PROJECTS – Binary counter & experimental mini-tenna

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How to Measure Reverberation

Audio Levels on Long Lines

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Solid State TV

(see page 35)

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BUILD

Inexpensive Calibrator for Scope & Voltmeter

(see page 42)

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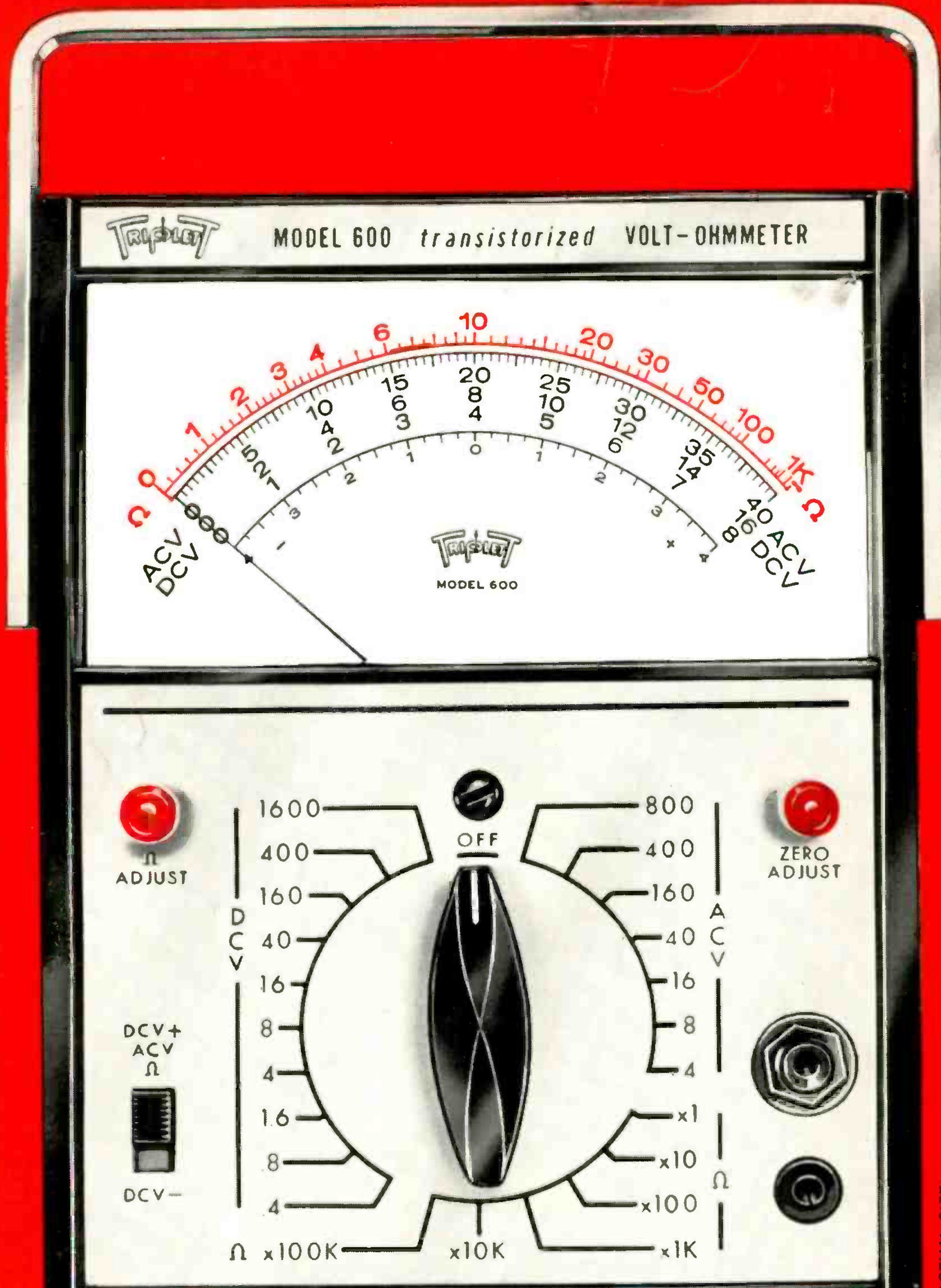

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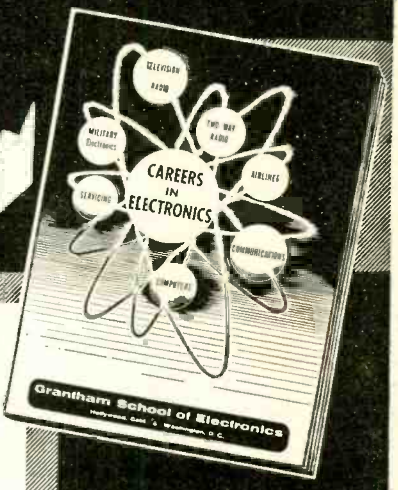

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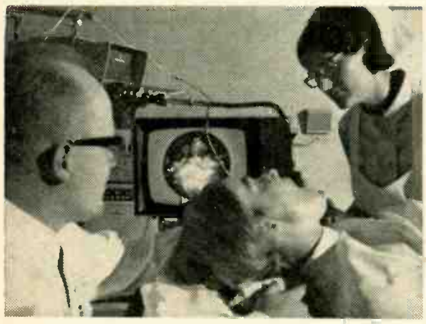


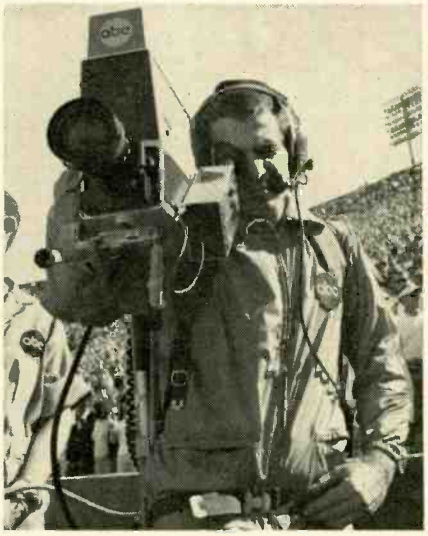
LIVING STOMACH IN LIVING COLOR—Flexible glass fiber-optics tube picks up optical image inside patient's stomach, transmits it to Siemens color TV camera. Physician watches monitor, makes accurate diagnoses.

IMPROVED VIDEO TELEPHONE—Currently under test is Bell Lab's new Picturephone for see-while-you-talk communication. System is scheduled for field tests between Pittsburgh and New York City in September.

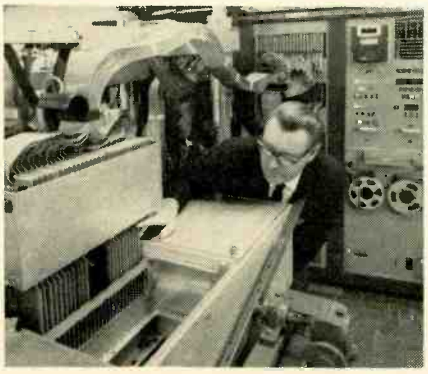
COMPUTER TO SPAN U.S.A.

Honeywell Inc. plans to install 40 terminal units next year at plants from Florida to California and Boston to Seattle that will be able to feed technical data on a cyclical time-sharing basis into three computers at the firm's Minneapolis headquarters. It will be able to handle 48 users simultaneously, when eight other remote terminals are installed later.

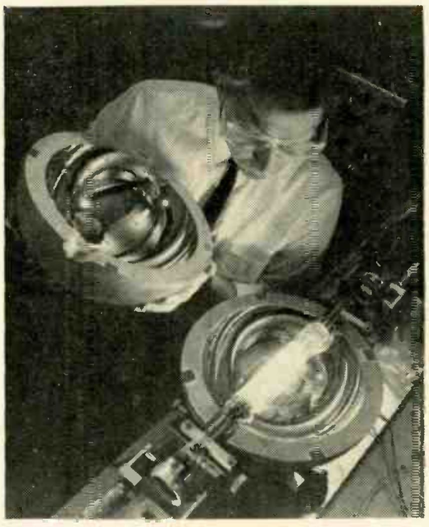
The effect of the new system will be the same as installing a computer at each of the company's engineering locations coast to coast. Engineers will be able to enter their problems directly in any of three computer languages—Fortran IV, in an interpretive algebraic language, or in a special scientific language. The system uses three computers, teletype terminals, and two tape units and two disc packs capable of storing up to 14 million bits of information.



ONE-MAN COLOR TV CAMERA—Weighing only 35 lbs, this color camera—developed by Ampex for ABC—offers closeup coverage of sports, conventions, news events.



FAST WIRING CHECKER—A man would need 10 years to verify by hand the wire connections in computerized defense equipment. Hughes Aircraft's FACT (Flexible Automatic Circuit Tester) tests connections of 10,000 wires in 30 minutes.



BALL-OF-LIGHT LASER—New kind of laser pump uses highly-polished bowl-like spherical mirrors to stimulate more efficient laser action. Pump was developed by Westinghouse Labs.

LARGE-SCALE 3-D PHOTOS—New RCA laser advance makes possible holograms of scenes up to 6 feet deep. System overcomes previous limit of inches-deep scene, may make 3-D window displays possible.

SOLID-STATE SALES

US manufacturers' sales of transistors during the first 9 months of 1967 declined 21%, according to EIA. This figure applies to total transistor sales. The surprise was the field-effect transistor. FET sales during the same period were up 23%. **R-E**

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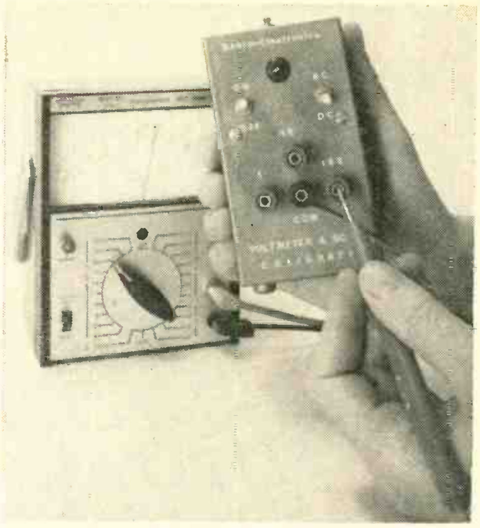
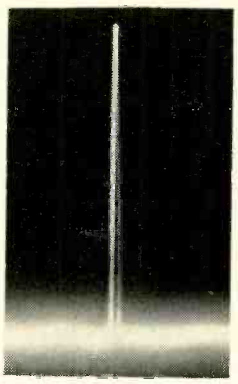
DEPARTMENTS



Handy voltmeter and scope calibrator, covers both ac and dc, with calibrating voltages of 1, 10 and 100. Uses only a handful of parts. Meter shown is a Triplett 600 transistorized volt, ohmmeter. See page 42



Pulses are used everywhere in electronics. How much do you know about them? Find the answers and enlarge your electronics knowledge. See page 38

Transistors become part of the antenna elements in this experimental device you can build. It's tiny and it's broadband. How well does it work? See page 32

RADIO-ELECTRONICS, FEBRUARY 1968, Volume XXXIX, No. 2. Published monthly by Gernsback Publications, Inc., at Ferry St., Concord, N. H. 03302. Editorial, Advertising, and Executive offices: 154 West 14th Street, New York, N. Y. 10011. Subscription Service: Boulder, Colo. 80302. Second-class postage paid at Concord, N. H. Printed in U.S.A. One-year subscription rate: U. S. and possessions, Canada, $5. Pan-American countries, $6. Other countries, $6.50. Single copies: 60c. ©1968, by Gernsback Publications, Inc. All rights reserved.
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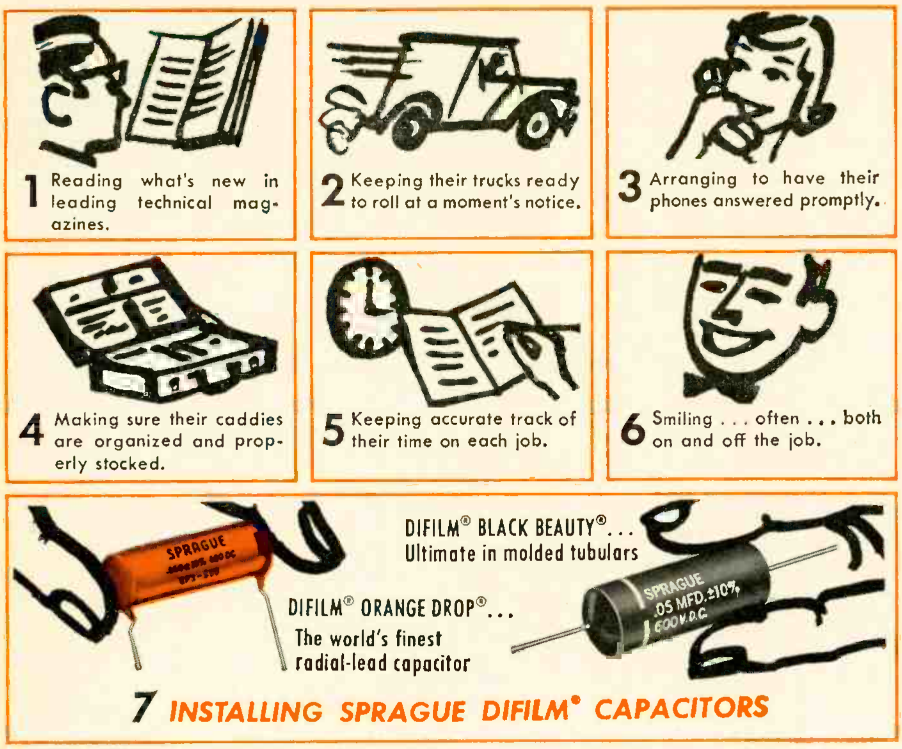

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Correspondence

HIGHER FI?

You really do have a first-class magazine! This has impressed me particularly at this moment, as I have had to go through quite a few back numbers. Somehow you manage to couple the practical with theory, or future developments in such a way that it not only makes for good reading, but keeps one up to date in the field. In this line: How about a thorough treatment of the operational amplifier, either IC or not? I suppose I cheat in looking to you for simple explanations to give to other people. Not that I want to enter any audio controversy with Peter Sutheim's article, "The Wider the Band the Higher the Fi?" (October 1967) but he appears to have overlooked the fact that while he knows all about the bandwidth of his amplifiers, he does not give as much information about his speakers, the cartridge or the recording equipment. After all, if only 15 kHz are recorded, one is not likely to hear 20 +.

JOSEPH G. BRADLEY, JR.
New York, N.Y.

Mr. Sutheim's contention is that one is not likely to hear 20+ regardless of what is recorded. We have an article in the works on operational amplifiers.

MANUFACTURERS AS VILLAINS?

