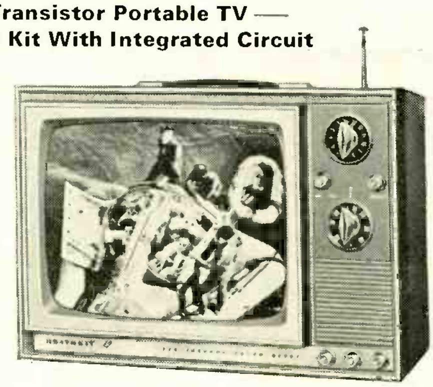
Kit AD-16 $399^{50} (less cabinet)

Save $170 By Doing The Easy Assembly Yourself.

Takes around 25 hours. Features solid-state circuitry; 4-track stereo or mono playback and record at 7½ & 3¾ ips; sound-on-sound, sound-with-sound and echo capabilities; 3 separate motors; solenoid operation; die-cast top-plate, flywheel and capstan shaft housing; all push-button controls; automatic shut-off at end of reel; plus a host of other professional features. 45 lbs. Optional walnut base $19.95, adapter ring for custom or cabinet installation $4.75

NEW 12" Transistor Portable TV — First Kit With Integrated Circuit

Kit GR-104 $119^{95}



Plays anywhere . . . runs on household 117 v. AC, any 12 v. battery, or optional rechargeable battery pack ($39.95). New integrated sound circuit replaces 39 TV parts; 3-stage IF for maximum gain with controlled bandwidth; gated AGC for steady, jitter-free pictures; instant "on" AC operation; preassembled & aligned tuners for peak performance; transformer-operated power supply; front panel speaker; 12-hour assembly; rugged plastic cabinet. 11½" H x 15¾" W x 9⅜" D. 27 lbs.

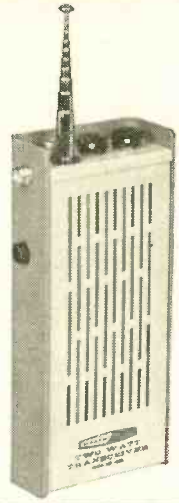
Circle 122 on reader's service card

Build Your Own Heathkit® Electronics!

23-Channel 5-Watt Transistor CB Transceiver

Assembled GWW-14
$124^95
(Kit GW-14 $89.95)

23 channel crystal-controlled transmit & receive. Only 2⅞" H x 7" W x 10½" D . . . ideal for car, boat, any compact installation. Front panel "S" meter, adjustable squelch, ANL, built-in speaker, PTT mike, aluminum cabinet. Operates on 12 v. DC. 8 lbs. GWA-14-1 AC power supply, 5 lbs. . . . $14.95. GWA-14-2, 23-channel crystal pack, 1 lb. . . . $79.95, GWA-14-4, 6 to 12 v. DC converter, 3 lbs. . . . $14.95.

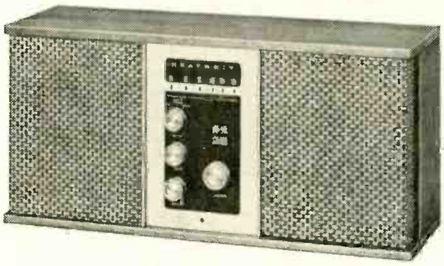


2-Watt Walkie-Talkie . . . Completely Assembled

Assembled GRS-65A
$99^95

Up to 6 mile inter-unit range . . . up to 10 miles with 5-watt CB base station; $20 rechargeable battery; 9 silicon transistor, 2 diode circuit; superhet receiver with RF stage; adjustable squelch and ANL; aluminum case. 3 lbs. Optional 117 v. AC battery charger plus car cigarette lighter cord $9.95. Crystals extra . . $1.99 each with order.