After being in this business as an electronic technician and following every bit of Mr. Gernsback's writings since 1938, I was shocked at your reply to V. N. Everts' letter (December 1967). A pat on the back for Mr. Evert for speaking out; more electronic technicians should come forward on this issue. It is the service technicians who keep the manufacturers in business. A fourth of my calls is to correct mistakes of the manufacturer and to try to explain why a customer's 10-year-old set, with a good picture, had to be repaired only three or four times in the past 5 years, when their new set has gone out three times in the first 3 *months*. Do you really think this is progress? We in the service business

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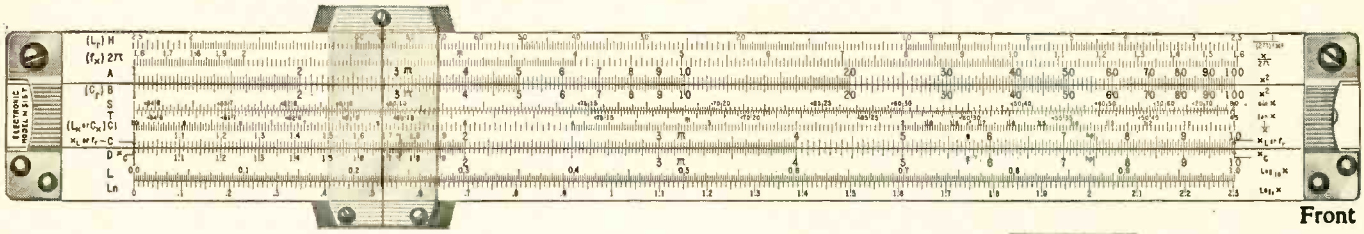
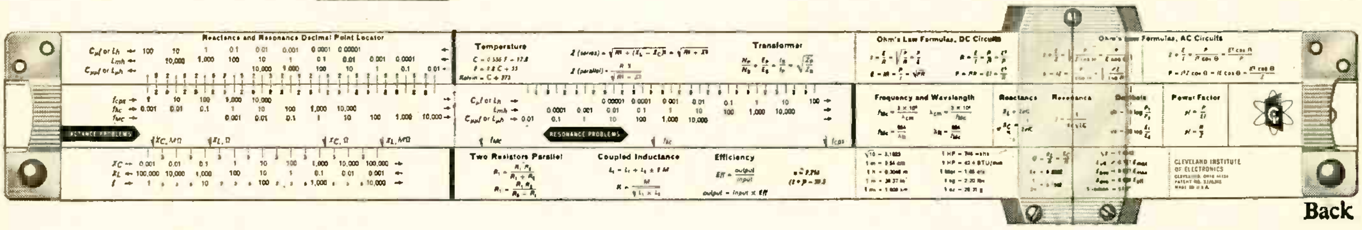

Front


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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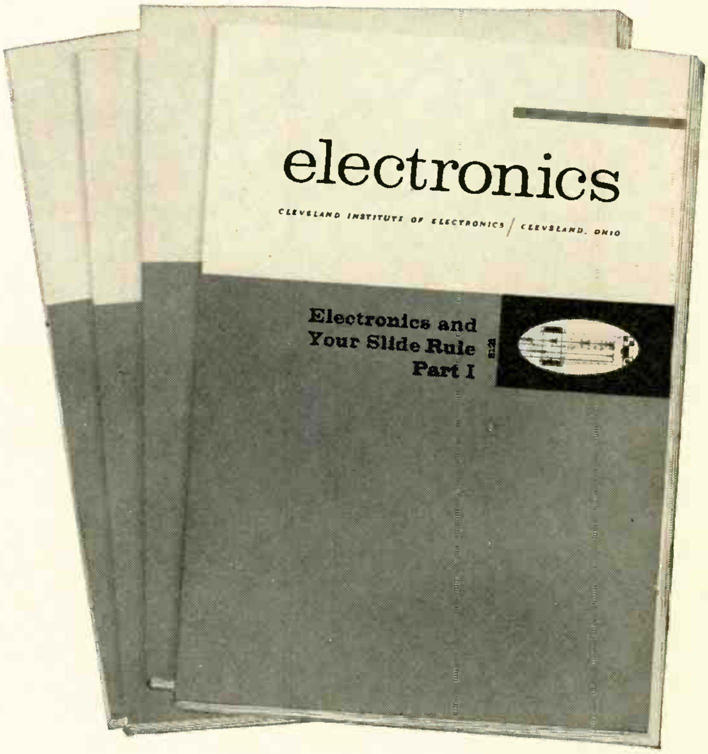

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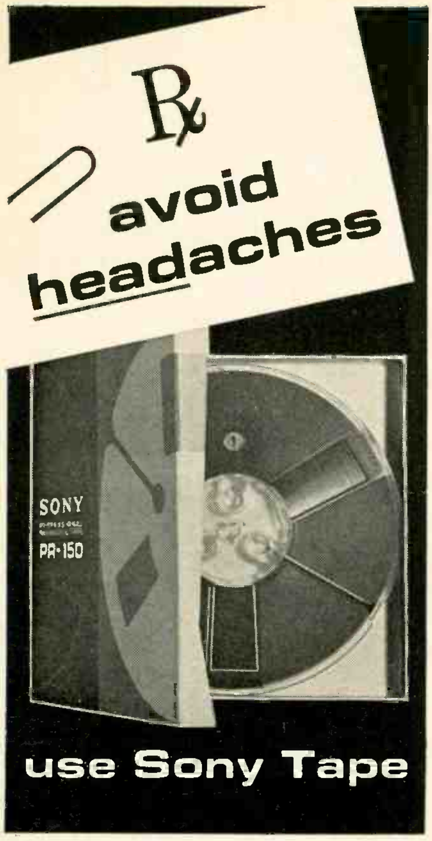

If you've been using any of the so-called bargain tapes, chances are you should have your heads examined. The odds are good that the heads are excessively worn and you're not getting the most out of your recorder. If you want to keep "factory-fresh" sound to your recorder—and avoid future "headaches" and keep it that way—Here's the prescription—buy Sony Professional-quality Recording Tape. Sony Tape is permanently lubricated by the exclusive Lubri-Cushion process. Sony's extra-heavy Oxi-Coating won't shed or sliver and is applied so evenly that recordings made on Sony Tape are not subject to sound dropouts. Sony Tape captures and reproduces the strength and delicacy of every sound—over and over again. There's a bonus, too, with every 5" and 7" reel of Sony Tape—a pair of Sony-exclusive "Easy Threader" tabs to make tape threading the easiest ever. And Sony reels are a sturdier, heavier gauge plastic for protection against possible warping. It's just what the "Doctor" ordered and yours for just pennies more than "bargain" tape.

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have enough to do on well-built sets where at the very least we can get at the parts. I use the very best equipment I can get and yet on these "Mickey Mouse" sets it is impossible to get at the parts even with medical tools. I would just love to see a factory service technician replace a transistor in a small TV tuner sealed with a spot weld on the side.

MARV POOLEY, WA0SDL
Mitchell, S. Dak.

DUST COLLECTOR WANTED

I am in need of schematic diagrams and information pertaining to the design of (1) a static-dust collector as used in small family dwellings and (2) a metal locator used to find small coins, jewelry, etc. at beaches.

WALTER BAER
Mineola, N.Y.

Walter, you'll find a metal locator in the November 1967 issue. As for a static dust collector, we don't have any (except for some old AM radios). Perhaps one of our enterprising contributors of electronic project articles, after reading this letter, will submit a workable project we can publish.

FM STEREO ADAPTER

I am interested in building the "Modern FM Stereo Adapter" (August 1967) but I am puzzled by one thing which appears to be an omission from the schematic diagram. I do not see any supply-voltage connection for transistors Q5 and Q6.

C. L. PARRISH
Melbourne, Fla.

Good catch C. L. The emitter of Q6 should also be connected to 14 volts. Should you desire to use a ready-made printed circuit board for this project, you can get one from Transitek Co., PO Box 205, Des Moines, Wash., 98016. Send $4.15 and ask for part No. MD116.

MAGNETRON MODULATION

While reading the article, "Creative Electronic Servicing" (September 1967) I was a little surprised to see Mr. Larry Allen's block diagram of a radar transmitter (page 40). I have worked on many types of radar but never ran across one where the magnetron feeds the modulator. In my opinion a pulsed radar transmitter can-

(continued on page 12)

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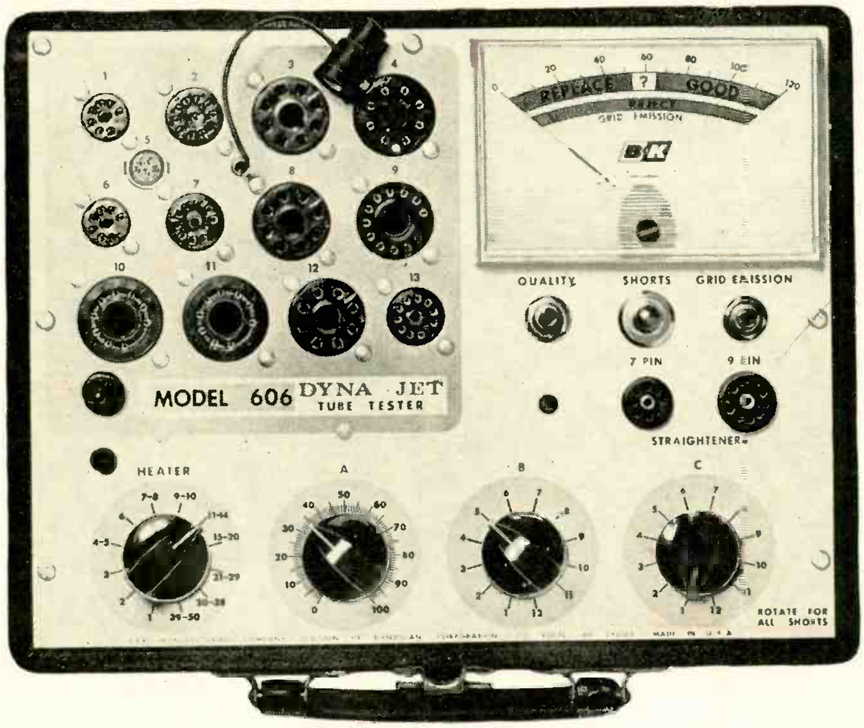

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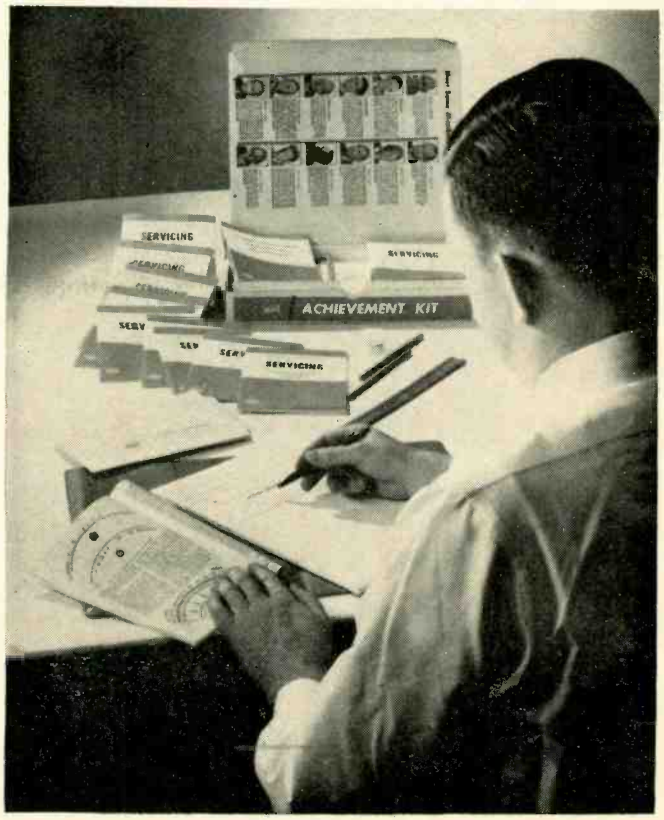

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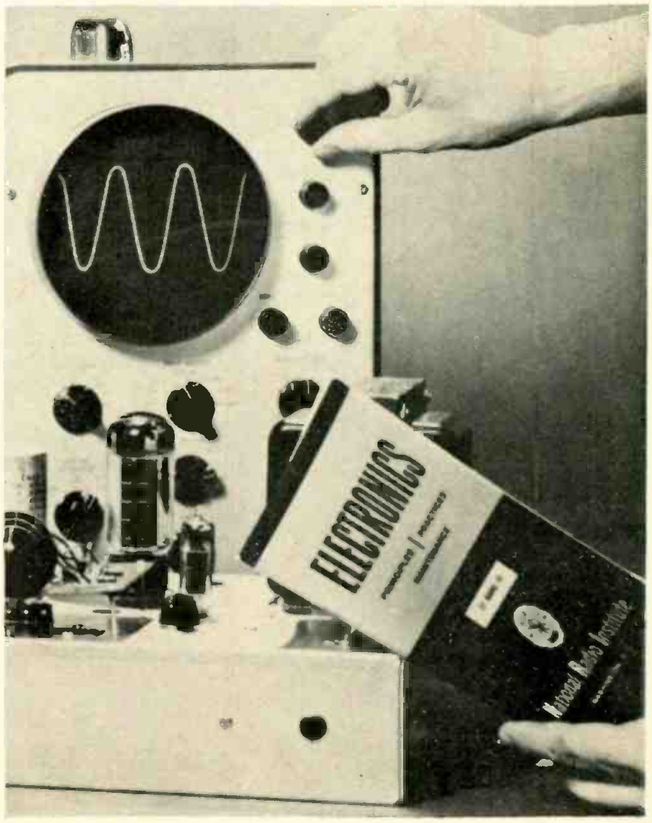

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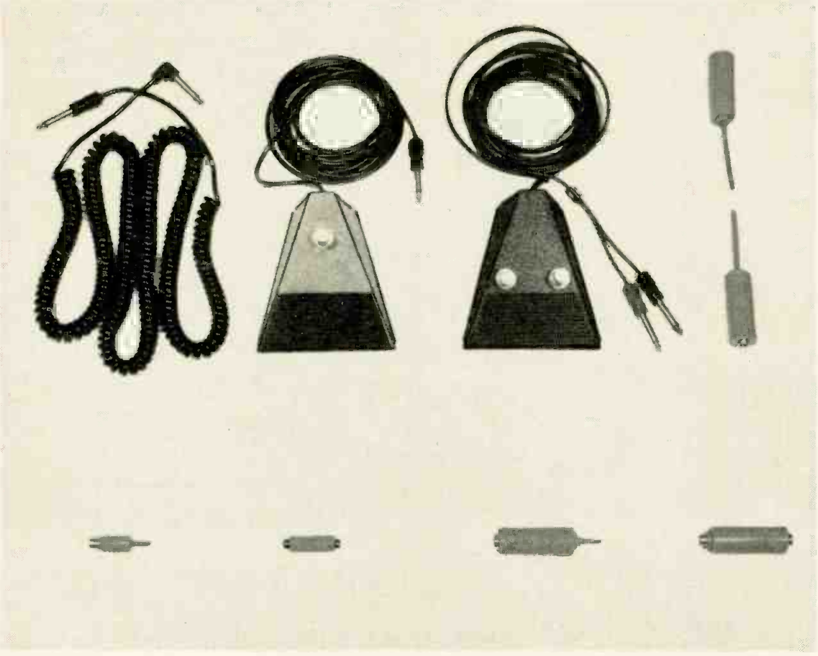
If a plug or accessory from BARKER is not shown here – it's in our catalog!

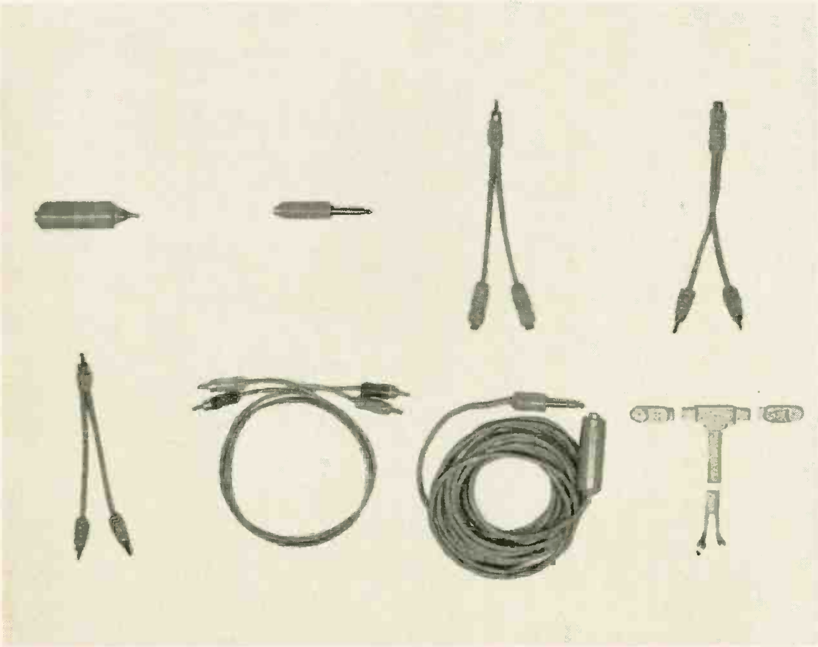


ABOVE: from left to right. **First row. Guitar coil cord 20' RSP-RE** in six colors—White—Beige—Grey—Red—Black—Blue. **FS-1 Foot switch single**—designed for amplification Shut-off. **FS-2 Foot switch—dual**—designed for amplifier and reverbrafication. **PJ-PJ Phone** Plug to phone plug adapter.

Second row. ATF "Molded on" Adapter—Adapts phono pin plug to miniature two (2) conductor phone plug. **AFF Phono jack** to Phono jack. **PJT phone jack** to tini-plug, **PJF** Phone jack to Phono jack.

BELOW: from left to right. **First row. PJM Phone jack** to Phono plug. **APF Phono jack** to Phone plug. **M-FF** 2 phono jacks connected in parallel to phono plug, 4" shielded cables. **F-MM Phono Jack** connected to 2 phono plugs 4" shielded cables.

Second row. M-MM 3 phono plugs connected in parallel 4" shielded cables. **D4 2** individually shielded cables with phono plugs each end color coding positively identifies each circuit 36"—72" & 12'. **20' 3LP-3PJ** "Molded On" three (3) conductor phone plug one end of 20' three conductor cable—Other end a "Molded On" three (3) conductor phone jack—For stereo head set application. **FM-1 Twin lead FM Antenna** Dipole type for indoor use—Has 6 Foot Lead-in with spade lugs.



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CORRESPONDENCE
(continued from page 6)

not be easily compared with a TV transmitter or any other CW transmitter.

BOB L. RUCKER
Wichita, Kans.

Okay, Bob, just flip the magnetron and modulator labels on the block diagram in Fig. 3. Also show the pulse generator going to the modulator and not to the magnetron. Mr. Allen was attempting to show that troubleshooting complex electronic equipment can be simplified.

PARTS FOR TREASURE FINDER

I am interested in building the Treasure Finder (November 1967). Can you tell me where I can buy a kit of parts?

M. E. LONG
Alameda, Calif.

Except for loop L1, which you make yourself, all parts are standard. No kit is available for this particular project. You should not have too much difficulty getting all these parts. You may have to try more than one supplier, in your area.

JACK DARR DOES NICE THINGS

Thank you very much for your (*Jack Darr's*) letter of Nov. 30 and the information about the Stromberg Carlson CD 20 TV models that you sent. Your kindness in sending it was one of the nicest things that has happened to me in a long time—and boosted my faith in humanity many points.

F. M. JACOBSEN
Whiting, Ind.

CONSTRUCTION VS. SERVICE ARTICLES

I've been a continuous subscriber since age 14 (1943 when it was Radio-Craft), so perhaps I have some right to voice my opinions. You might best label me an advanced experimenter—lots of construction skill but limited electronic design capability. I've depended on R-E (and R-C) for schematics for many projects. But you've steadily abandoned this type of reader in favor of the service technician. In short, I'd like to see much more in the way of construction articles of all kinds.

M. D. RATCLIFF
Vero Beach, Fla.
R-E

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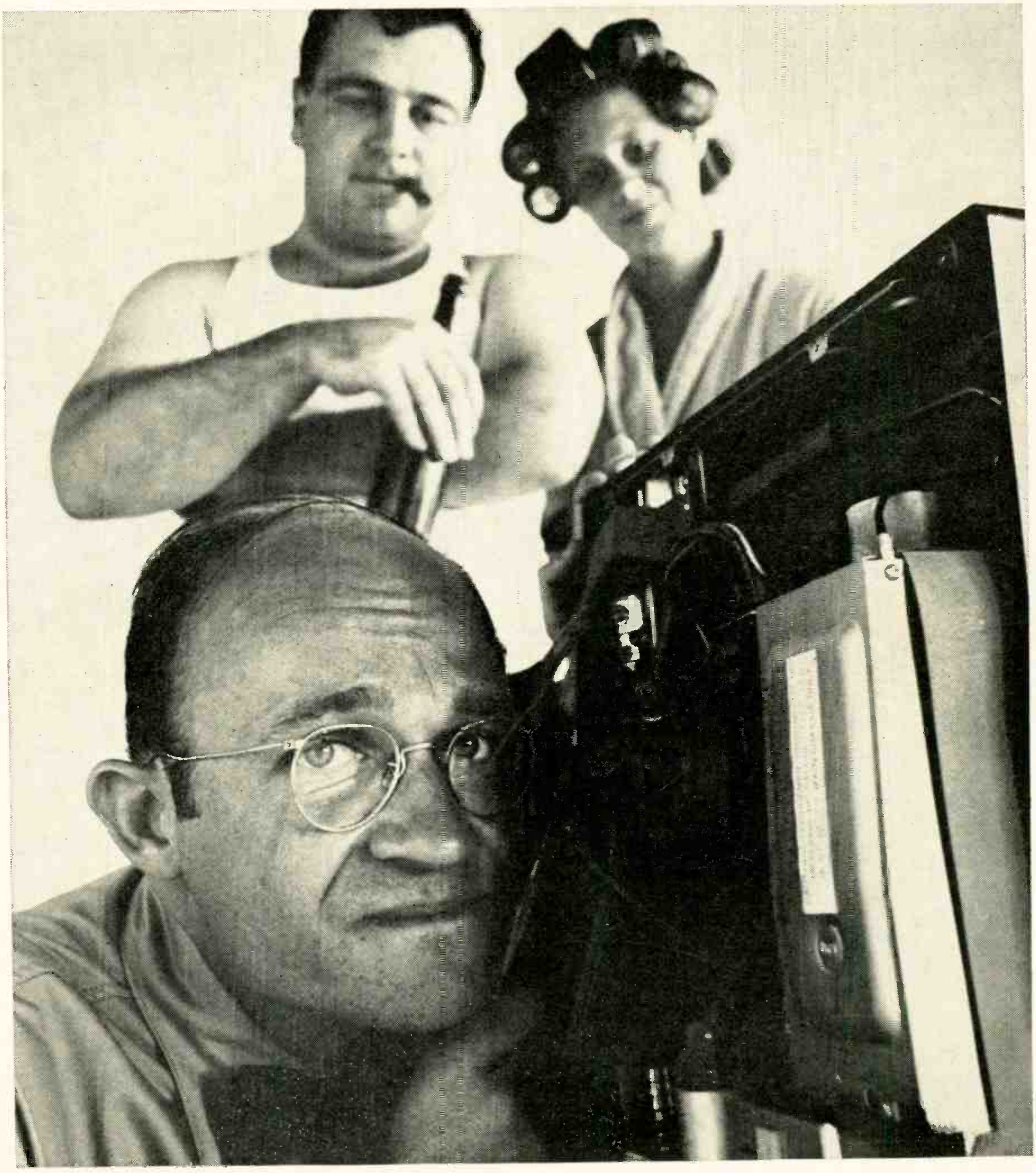

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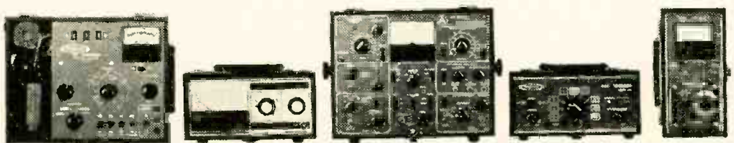

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TOMORROW'S THINKING IN TODAY'S PRODUCTS

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In the Shop . . . With Jack

By JACK DARR

CASE OF THE DISORGANIZED ORGAN

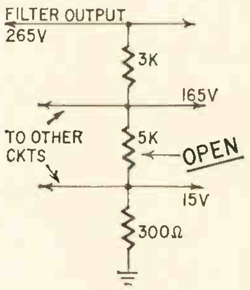
THERE ARE TIMES, IN THE ELECTRONics repair business, when we run into things which "don't make sense". We get that "Now, why did it do *that*?" reaction. Things happen that seem to violate the laws of electronics. They don't, of course, but they seem to—they can throw you a curve. So, we have to keep up a kind of mental agility while we're working—be ready to admit any possibility, no matter how remote it might seem. If we freeze on one line of thinking, we've had it. We'll be there all night!

Here's a case in point. A big old Baldwin electronic organ was acting up. It was an oscillator-frequency-divider type, with one tone generator for each note. An oscillator generated the highest frequency, then a succession of blocking oscillators divided this by two, for the similar notes in each of the other octaves.

So, any trouble usually showed up as a "burble" or flutter in the faulty note, and in all the similar notes in the octaves below. All you had to do was count down to the note in the highest octave that was burbling—say the third from the top—and go into that divider stage. Leaky capacitors, drifted resistors, etc., would make the divider misfire or run off frequency.

Now, though we were stuck. The highest "C" was okay, but all the rest were burbling, indicating trouble in the first divider stage. However, everything in that stage checked out okay. A couple of dubious capacitors were replaced, with no results. All of the other notes on the organ worked beautifully.

Finally, we made a mock-up and hooked the tone generator up on the bench, using the same voltages found in the organ. Now, we could check it with a scope. Setting the sweep to show 4 cycles at the oscillator frequency, the first divider should show 2, the next 1 and so on. However, the first divider showed 4 cycles, jittering. This was the burble we'd been hearing.



Experimenting desperately, we found that varying the plate voltage had little effect or none. However, a +15-volt applied bias was fed to the divider cathodes, and varying this did have an effect! Most definitely it did. Now, we checked the "service data."

This showed us what was happening. The bias voltage held the dividers at cutoff unless there was a drive signal from the oscillator.This voltage set the firing point of the blocking oscillators. By varying this bias, we could make the first divider trigger beautifully, and all the rest as well.

Hmmm. The schematic showed +165 volts on the plate and +15 volts of bias. We had read +200 volts and +10 volts at the church where the organ was used. This much variation was out of tolerance. We pulled the power supply, which had not been considered as a source of trouble, because all the other notes were working.

Power supply very ordinary. Rectifier, filter, bleeder resistors, etc. okay, although the supply was pretty complex, with so many stages to feed. Our tone-generator supply had a 3-resistor bleeder/voltage divider. From the +265 volt source, there were 3000, 5000 and 300 ohms to ground, with the voltages shown.

The 5000-ohm resistor was open. Parallel paths in the circuitry kept the voltage from disappearing entirely, but it wasn't at the right value by a long shot. We replaced the open resistor, and all voltages went back to normal. So did the C generator! Now,

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.

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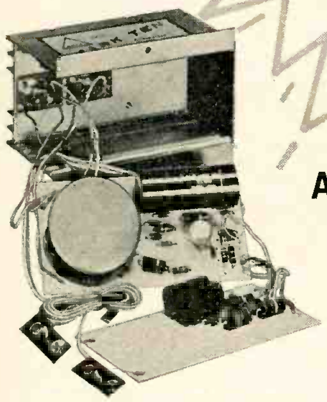

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In the shop . . . With Jack

(continued from page 14)

all notes played as sweet as a bird!

Now, there was the problem. With about 16 tone generators, counting sharps and flats, *why* did this loss of voltage affect *only the one*? The same power supply fed all of the rest, in parallel! The best guess that we could make was that this one was affected first because of its high frequency, or because its parts were right on the limit of tolerance (or something!)

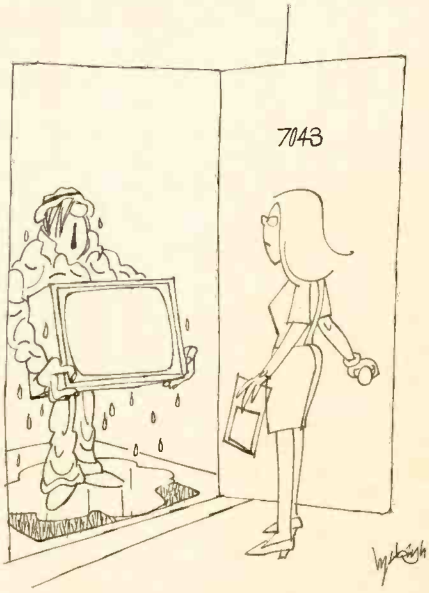
The moral of this, of course, is: "Check *everything!*" This includes the power supply to the thing being tested. This ought to be checked first no matter what kind of gizmo you're working on.

Limiting Amplifier for Taping Speech

I record speech on a miniature tape recorder. Later, this is re-recorded on a larger machine, where the problems set in. Because of the necessary mike placement, I get some voices very loud and others very low, and on the re-recording, it sounds awful! Is there any way that I could equalize the voice level?—A.W., Newark, N.J.