NEW! Deluxe Solid-State FM/FM Stereo Table Radio



Kit GR-36
$69^95

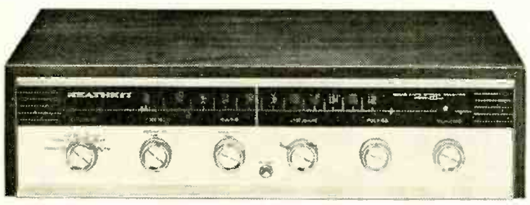
Tuner and IF section same as used in deluxe Heathkit transistor stereo components. Other features include automatic switching to stereo; fixed AFC; adjustable phase for best stereo; two 5¼" PM speakers; clutched volume control for individual channel adjustment; compact 19" W x 6½" D x 9¼" H size; preassembled, prealigned "front-end"; walnut cabinet; simple 10-hour assembly. 24 lbs.

NEW Transistor Portable Phonograph Kit

Kit GD-16
$39^95

Worth At Least 50% More! And it sounds better. Assembles in just 1 to 2 hours . . . simply wire one small circuit board, mount the 4" x 6" speaker and plug in the preassembled changer . . . ideal beginner's kit. Features automatic mono play of all 4 speeds; dual Sapphire styli for LP's or 78's; 45 rpm adapter; olive and beige polyethylene over sturdy, preassembled cabinet. Operates on 117 v. AC. 23 lbs.

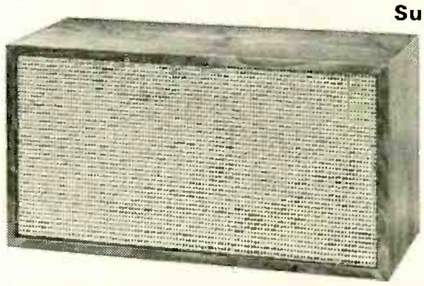
30-Watt Solid-State FM/FM Stereo Receiver



Kit AR-14
$99^95
(less cabinet)

World's Best Buy In Stereo Receivers. Features 31 transistors, 10 diodes for cool, natural transistor sound; 20 watts RMS, 30 watts IHF music power @ ± 1 db, 15 to 50,000 Hz; wideband FM/FM stereo tuner; plus two preamplifiers; front panel stereo headphone jack; compact 3⅞" H x 15¼" W x 12" D size. Custom mount it in a wall, or either Heath cabinets (walnut $9.95, beige metal $3.95). 18 lbs.

NEW! Compact 2-Way 2 Speaker System With Acoustic Suspension Design



Kit AS-16
$49^95

Handles 10 to 25 watts of program material. Features wide 45 to 20,000 Hz response; 8" acoustic suspension woofer with 6.8 oz. magnet; 3½" tweeter with 4.8 oz. magnet; high frequency level control; 8 ohm impedance; 1500 Hz crossover frequency; assembled walnut veneer cabinet has scratch-proof clear vinyl covering for easy cleaning. Measures 10" H x 19" W x 8½" D. Speakers are already mounted; just wire the crossover and connect cables — complete in one or two hours! 17 lbs.