There is one thing you might try first: Place the mike *farther* from the people if you can't locate it in a central position. Mikes will pick up sound from much greater distances than most people believe. Turn the record gain

(continued on page 22)



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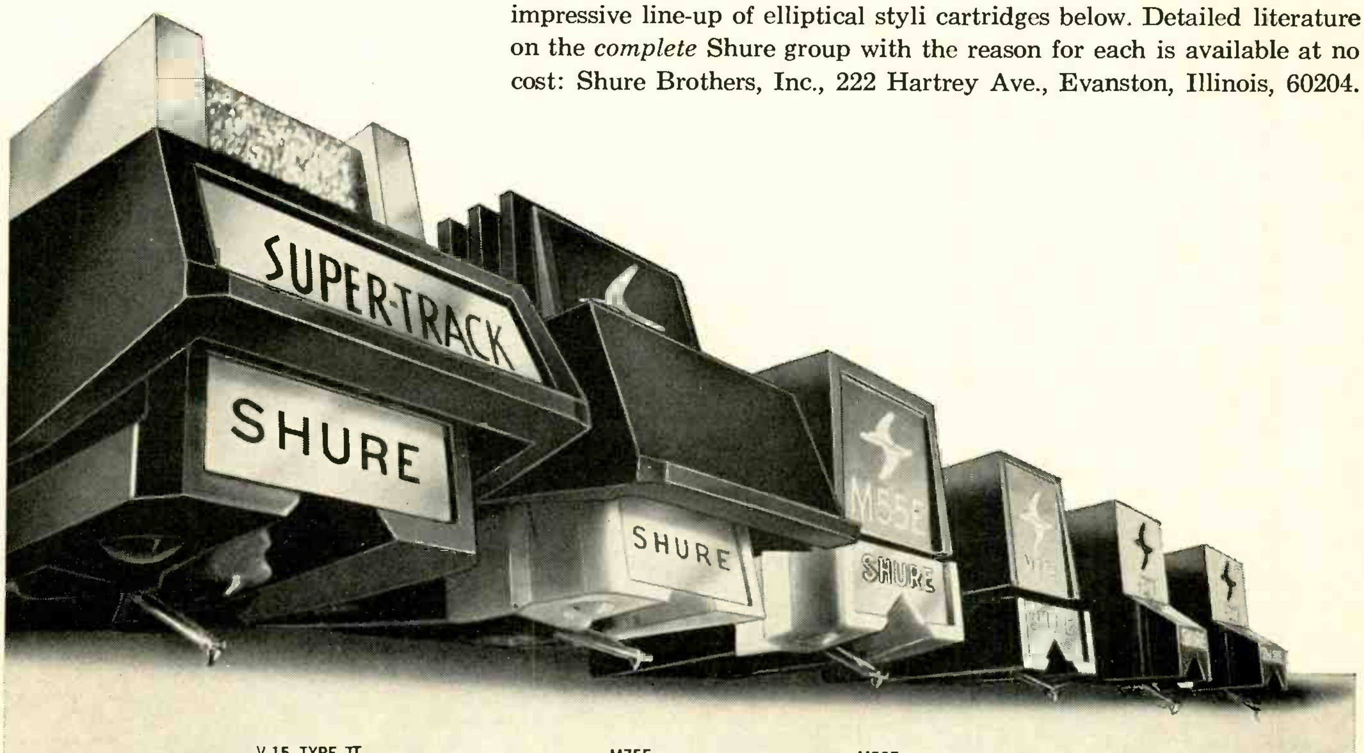

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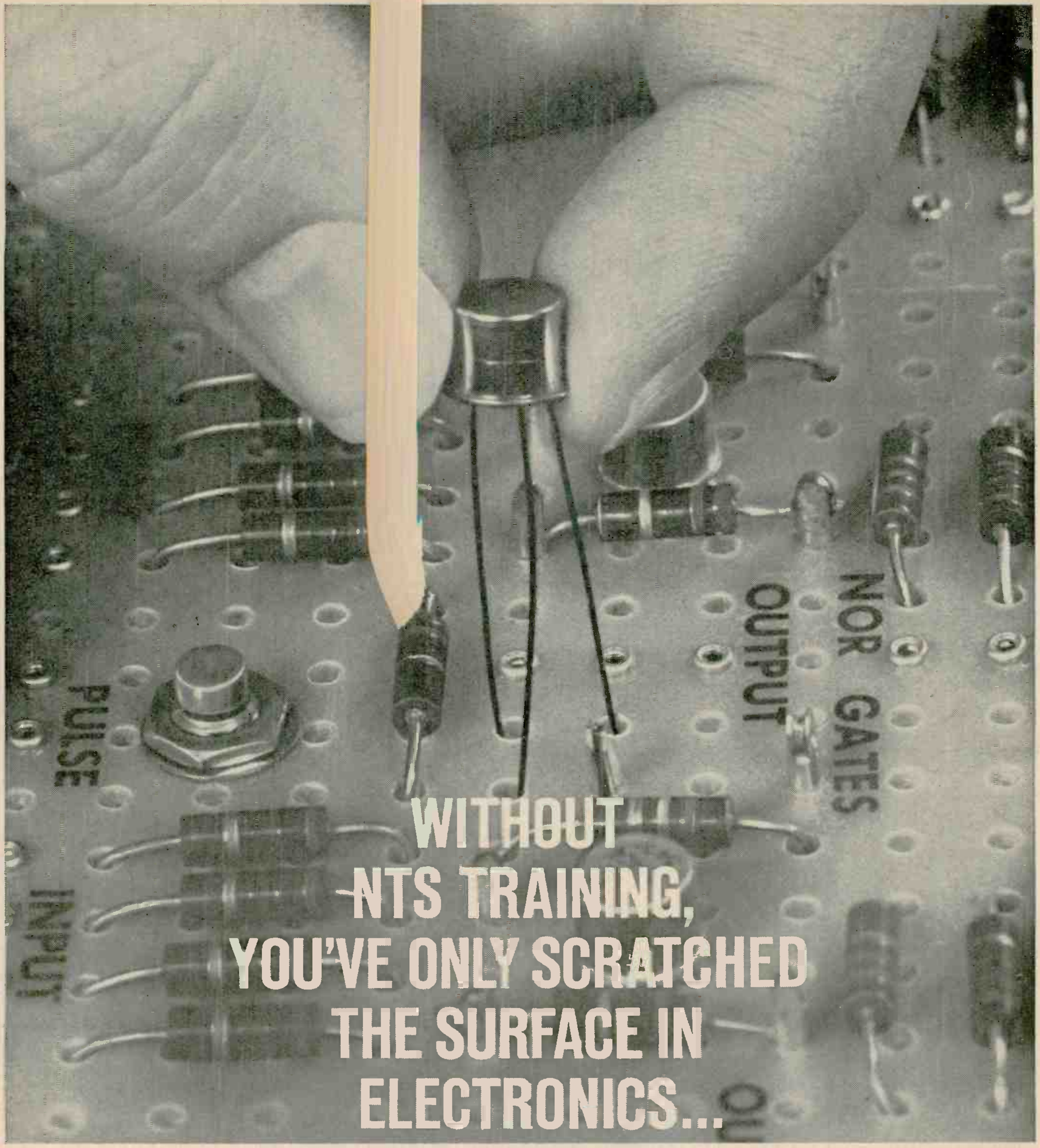

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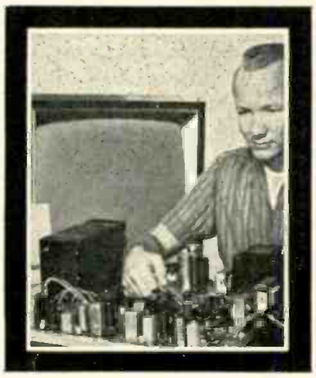

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In the shop . . . With Jack

(continued from page 16)

up to compensate for the lower level.

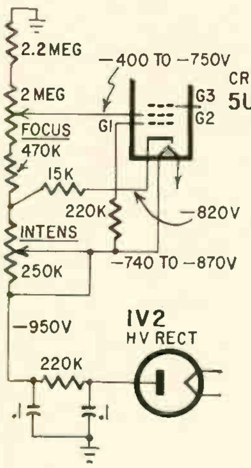
Otherwise, you might get hold of one of the *speech compressors* used with CB transmitters. There are quite a few of these being made now, at different prices. These are actually simply *limiting* amplifiers, which have avc. A portion of the output signal is rectified, and applied as bias to the input or second stage. If the gain goes too high, it cuts itself down. Similar equipment is used in most radio and TV stations, too.

You could get a compressor, put it between the mini recorder output and the bigger one's input, and then set it so that the overall output would be more uniform.

Uncontrollable brightness

The intensity control on my EICO 460 scope won't change the brightness of the trace. I don't have too much brightness as it is. I get —1500 volts on pin 2 of the 5UPI and it doesn't vary with the intensity control. What's the matter?—L.G., Jersey City, N.J.

You've got an open resistor somewhere in the voltage divider. The diagram shows how this works; your operating voltages are taken from the high-voltage rectifier cathode (1V2), and they're all too high, indicating that the divider is not loading the HV supply enough.



Normal voltages are shown in the diagram; notice that your total HV should be —950 volts, and you've got —1500. The cathode and grid voltages should vary as shown. However, if the divider is open, they won't! Crystal-ball diagnosis: One of the resistors "above" the controls is bad.

Organ trouble

I'm working on a middle-aged electronic organ. At first, none of the C notes worked. A new 0.051-μF capacitor in the C-oscillator stage fixed that. Now, the C's work, but only if I leave the vibrato off! I get a "warble" tone, and the note comes up to pitch very slowly, if I hold the key down. What's causing this?—J.M., Odenton, Md.

Basics: This type of organ uses an oscillator stage which is tuned to the

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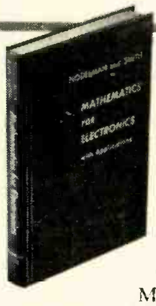

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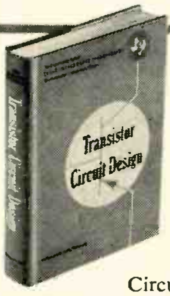

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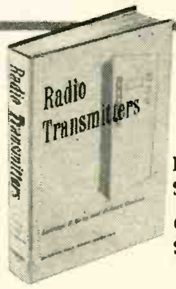

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(continued from page 22)

highest note on the keyboard. Then this signal goes to a series of frequency dividers; each makes the "next lowest note" (one octave down in musical notes means half the frequency).

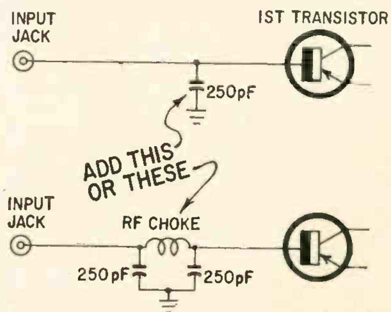
A true vibrato means a slight change in *frequency*; it swings back and forth around the original pitch. Many organ circuits use a dual triode tube in each tone generator: One is the tone oscillator, the other a very-low-frequency oscillator, down around 4–6 cycles per second. This signal is fed to the tone oscillator in such a way that it swings the frequency back and forth. Does it by varying grid bias.

Look for something like a coupling capacitor with a very small dc leakage, a resistor which has drifted far above normal value, or even a slight leakage across the socket through dirt accumulation. Watch for anything which would throw the vibrato oscillator off frequency, and cause it to affect the operation of the tone oscillator when it shouldn't. Most of the troubles in these circuits are due to bad capacitors or resistors.

Rf noise in stereo amplifier

I have a new V-M 20097 amplifier that's noisy. Another one like it picks up signals from a two-way radio in the owner's car when he gets close to his home. The volume control won't cut this out.—B.S., Sabattus, Me.

Your main problem here is that the amplifiers are too sensitive. They're picking up rf noise, CB radio signals and all kinds of electrical interference,



in their input circuits. Since the volume control in these is in the input, naturally it will have no effect on this kind of pickup.

The cure is to kill the rf signals at the input, without affecting the audio input. Try connecting a small capacitor, say about 250 pF, directly from base to ground of the input transistor on each channel. This being stereo, you'll have to fix both channels!

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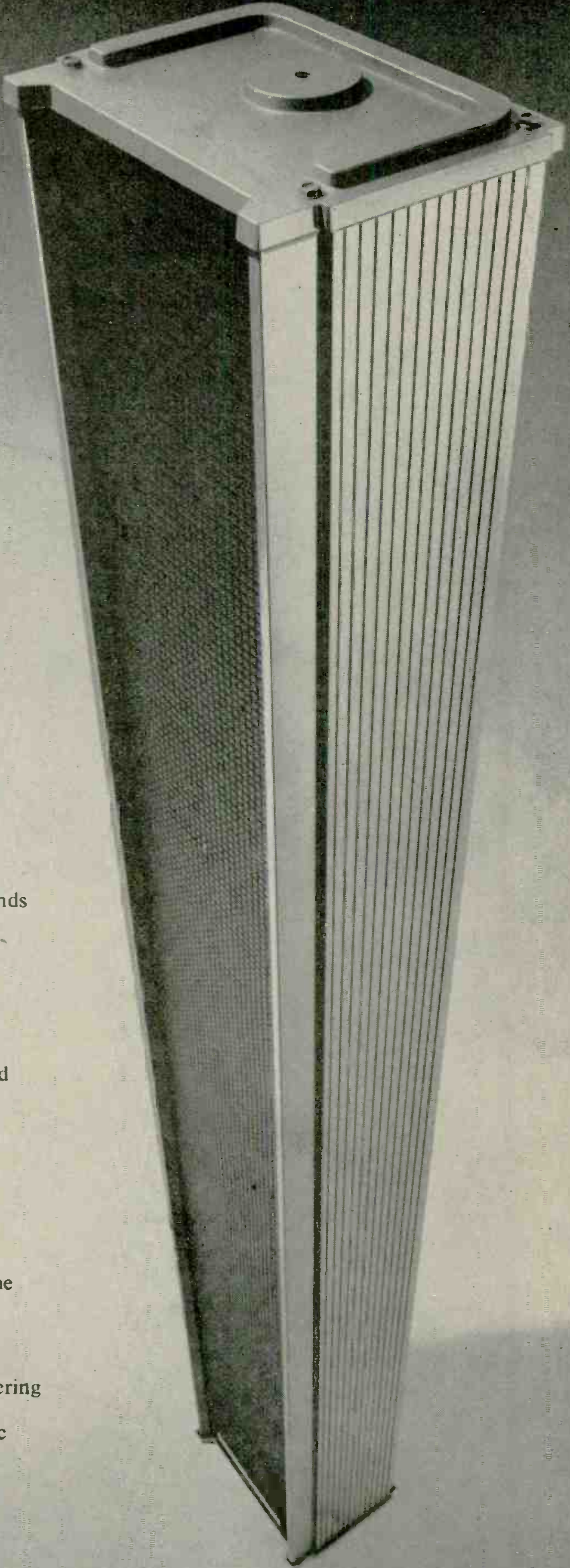

EV Column speakers look simple. Do it yourself? Why not!

Just hammer up a long box, grab a handful of radio-set speakers and a few feet of wire, and hook them up. Now cover the face with a couple of yards of hi-fi grille cloth and you're done. And it may even work.

Of course it won't be perfect.

It will be very heavy.

It won't be weatherproof.

Its polar pattern will be irregular — high frequency output lobes may appear almost anywhere (with at least one off the ends or back, right where you need a quiet spot for a microphone).

And finally, it may sound like nothing more than a long, narrow table radio. Or worse.

The new LR4SA Line Radiator* was designed to combat the many ills of hit-or-miss column speaker construction.

Start with the housing. We use a single channel of extruded aluminum, plus cast end caps. Very light. Weatherproof. Much stronger pound-for-pound than wood or steel. With no maintenance needed — indoors or out.

The grille is equally unusual. Acoustifoam®. We developed this foam plastic to be completely transparent to sound — yet act as a solid barrier to water!

And the LR4SA sounds better. You get solid coverage of a wide area with flat response. Unwanted lobes of energy at the backs and sides are sharply suppressed. It's quite a trick — and very useful to you.

It's accomplished in the LR4SA with very special 3″ x 5″ speakers, chosen for rising response, teamed with electrical filtering that progressively rolls off highs at the ends of the column. This "contouring" of the response of every speaker is the basic difference between column speakers and a Line Radiator.

The next time you face a job that calls for a column — try the LR4SA Line Radiator instead. It can make your day!

*T.M.

Specifications: Frequency Response 200 to 10,000 Hz; 80 Watts Peak Power; Dispersion 160° Horiz. 30° Vert.; Net Weight 25 lbs.; Size 48-3/8″ L x 6-5/8″ W x 4-7/8″ D; $150.00 List (less normal trade discounts).

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Circle 22 on reader's service card

In the Shop . . . With Jack

(continued from page 24)

If this doesn't get rid of it completely, add a very small rf choke in series with the input lead, right at the base of this transistor, and put a 250-pF capacitor to ground from either side of the choke, as in the diagram.

You can get small chokes already made, say about 15–20 μH, or wind one up out of about No. 30 enameled wire. About 20 turns on a ⅛-inch form ought to do; self-supporting. These parts are so small (electrically) that they'll have no effect on the audio signals, but they should shunt out the radio-frequency signals so that they can't get into the amplifier.

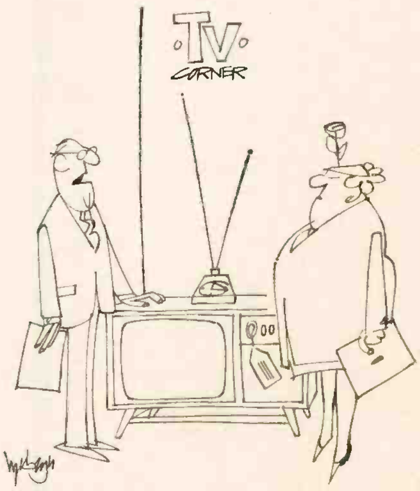
Check the ac line input to the power supply; you may have to add a pair of line bypass capacitors, about .05 μF, from each side of the ac line to chassis. This will help to keep interfering signals from being carried inside the shielding through the power line.

Turns-per-volt ratio

I've got an old TV power transformer, and I want to wind on some special secondaries. How do I figure out the turns-per-volt ratio?—A. B., Lynchburg, Va.

Take the "shells" off, pull the laminations (carefully!) and locate a winding of known voltage: the easiest one is usually the 5.0-volt 5U4 filament winding (yellow wires). Now, unwind this, counting the turns. Divide this by 5, and there you are.

For instance, if you get 25 turns all together, then it has a 5 turns per volt ratio. This will hold for any other windings you want to put on. **R-E**



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Circle 23 on reader's service card

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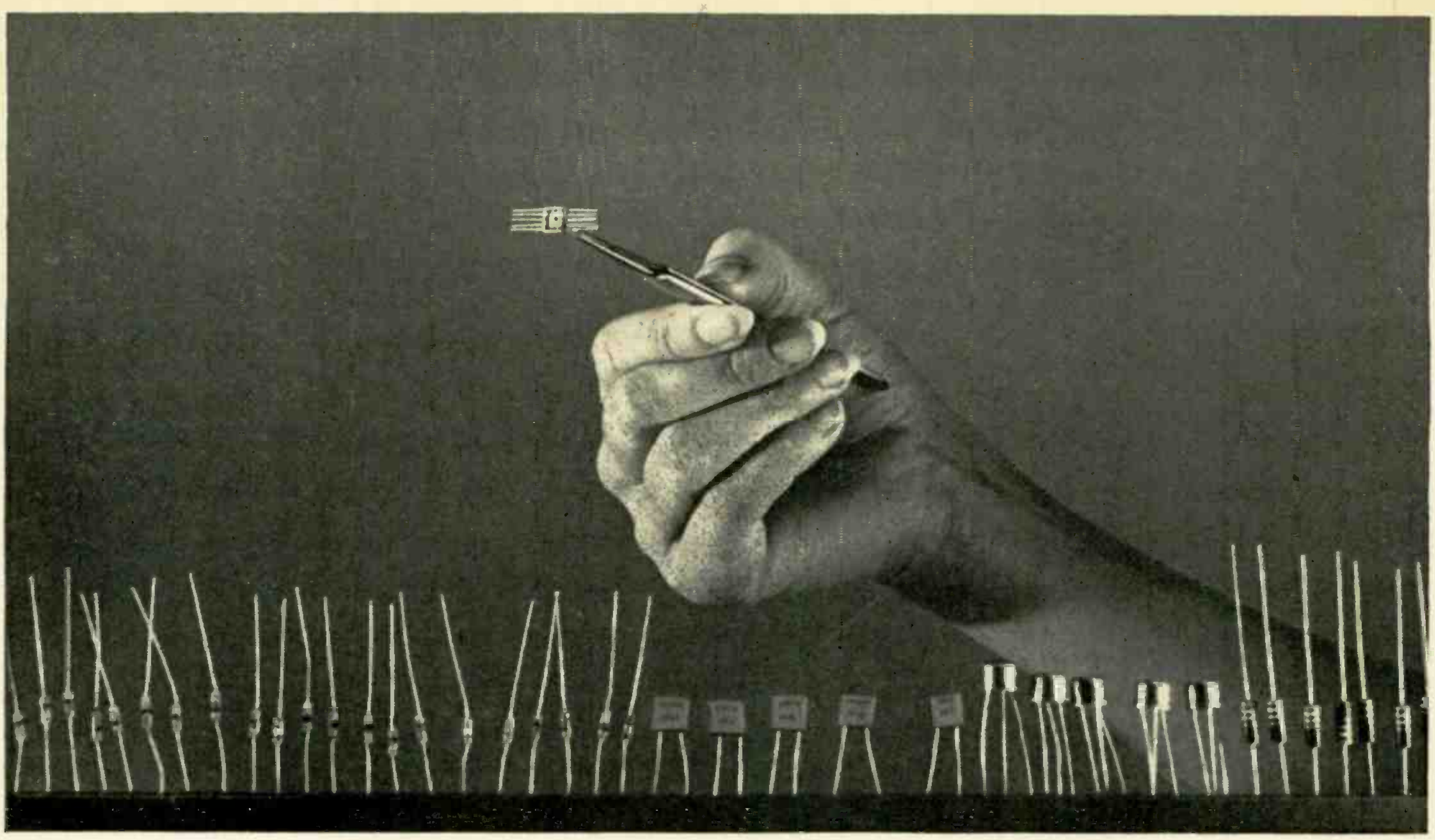

50 functions in a single chip. *The functions of 50 separate transistors, diodes, resistors and capacitors can now be formed by the tiny dot in the center of the integrated circuit held by the tweezers.*

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.

Circle 24 on reader's service card

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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.

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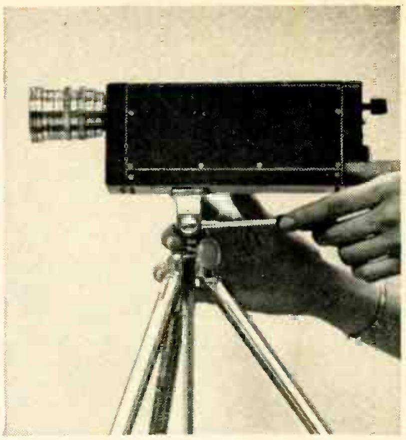
Because of rapid developments in electronics, CIE courses are constantly being revised. Students receive the most recent revised material as they progress through their course. This year, for example, CIE students are receiving exclusive up-to-the-minute lessons in Microminiaturization, Logical Troubleshooting, 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.*



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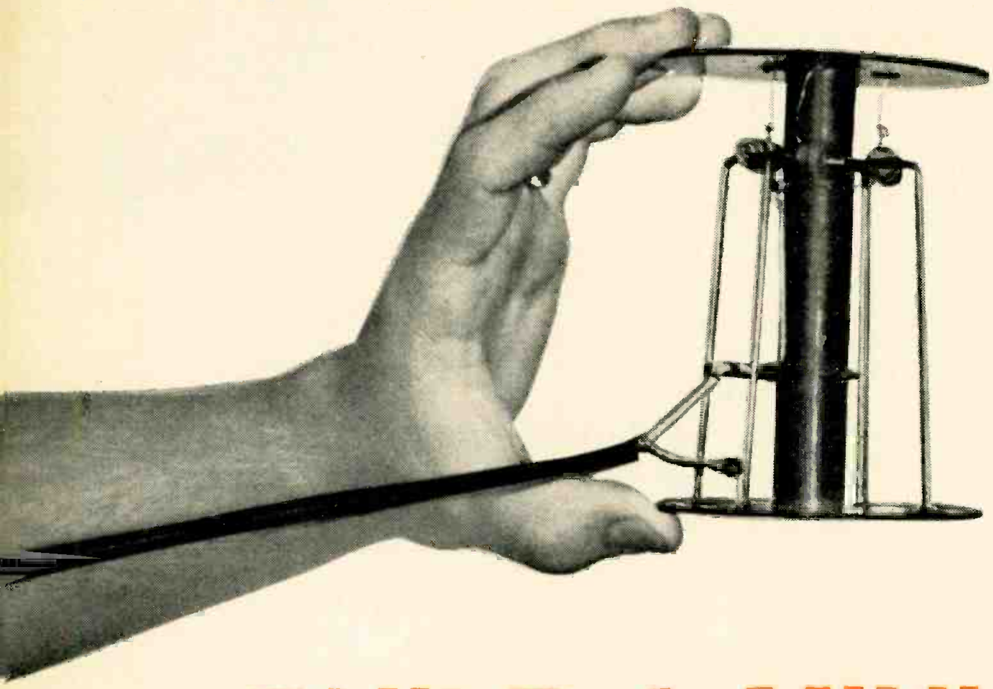

BUILD A MINI-TENNA

By JAMES A. GUPTON, JR.

Here's a construction project designed around one of the most controversial recent developments in electronics—the *Subminiature Integrated Antenna*, or SIA. You can build it in less than an hour, for only a few dollars. And you'll be learning something about the latest state-of-the-art development in antennas.

Background of SIA

In the spring of 1967 a new military communications development was revealed.* Researched and built by the US's Edwin M. Turner and Germany's Dr. Hans Meinke, the SIA was branded with an astounding claim—only 1/50 wavelength long, it can perform as well as a conventional quarter-wavelength model.

Normally, a small antenna (with respect to wavelength) has little capture area, hence doesn't pick up much rf signal. Thus gain is low and the antenna is inefficient. At frequencies above about 30 MHz, moreover, the signal-to-noise ratio of a small antenna is poor. Generally, then, an antenna should be a quarter-wavelength or longer in size to provide a clean signal.

In the SIA, transistors are connected *directly* to antenna elements. Thus the transistor multiplies the rf current in the antenna element by a factor equal to the gain of the transistor. Another way of looking at the situation: In a passive (conventional) antenna, resonant frequency depends solely on element length (unless electrically altered by inserting capacitance or inductance). But the SIA's transistors *lower* the resonant frequency. They also make the frequency response quite broad, so a few inches of wire will have good response.

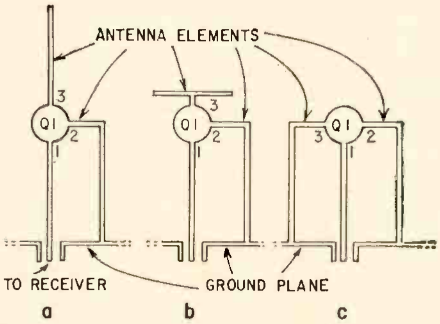

Fig. 1—Secret of SIA is that transistor becomes integral part of antenna.

Its developers claim that the SIA can operate over a wide frequency band—from a ratio of 2:1 to perhaps 50:1. Because the bipolar transistor used is a low-impedance device, an SIA usually needs no special matching circuit to drive coaxial cable directly.

Some antenna engineers, however, question the value of SIA. The same results could be obtained, they say, by using an ordinary passive antenna with a booster. Transistor noise levels, they note, can also limit performance of the SIA. And no study has been made of crossmodulation in the new device.

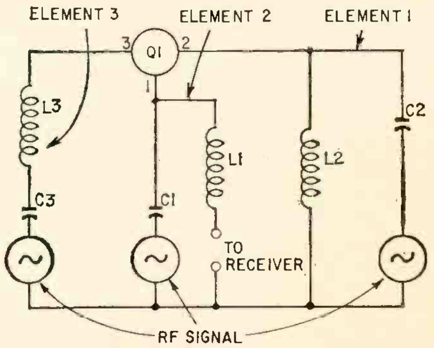

Fig. 2—Equivalent circuit of SIA's shown in Figs. 1-a and 1-b. RF signal is picked up by all antenna elements.

The controversy grew when some predicted a 2-inch-long SIA for home TV receivers would obsolete rabbit ears and rooftop antennas. But it mustn't be overlooked that the tiny antenna was developed for military use

* See "Major Antenna Breakthrough?" in News Briefs, RADIO-ELECTRONICS, July 1967.