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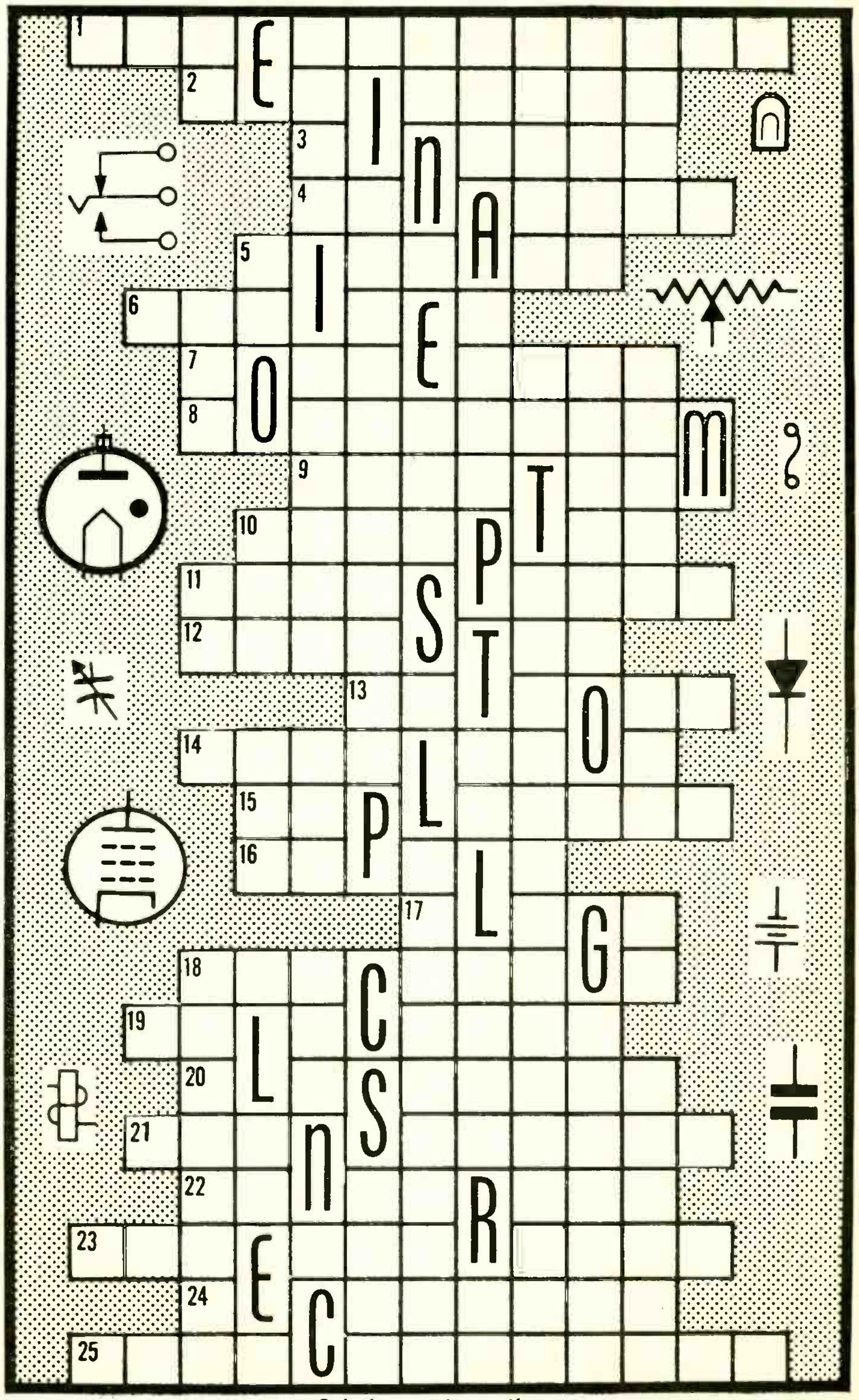
R-E PUZZLER

There are no ups or downs to this only-across-word puzzle but each word is connected to the word above by one letter and below by another.

1 Variable resistor.
2 Devices to oppose the flow of electric current.
3 Coil of wire in a transformer.
4 A type of negative-resistance oscillator using a 4-element vacuum tube.
5 Type of wire splice.
6 Unit used to express relative loudness of sounds.
7 Obsolete term for a capacitor.
8 Metallic element sometimes used for grid or plate electrodes.
9 A measuring unit for wavelength of light and other radiation.
10 Describing a 14-pin tube base.
11 Region of electrically charged air beginning about 25 miles above earth's surface.
12 Device in which resistance varies with applied voltage.
13 A 4-electrode vacuum tube.
14 High-resistance support or separator for conductors.
15 Device which increases power and/or voltage or current.
16 Basic two-terminal antenna.
17 To adjust components of a system to proper interrelationship.
18 Release of energy stored in a capacitor.
19 A thousand cycles.
20 Electric discharge through air.
21 Non-vacuum electronic devices similar in use to electron tubes.
22 Straight-line response to an input signal.
23 What causes confusion at receiver.
24 Converts bidirectional into unidirectional current flow.
25 Material having less resistance than insulator but more than metal.



Solution next month.

WHAT'S YOUR EQ?

These are the answers.
Puzzles are on page 56.