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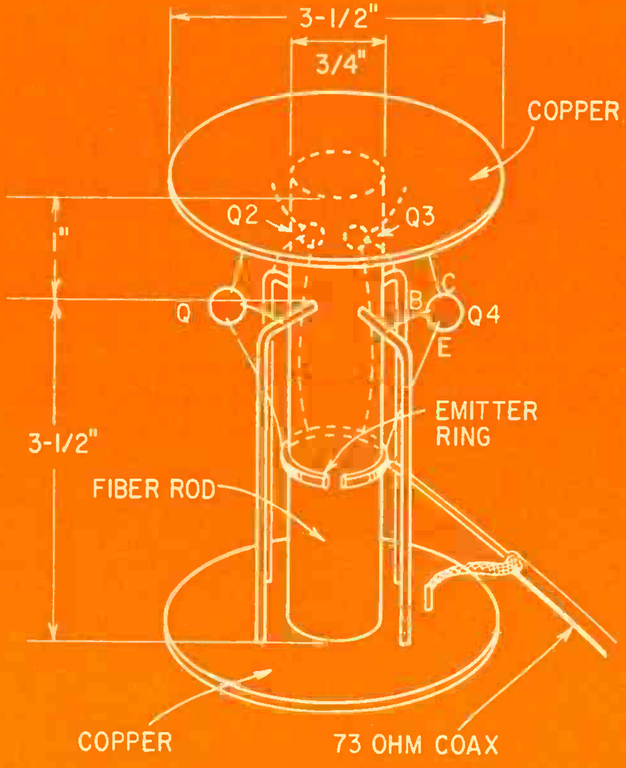
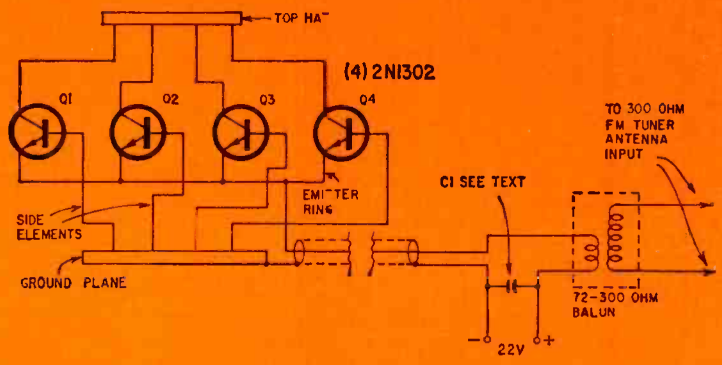


New experimental antenna blends solid-state elements with conventional skywire in new approach.

Fig. 5—(left) Construction uses capacitance of top and bottom "hats" for wide frequency response.

Fig. 6—(below) Diagram shows dc and mechanical circuit, but not distributed capacitance and inductance.



where large antennas simply can't be used and where some inefficiency must be tolerated.

How It Works

The simplest form of an SIA is merely a transistor connected to antenna elements in any one of three basic forms (Fig. 1). The ground plane is connected to one side of the lead-in, and a transistor lead to the other side.

In Fig. 2 you can see the equivalent circuit of antennas B and C of Fig. 1. Generator symbols represent the rf signal picked up by the three antenna elements. Distributed capacitance and inductance are shown, as well as the transistor and the lead-in terminals. Note that antenna elements 1 and 2 form loops, and respond to the magnetic rf field. All three elements respond to the electric field.

There are also three ways to connect a transistor to the antenna elements (Fig. 3). The emitter–base lead-in connection (B) seems the most likely to match low-impedance coaxial cable and receiver inputs. A practical model of this antenna might look somewhat like Fig. 4.

FM Mini-Tenna

My choice for an experimental model of an SIA was what I call a Mini-Tenna, for it stands only 4½ inches high and is 3½ inches in diameter.

You can see the simple construction in Fig. 5. A ¾-inch-diameter fiber rod forms the main support (you can also use Lucite, wood or any nonconductor here). At each end of the rod is a 3-inch-diameter round piece of copper-clad print board (a piece of sheet metal will do)—one forms the top hat, the other the ground plane. The copper sides of the boards face inward. Four lengths of No. 10 copper wire form the side elements, and another section of wire the emitter ring.

The electrical circuit, shown in Fig. 6, is just as simple. *Not* shown here are the distributed capacitances and inductances in the metallic elements. Battery bypass capacitor C1 is merely a

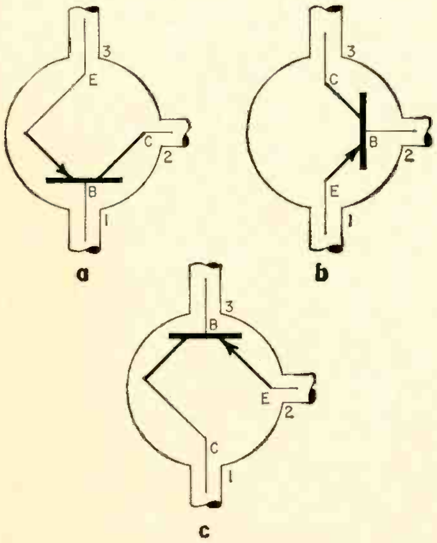


Fig. 3—Three transistor elements may be connected three ways in the SIA.

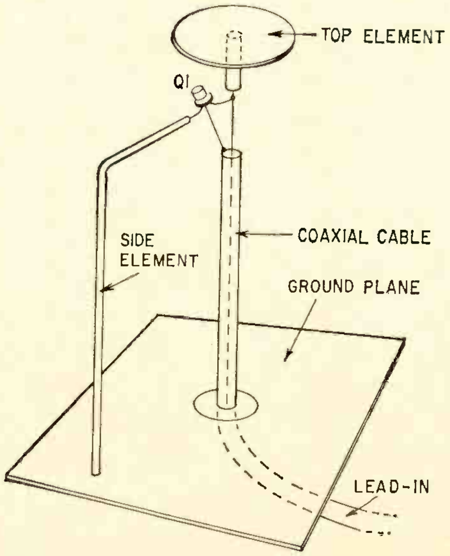


Fig. 4—Developmental version of SIA shows practical method of connections.

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gimmick with a value of a few picofarads. You can solder a short piece of hookup wire to each battery terminal, then twist the insulated ends together to form the gimmick.

Mini-Tenna's dimensions are cut to about 1/35 wavelength (at 100 MHz). I tried a 1/50-wavelength model, but the present antenna performs better. Since the antenna isn't sharply resonant, but is broad-band, exact dimensions don't seem too important. In fact, the larger the antenna, the more capture area, and the more signal.

Mini-Tenna Performance

Two* Radio-Electronics *editors borrowed author Gupton's small antenna to evaluate its performance. Their reports follow.

I compared the Mini-Tenna pickup capability with that of a dipole. The reference antenna was a 50-inch, 72-ohm open dipole, gamma-matched to 72-ohm coaxial cable. I oriented the dipole horizontally, north–south, and placed it 7 feet above the floor of my ground-floor apartment in Manhattan, at a location where the field intensity of the stronger local FM stations is approximately 250 to 500 mV/m.

The coax was fed through a 72-to-300-ohm balun into my mono Eico HFT-90 FM tuner. In the tuner, the agc network was disabled and all stages run at constant gain. The limiter grid voltage was monitored by a Heathkit IM-25 solid-state vom with 11 megohms input resistance. This monitored dc grid voltage was then essentially proportional to received signal intensity.

First I made a control run, measuring limiter grid voltage for signals from 14 local FM stations. Later measurements were plotted against this reference run.

Next I physically removed the dipole from its mounting at the end of the coax, and inserted a 4½-inch stub of wire in the coax plug; I oriented the wire vertically. The stub represented the Mini-Tenna reduced to the bare minimum. By remeasuring the same 14 FM stations, and plotting the differences against the reference dipole readings, I got curve (A) (see graph).

Then I mounted the Mini-Tenna in place of the wire stub—at the same point the dipole had been. With a 22-volt battery and a bypass capacitor in place, the "active" curve (B) was obtained. Next I removed the battery and placed a jumper across the break in the coax shield; this produced "passive" curve (C). Finally, all transistors were removed from their sockets and a short jumper was placed between the emitter ring (at the point where the coax ties to it) and the top hat. This gave curve (D), or "shorted."

As the graph indicates, there seems little difference in the pickup of the wire stub, the shorted or passive Mini-Tenna. It appears that the mass of metal in the Mini-Tenna, as well as the unpowered transistors themselves, contribute little or nothing to signal pickup.

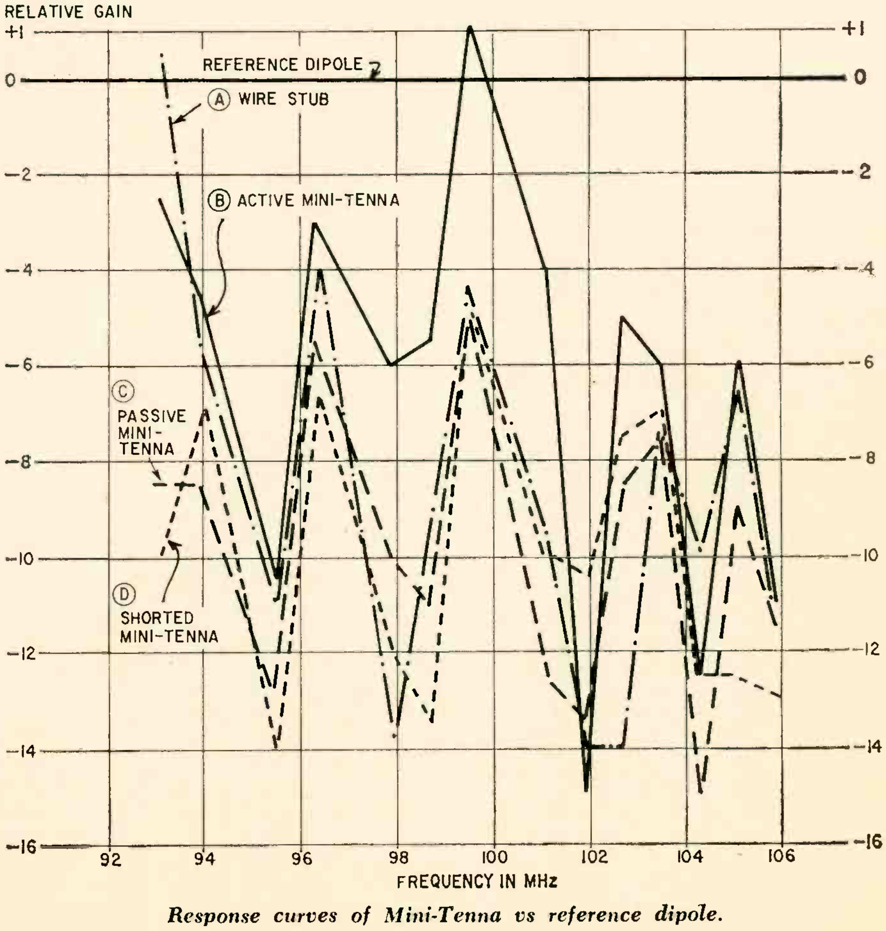
The active Mini-Tenna, however, seems to produce some significant improvement over the other modes of operation. It hasn't the pickup of a dipole, but it did produce fully quieted signals on local stations. The Mini-Tenna seems essentially nondirectional, but this might or might not be an advantage in metropolitan receiving locations. I did not evaluate this antenna for stereo.—*Thomas R. Haskett*

I found the Mini-Tenna to have no discernible effect (good *or* bad) on stereo FM reception at my apartment in Brooklyn. Presumably the broadband character of the antenna makes it frequency-flat and phase-flat over the necessary range of frequencies, so that stereo separation isn't affected.

However, like all more-or-less omnidirectional antennas, this one may intercept delayed reflections of signals just as well as it intercepts the direct signal from the transmitter; hence it may give distorted reception or poor separation on some FM stereo stations.

Signal strength was higher with the battery jumper open than with it closed (when the battery was not used). The gimmick had no noticeable effect. A 0.001-μF disc ceramic bypass capacitor connected in place of the jumper had the same (negative) effect as closing the jumper. (The reactance of 0.001 μF at 100 MHz is approximately 1.5 ohms.) This suggests that the gimmick has no significant bypassing effect. I estimate its reactance (100 MHz) at 1000-2000 ohms—vastly greater than the impedance of the battery or that of any other component in the system.

In short, the Mini-Tenna seems to perform about as well as a small piece of wire.—*Peter E. Sutheim* **R-E**



Response curves of Mini-Tenna vs reference dipole.

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Update Your Solid-State TV Servicing

Increased popularity of transistor TV receivers demands solid know-how

By MATTHEW MANDL

SERVICE TECHNICIANS ARE ALREADY familiar with some solid-state repair because transistor radios and hi-fi amplifiers have been with us for some time. You yourself have probably run across a few transistor circuits in hybrid TV sets and have had some experience with transistor portables.

In contrast to what they do in radios and hi-fi amps, solid-state circuits in TV must handle high-frequency video signals, pulse signals and sweep waveforms. TV troubles are often more complex. It is vital to follow certain precautions in solid-state servicing, not only to cut down on repair time, but to prevent damage to transistors.

To do an A-1 job in solid-state TV repairs we must also keep in mind the bias relationships between pnp and npn transistors. When we look at a manufacturer's schematic, the bias voltages don't always seem to follow textbook rules. We can best learn how to reconcile theory and practice by re-

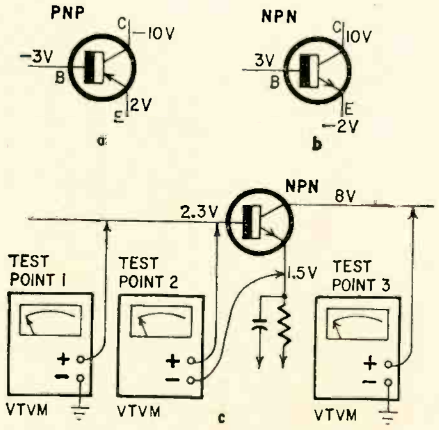

Fig. 1—Getting straight this matter of transistor bias voltages. It's easy.

examining bias rules and relating them to an actual TV circuit. Later, we'll examine some servicing procedures.

The rule for class-A amplification in *any* transistor is *forward bias between emitter and base,* and *reverse bias between emitter and collector.* This holds for either the pnp or npn. If it's a pnp, the first letter p indicates a *positive emitter,* the second letter n a *negative base* and hence forward bias. The final letter p relates to the collector, but since reverse bias is necessary, the collector is made negative. These bias relationships are shown in Fig. 1-a, where +2 volts is present at the emitter, −3 volts at the base, and −10 volts at the collector.

For the npn, shown in Fig. 1-b, the first two letters np denote that forward bias means negative emitter and positive base. The final n for the collector indicates, as before, that the collector-base junction would be forward biased with a negative voltage on the collector; but since that junction must be reverse-biased, it gets a postive voltage. If you apply forward bias between emitter and base as well as between base and collector, the transistor will burn out. It will conduct too much current.

Fig. 1-c is a typical video i.f. stage of a solid-state TV receiver (Sylvania AO4-1,2 chassis). Here it *appears* that our rule does not hold, because the emitter is positive. Actually, the rule is still followed because the emitter is negative with respect to the base by 0.8 volt, because the base is more positive than the emitter, making the emitter negative with respect to the base. If you read a voltage at test point 1 as shown, the reading is +2.3 volts.

At test point 2, however, we would read 0.8 volt, with the minus probe at the emitter as shown. Thus, test point 2 is the place to read the actual forward bias on the transistor. Reading from emitter to ground would show +1.5 volts, which is not the true bias. Collector voltage can be read from collector to ground as shown at test point 3, but if the reverse bias is to be checked the reading must be taken between emitter and collector. For this case it would be 6.5 volts.

Practical matters

In Fig. 2 the complete three-stage i.f. section of the Sylvania receiver is shown. A number of factors must be considered when servicing or checking such stages besides the bias testing just described. Often the transistor types are not given in the schematic, only the manufacturer's part number. Just because each stage performs the same

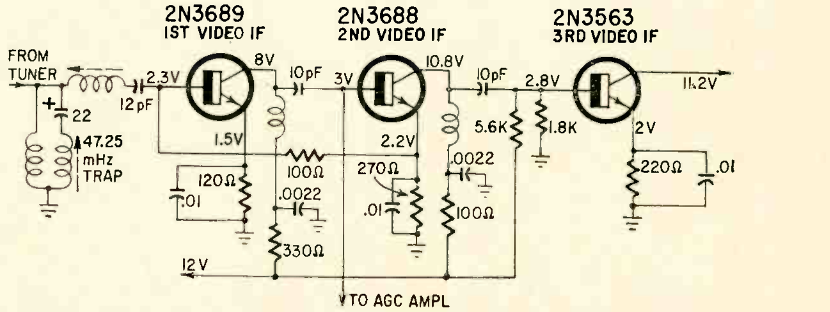

Fig. 2—Video i.f. stages from a Sylvania A04-1. Note untuned, capacitive coupling between stages. Leakage in coupling capacitors can overbias the following stage.

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function, don't assume the transistors are alike. Note the different types used for each stage in Fig. 2 to take care of gain and bandwidth considerations. When replacement is necessary, make sure you use an exact replacement.

When replacing transistors make sure the set's power is off. In i.f. stages, clip the transistor leads to the same length as the originals to maintain the same lead inductance. When soldering, hold the transistor lead with long-nose pliers to absorb excessive heat. Make sure terminals are clean and solder as fast as possible while still making a good joint. This is particularly important when the transistor is mounted on a printed-circuit board. Avoid excessive heat to prevent damage to both the transistor and the printed wiring.

If a transistor is found to be defective, check associated parts to make sure they are not the cause. Transistors often can't take even moderate overloads. Even test equipment which is not

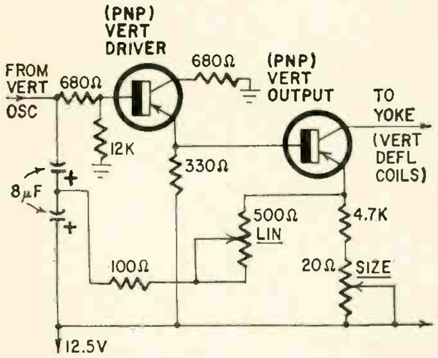

Fig. 3—Vertical sweep amplification in Motorola TS-460. In direct-coupled circuits like this one, excessive leakage or a short in one transistor will often affect voltages around the other and destroy it.

well isolated from the power line can ruin a transistor.

Forward bias can be upset by a leaky coupling capacitor between the collector of one stage and the base of another. Note the third i.f. stage in Fig. 2, for instance. Here the emitter is +2 volts and the base +2.8, providing a forward bias of 0.8 volt. If the 10-pF coupling capacitor is leaky, some of the 10.8-volt collector potential can get to the base and increase forward bias.

Increased forward bias on a transistor increases current flow and can cause overloading. Read the voltage between base and emitter. If it is more than 1 volt when the schematic calls for 0.8, check parts for defects.

Note the 0.0022-μF decoupling capacitors across the series resistors in the collector circuits. If these *open,* signal cross-coupling between stages can occur with consequent oscillations. This can cause interference lines on the screen. If these capacitors *short,* the collector voltage is shorted to ground and video signals are lost. The collectors resistor will also heat up—a sure clue to a shorted capacitor or possibly a transistor.

Generally resistors give little trouble, though routine checks should be made when circuit troubles are evident. Make voltage checks first and, if a resistor is suspected, unsolder one end and take an accurate ohmmeter reading. When making voltage checks with power on, set contrast and brightness at a minimum unless otherwise specified in the manufacturer's notes.

Scope tests

Too many service technicians still do not use their scopes enough in troubleshooting. Either they don't understand the scope or they feel it's too much trouble to set up. But a scope can save you so much time and pinpoint troubles so precisely that it's foolish not to use it. You are practically

Fig. 4—Correct vertical driver pattern for the circuit described in Fig. 3.

Fig. 5—Cheap scopes often produce fuzzy patterns with prominent retrace lines, especially at higher frequencies and with high horizontal-sweep rates.

working blind if you don't use it.

Take the case of sweep drivers in most solid-state TV sets. These drivers or amplifiers are used between the sweep generators and the output stages. It is important that they provide sufficient gain, or height and width will suffer. If trouble is suspected it is much easier to take a scope reading than to check components and transistors. If the peak-to-peak waveform voltage is below the recommended value, much time is saved in pinpointing the defective stage.

A typical vertical driver circuit is shown in Fig. 3 (Motorola TS-460 chassis). Here an emitter-follower circuit is used, directly coupled to the vertical output stage. Since the collector is not bypassed, however, it makes a good check point for the scope connection. The waveform obtained here is shown in Fig. 4 and is a typical sawtooth signal. For this set the waveform should be 7 volts peak-to-peak. More than a ½-volt difference indicates a decrease from normal stage gain.

Because direct coupling is used, the only capacitors are those involved with the linearity-control feedback loop. Hence, low gain is often caused by a defective driver transistor.

Insufficient vertical oscillator signal could, of course, be a contributing factor. Thus, a scope reading should be taken between the base of the vertical driver and ground. The peak-to-peak voltage should be approximately 3.2. The waveform would be opposite in phase to that shown in Fig. 4.

Scope measurements

A good scope accurately calibrated to read peak-to-peak voltages is very helpful for signal waveform observation and voltage measurements. A poor scope may suffice for signal tracing, where the absence of presence of the signal is all we need to check. For pulse and sawtooth waveforms, however, the high-frequency signal components will be diminished in a scope having poor response, and the waveform will then be distorted.

Note the waveform shown in Fig. 5, taken with a scope having poor response. The long, sloping trace (sawtooth sweep) has a long rise time and hence shows up well on this scope. The sudden drop from the high to the low level, however, is too fast and the scope is unable to respond as well; hence the trace is fuzzy compared with that of Fig. 4. Also, note the presence of the scope's retrace line in Fig. 5, which can be blanked out on better scopes as shown in Fig. 4. The sawtooth scan in Fig. 5 shows some traces of nonlinearity in the upper portion and you're never sure, with a cheap scope, whether this is in the TV circuit or in the scope. (The number of cycles shown depends on the setting of the scope's horizontal frequency control.)

The horizontal driver and output stages of the Magnavox T021 receiver are shown in Fig. 6. This set uses a 9XP4 picture tube and is all solid-state. Note the low voltage (−11.6) at the damper collector, compared to the high boost voltages in tube dampers. Where normally we would not take scope readings on the horizontal output section of a tube-type receiver, we can safely take readings on the solid-state units. A scope pattern taken at the emitter of the horizontal output transistor is shown in Fig. 7. It should have an amplitude of 80 volts peak-to-peak on your scope.

In making voltage checks on these circuits, note that the driver and

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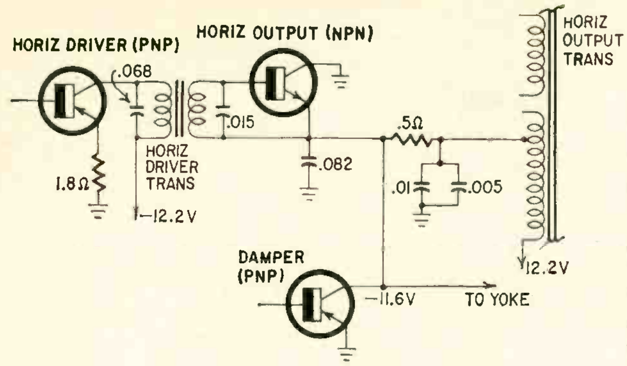

Fig. 6—Magnavox T921's horizontal output. Maximum peak-to-peak voltages in this circuit range around 80, and are perfectly safe to measure with ordinary instruments. Note the pnp driver and damper versus the npn output transistor.

damper transistors are pnp types and the horizontal output is an npn type. For this receiver the positive potential is at ground level, hence the emitters of the driver and damper have the proper polarity. For the output transistor emitter, however, we have a common minus-voltage linkage between it and the collector of the damper. To check the amount of drive, observe the peak-to-peak waveform at the collector of the driver. The correct potential should be 20 volts peak-to-peak.

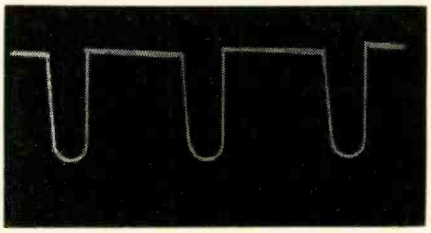

Fig. 7—A scope at the emitter of the horizontal output transistor in Fig. 6 should show the above waveform when the circuit is operating in a normal manner.

Because of the direct coupling, horizontal-output transistor troubles can affect the damper circuit and vice versa. Both transistors should be checked if troubles are evident.

Because of their low impedance, the sweep output transistors can be connected directly (or via a capacitor) to the deflection coils without transformers. In the horizontal system the transformer is used only to generate the high voltage for the picture tube.

When replacing any power transistor, apply silicone grease to the mica insulator and the bottom of the replacement transistor. Without the grease the thermal resistance of the heat sink increases and the transistor may overheat and have a shorter life.

When servicing *any* transistor circuits, don't bridge a suspected capacitor with another capacitor while the set is turned on. When you shunt one capacitor with another you can damage a transistor easily because of the surge voltages set up in the circuit. This practice, even in tube sets, will tell you only if a capacitor is open. If a capacitor is shorted, shunting it with another is of no help.

Low-voltage troubles

In some solid-state TV receivers elaborate precautions are taken in the low-voltage supply to keep it steady. This assures constant bias for transistors even with line-voltage variations.

A typical system is shown in Fig. 8. It is used in the General Electric TC chassis receiver. (The same principles are also used in the Westinghouse V-2483-1 chassis and the Zenith 1M30T20 chassis.) Three transistors supplement the Zener-diode voltage regulator. This voltage-regulation method is particularly useful in sets which combine line-voltage input with battery-charger facilities.

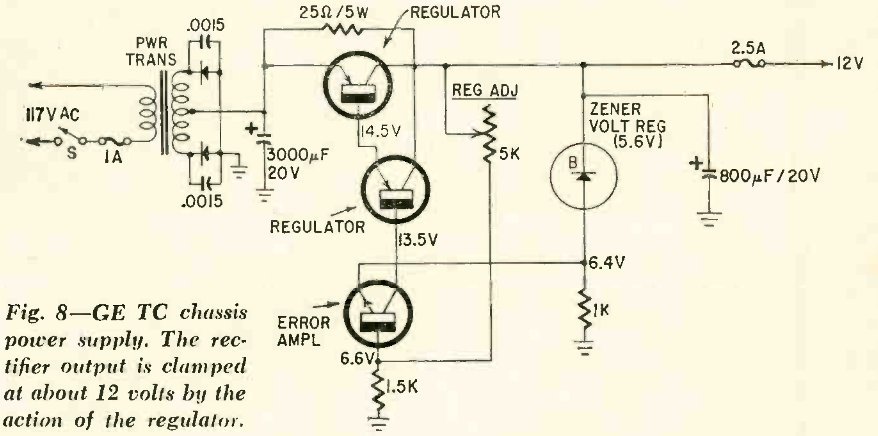

Fig. 8—GE TC chassis power supply. The rectifier output is clamped at about 12 volts by the action of the regulator.

The top regulator transistor acts as a dynamic resistor in series with the load and regulates current flow. The resistance of this transistor is controlled by its bias voltage which is developed across the other regulator transistor (preregulator). The preregulator in turn is controlled by the error amplifier. The error amplifier senses the voltage drop across the 1000-ohm resistor, and makes the system responsive to small changes.

(Note that the emitter of the error amplifier is connected to the junction of the 5.6-volt Zener diode and the 1000-ohm resistor. These two components act as a voltage divider across the output which is to be regulated. Any variation in the voltage on this line varies the current flowing through the divider. The voltage drop across the Zener is constant at 5.6, this in effect, puts the full error voltage across the resistor.)

An increase in voltage either at the source or due to a lighter load tends to increase the voltage drop across the 1000-ohm resistor. This puts a more positive voltage on the emitter of the error amplifier in opposition to its forward bias and effectively increases its dynamic resistance. The higher voltage developed across the error amplifier increases the voltage on the base of the preregulator which tends to cut down its current flow (effectively increasing its dynamic resistance) and increases the positive voltage applied to the base of the top regulator and tends to "pull" the output voltage down to normal. A lower than normal voltage at the source or the output will cause a reverse action. The Regulator Adjust Control sets up the center of operations for this solid state voltage-divider network.

When replacing a defective Zener, make sure you wire it in with the same polarity as the original, and that it has the same voltage rating as the original. The replacement can be of larger wattage, but must have the same voltage rating as the original.

In Fig. 8 the 5000-ohm potentiometer sets the bias voltage for the error-amplifier transistor by increasing or decreasing the voltage drop across the 1500-ohm base resistor. As this voltage is raised it approaches that of the emitter and decreases bias. If any regulator transistor is replaced, set the regulator adjustment control for the voltages specified by the manufacturer.

For the General Electric set shown, the base of the error amplifier should have 6.6 volts, and the emitter 6.4 volts. If the other regulating transistors are all right, 13.5 volts should appear at the base lead of the lower

(continued on page 93)

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Pulses and Pulse Circuits You Should Know

Differentiate and integrate to keep in sync

By ROBERT G. MIDDLETON

ANYONE SERIOUSLY INVOLVED WITH electronics should be vitally concerned with pulsed circuit action. Unfortunately, many technicians are hampered by an incomplete or inaccurate understanding of pulses and pulse-forming circuits. For example, the pulse voltage in Fig. 1 produces zero reading on a dc voltmeter, in spite of the fact that the positive-peak is greater than the negative-peak voltage. The reason is simply that the pulse waveform contains equal *quantities* of positive and negative electricity (current × time). Since a dc voltmeter is a current instrument—albeit a *small-current* instrument—the equal positive and negative quantities cancel each other and give a zero reading.