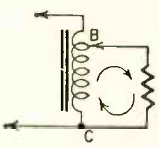
Transistor Current

Correct answer is (1), for I_B is greater than I_E. Here's how to figure the currents:

$$I_E = \frac{E_B - E_{BE}}{R1}$$
$$= \frac{11 - 0.5}{1{,}000}$$
$$= 10.5 \text{ mA}$$
$$I_B = I_E + \frac{E_B - E_C - E_{BC}}{R2}$$
$$= (10.5 \times 10^{-3}) + \frac{11 - 10 - 0.5}{100}$$
$$= (10.5 \times 10^{-3}) + (5 \times 10^{-3})$$
$$= 15.5 \text{ mA}$$

Current Mystery

That portion of the autotransformer winding from B to C appears to the load as a separately wound secondary. Thus the 6-amp current flows only like this:



Section B to C, however, is also a portion of the primary winding, section A to C. The load requirement is 36 watts. Since the complete primary has 117 Vac across it, primary current is only 308 mA (assuming no losses in the autotransformer). END

NEW BOOKS

CREATIVE ELECTRONICS FABRICATION, by Owen G. Patrick. *Holt, Reinhart and Winston, 383 Madison Ave., New York, N. Y. 10017. 6 x 9 in., 272 pp. Cloth, $6.50*

Despite the title, an immensely practical book on the mechanical procedures in building electronic devices.

Includes planning, sketching, metal working, finishing and labeling, plus assembly and wiring. One section is devoted to a step-by-step example: building a signal tracer. Section on tools crams more than ordinary amount of information into its 100 pages. Ended with an informative appendix and a fair index, this smooth-reading book should serve experimenter and prototype designer alike. END

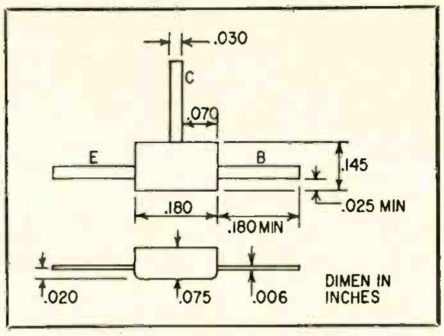
TWO MYSTERIES OF SCIENCE . . . lightning phenomena and UFO's will both be explored in a comprehensive article by our science editor. If you want to be prepared for strange things you may see in the sky this summer, read "Lightning, Plasmas, and Balls of Fire" in April RADIO-ELECTRONICS

91

NEW SEMICONDUCTORS, MICROCIRCUITS & TUBES

FLAT-PACK TRANSISTORS

A recent addition to the G-E line of consumer and industrial transistors includes a series of silicon planar passivated npn transistors in flat packages



with strip-type leads as shown in the drawing. The D24A3390, D24A3390A, D24A3391 and D25A3391A are intended for low-noise preamplifier applications. They are electrical equivalents of the 2N3390, 2N3390A, 2N3391 and 2N3391A, respectively.

The D243392, –3393 and –3394 are designed as small-signal amplifiers. They feature tight beta control at extremely low price. They are the same, electrically, as the 2N3392, 2N3393 and 2N3394, respectively.

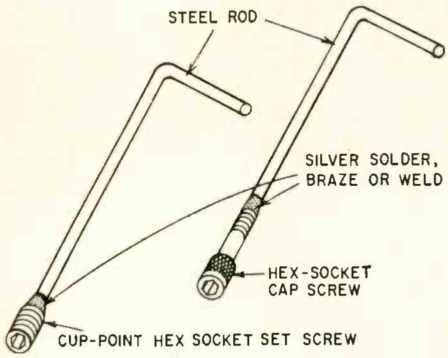
TEMPERATURE-SENSING RESISTOR

Sensistor is the name Texas Instruments applies to its line of thermistors featuring a *positive* temperature coefficient. The type TG ⅛ is an ⅛-watt (0.125 mW) unit in a hard-glass envelope 0.1 inch in diameter and 0.3 inch long with 1.2-inch leads. It consists of a silicon sensing element pressed between molybdenum end slugs which serve as heat sinks. Maximum power dissipation is 250 mW up to 25°C and 125 mW at 100°C ambient temperature. Standard zero-power resistance values range from 10 to 2,700 ohms in the standard EIA values for 10% tolerance resistors. TG ⅛ series Sensistors are available in 5% and 10% tolerances. END

TRY THIS ONE

MIDGET SOCKET WRENCHES

Nutdrivers and socket wrenches for some of the tiny nuts used in today's electronic equipment and components are expensive and not readily available from usual sources. You can make a set of midget hexagon nutdrivers for little cost.

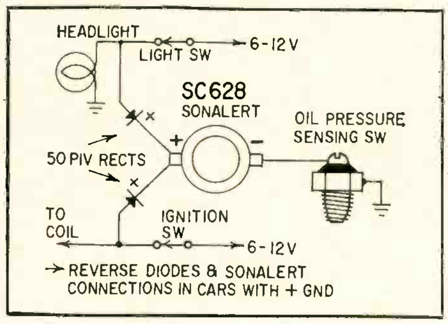


Select small cap screws and cup-point setscrews with hexagon sockets of the required sizes. Silver-solder, braze or weld them to short lengths of steel rods used as handles. The drawings show how they are made.—*Paul T. Hennig* END

NOTEWORTHY CIRCUITS

A SIMPLER LIGHTS-ON REMINDER

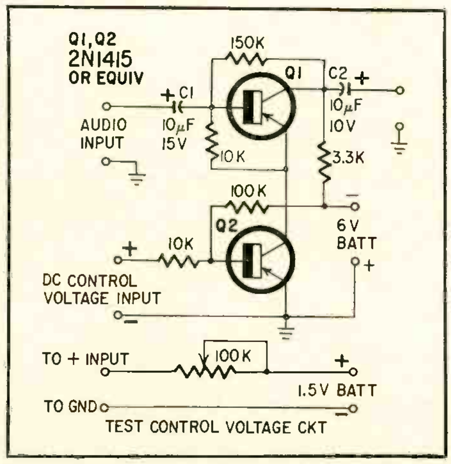
I read with interest the article on the lights-on reminder for automobiles on page 53 of the December issue. There's an easier and less expensive way to do it. All you need is a Mallory Sonalert solid-state signal unit and a pair of inexpensive silicon diodes to get a good warning that the lights have been left on after the ignition has been turned off. In addition to the lights-on warning, you also get an audible warning when oil pressure drops below normal.



The schematic shows the hookup. The negative side of the Sonalert goes to the pressure sensor, and the positive side to the headlight and ignition circuits through the diodes. The diodes prevent the headlights from being turned on by the ignition switch and vice versa.—*Wm. F. Mullin*

TRANSISTOR VARIABLE GAIN CONTROL

When you want to control the gain of a transistor audio amplifier with a dc voltage, many disadvantges can be found in the conventional method of changing the bias of a transistor used as an audio amplifier. Some degree of gain control can be obtained this way but it is usually because the transistor is operating in the nonlinear portion of its characteristic curve. When a transistor is used as an audio amplifier, some distortion is usually introduced by this method.



The two-transistor circuit shown gives a good range of gain control and will add very little distortion to the signal that is being amplified.

In operation, the audio signal is fed to the base of Q1 through capacitor C1. The output signal is taken off of the collector through C2. Q1's emitter is grounded through the collector-to-emitter resistance of Q2. With little or no control voltage applied to the base of Q2, the collector-to-emitter resistance is very low and the amount of degeneration introduced into the amplifier stage (Q1) is very small. As the control voltage is increased (positive direction), the resistance of Q2 increases and more degeneration is inserted, resulting in a reduction of gain in the amplified signal.

To simulate a control voltage, a 1½-volt battery and a 100K potentiometer can be connected to the input of Q2.

With an input signal of 10 mV rms (1-kHz sine wave) and zero voltage applied to the dc control input, the output is 200 mV rms, a voltage gain of 20 is obtained from the audio amplifier. As the dc control voltage is increased the gain drops to less than two without adding excessive distortion to the amplified signal.

This circuit can be used as a basic circuit for an audio volume expander, audio limiter, remote volume control, etc.—*Charles D. Rakes* END

ANTENNA PREAMPLIFIER SPECIFICATIONS

aren't always easy to understand. They will be from now on, if you read "Transistor Antenna Preamps." This important exposé of what is meant by gain, noise figure, bandwidth, and other technical jargon will be part of the Annual Spring Antenna Section in

April RADIO-ELECTRONICS

4 easy ways to increase your know-how on microelectronics and solid state!

How to Build Tiny Electronic Circuits

By Morris Moses. Explains "miniaturized" electronics to the hobbyist, experimenter and service technician. Not only takes the mystery out of "making it smaller", but is a veritable "how to do it" of electronic miniaturization. Covers subminiaturization, microminiaturization, high-frequency receiver, molecular electronics, meter amplifiers, tone generators, semiconductor thermometers, making tools, preamplifiers, comparators, pocket radios, photorelays, components, techniques, modules, practical projects and devices, construction and repair hints. 192 pages.

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Getting Started With Transistors

By Louis E. Garner, Jr. Transistor know-how begins with this volume. Shows how transistors began, how to read electronic diagrams, how transistors work, facts on oscillators, transistor types, diodes, phototransistors, rectifiers, transistor ratings, testing transistors, Excellent text, diagrams and photographs carry you through every phase of transistors to give you a complete grasp of the subject. 160 pages by an expert in the field.

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By M. G. Scroggie. Provides a complete background in semiconductor devices, beginning with basic facts on electrical conduction through transistors, rectifiers, photoelectric devices, thermistors, varistors, diodes, cryosars, etc. Supplies enough theory in a simple way to make it possible to understand more advanced literature. Also explains how the special properties of semiconductors are being applied in many kinds of useful devices. Dozens of charts, diagrams and photos. 160 pages.

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By Editors of Radio-Electronics. Carefully selected articles from Radio-Electronics combined in a unique handbook to show you how to build all-transistor test equipment, and how to test transistors. Clear, practical know-how on power transistors. Direct-reading transistor tester, lab type checker, mini-tracer, TV bar generator, A-I-R generator, black box oscillator, scope calibrator, kilovolter, etc. 96 pages.

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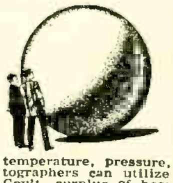

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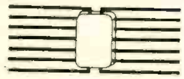

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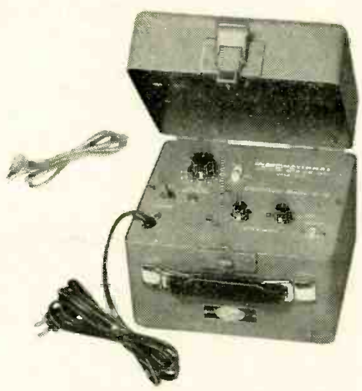

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Circle 148 on reader's service card

Model 1110 SECONDARY

FREQUENCY STANDARD

The Model 1110 is an economy portable secondary standard for field or bench use with self contained battery. Using any general coverage communications receiver the unit provides the necessary standard signal for measuring frequencies. Easily calibrated against WWV to provide an accuracy of 1 x 10^6. Long term stability of ±10 cycles over range 40°F to 100°F. All transistor circuits provide outputs at 1 mc, 100 kc and 10 kc. Zero adjustment for oscillator on front panel. SHIPPING WEIGHT — 12 lbs.

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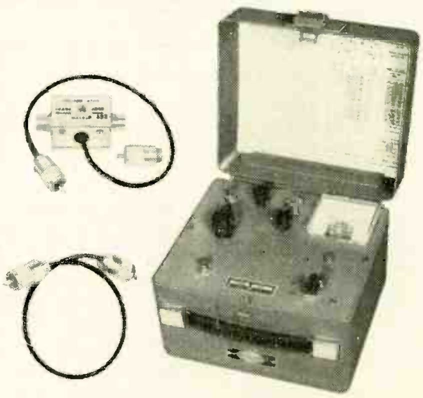
Cat. No. 620-106 .... $125.00



C-12B FREQUENCY METER

For Citizens Band Servicing

This extremely portable secondary frequency standard is a self contained unit for servicing radio transmitters and receivers used in the 27 mc Citizens Band. The meter is capable of holding 24 crystals and comes with 23 crystals installed. The 23 crystals cover Channel 1 through 23. The frequency stability of the C-12B is ± .0025% 32° to 125°F, .0015% 50° to 100°F. Other features include a transistorized frequency counter circuit, AM percentage modulation checker and power output meter. Shipping weight: 9 lbs.

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