Polarity reversal of a pulse

When a "positive" pulse is passed through an amplifier stage (a video amplifier, for example) it becomes a "negative" pulse (Fig. 2); a sine wave passed through a similar amplifier

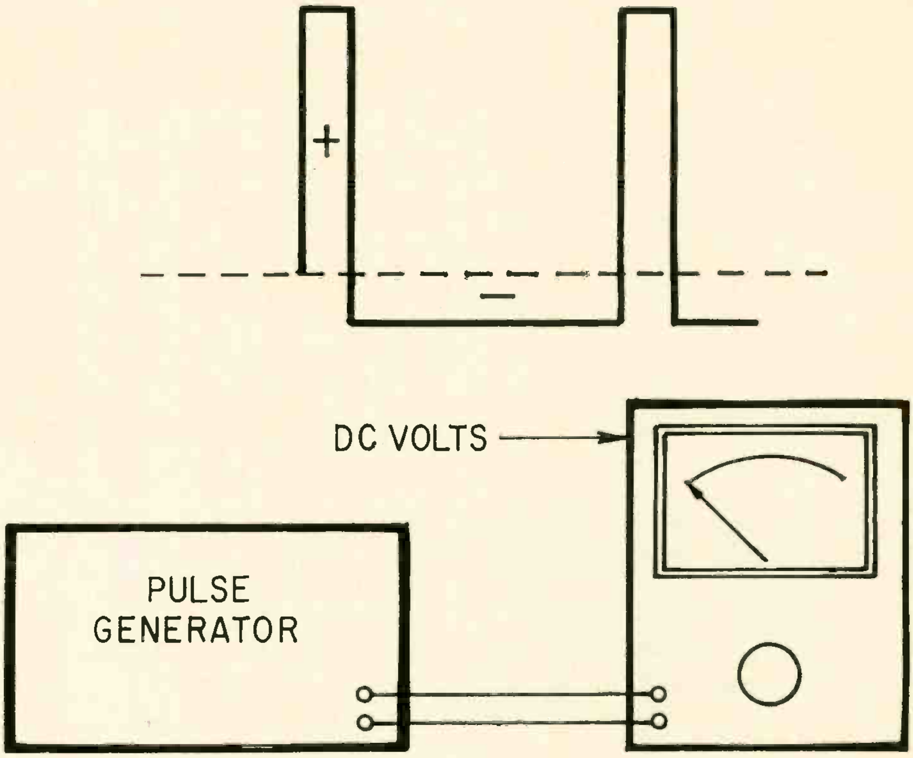


Fig. 1—Since a dc voltmeter actually reads average current, the pulse shown will cause no indication on the meter . . . average dc voltage and current is zero.

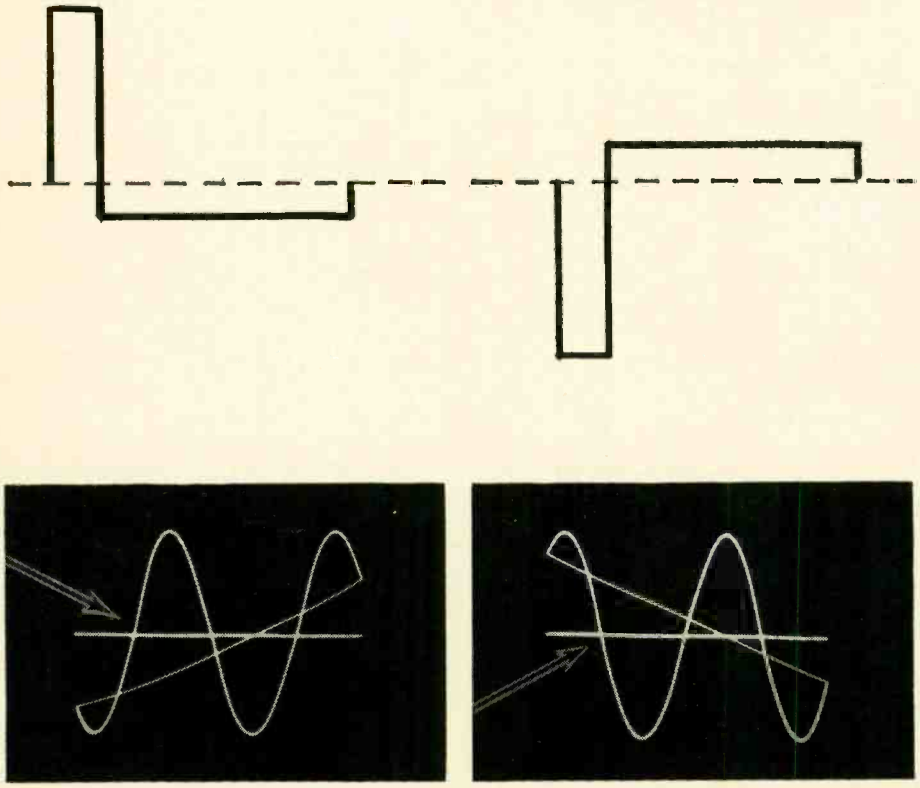
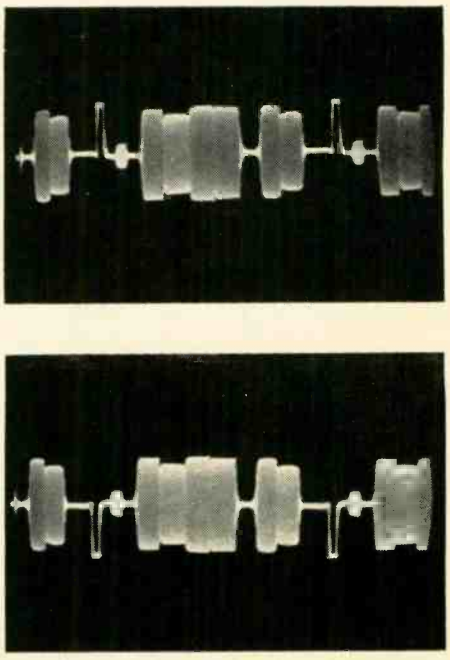


Fig. 2—Waveforms, whether pulses or sine waves, are inverted by an amplifier stage. The terminology, however, is different for the two types of waves.

a



b

Fig. 3—Color-bar video waveform in positive (a) and negative (b) modes.

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stage is shifted in phase 180°. These two facts are equivalent. The sine wave also can be regarded as being inverted in polarity. Since both half-cycles of a sine wave are symmetrical, however, one half-cycle is not distinguishable from another. The amplifier action is thus described as a 180° phase shift.

Polarity reversal of a complex waveform is illustrated in Fig. 3, the examples taken from a color-bar generator provided with a video-polarity switch. When the switch is in the positive position, the horizontal-sync pulse is positive (Fig. 3-a). When the switch is thrown to the negative position, the sync pulse is negative (Fig. 3-b). The chroma bars (blocks of 3.58-MHz sine waves) come after the color burst signal which comes after the sync pulse.

What really happens when we pass a chroma-bar signal through a stage of amplification? Recalling the sine wave of Fig. 2, we'd expect the 3.58-MHz sine waves to be shifted 180° in phase. This means that R − Y will be changed to −(R − Y), and B − Y will be changed to −(B − Y), etc.

The color burst has the −(B − Y) phase. Hence, if the color burst is

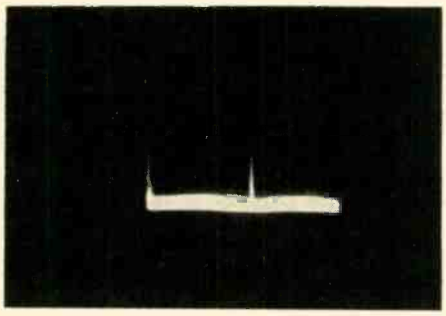

Fig. 4—Narrow vertical pulses appear dimly on the screen of a service scope.

passed through a stage of amplification, it changes to the B − Y phase. Note that the burst is a complex type of pulse waveform having a complete envelope. This results from a sine wave of the −(B − Y) phase being modulated by a pulse which has the same width as the horizontal-sync pulse. The chroma-bar signals also form pulse envelopes, but the modulating pulses are wider than a horizontal-sync pulse.

Display of pulse waveforms

The horizontal-sync pulses of Fig. 3 are clearly visible, primarily due to the comparatively slow rise and fall time of the sync pulse and the appreciable width of the pulse. On the other hand, consider the pulse in Fig. 4. This pulse, generated by a white-dot generator, has a fast rise and fall, and the pulse is also comparatively narrow. As a result, it can be displayed only with difficulty on the screen of a service-type scope—the vertical deflection of the beam is so rapid that the pulse is quite dim. In some cases, a white-dot pulse is so narrow that it is completely invisible in the scope pattern, and it could be falsely concluded that the generator was not supplying pulses.

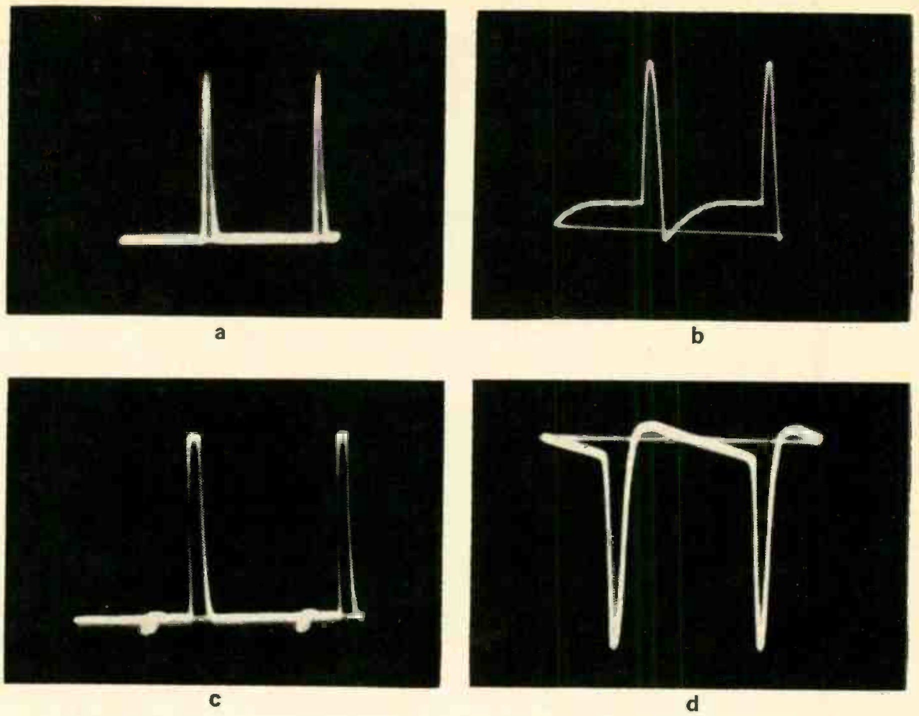

Fig. 5—These various waveforms may all be properly classified as true pulses.

To display very narrow fast-moving pulses satisfactorily, you need to use a lab-type scope. Lab scopes also have beam-unblanking circuitry which intensifies the relative brightness of the pulse.

Pulse classification

Some familiar waveforms are clearly classified as pulses, while analysis of others can be difficult. For example, there is no hesitation in describing the waveforms in Fig. 5 as pulses. Although three of the photos exhibit un-

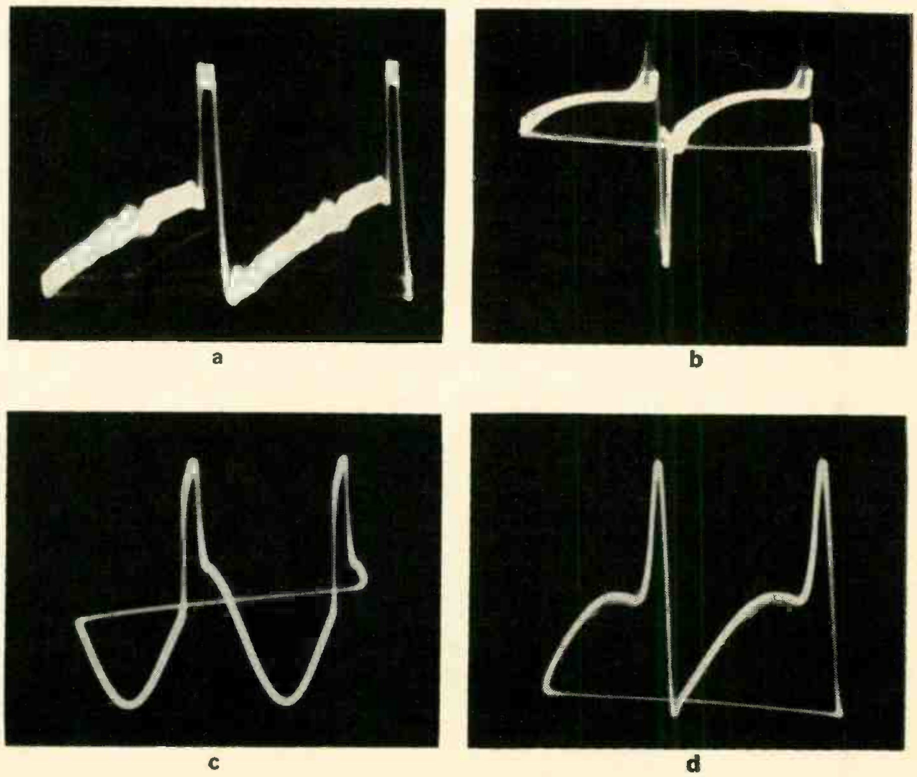

Fig. 6—These waveforms may be regarded either as pulses or as complex waves.

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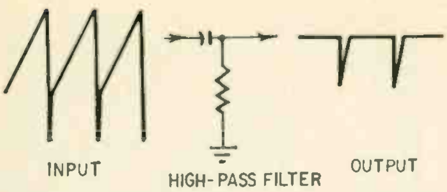

Fig. 7—Differentiator passes only high-frequency harmonics of peaked sawtooth.

even base lines, the pulse component in each waveform is dominant and unmistakable. The base lines could be described as sloping in Figs. 5-b and -d.

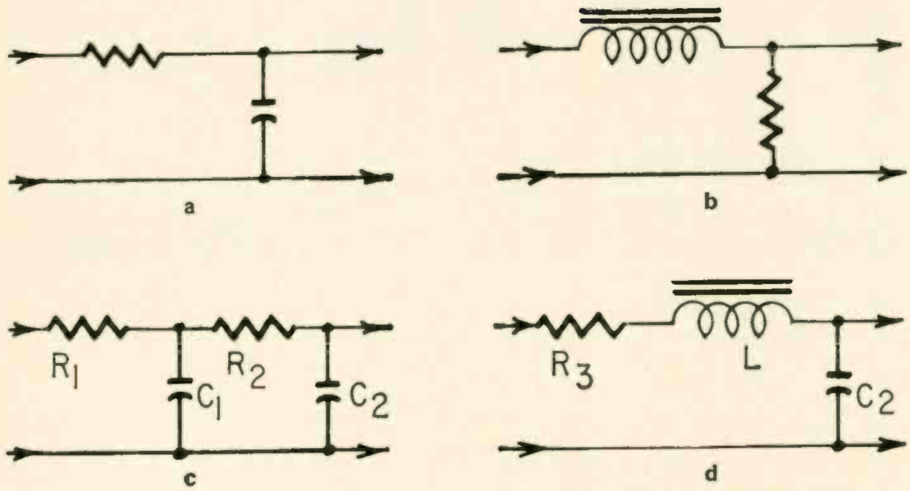

Fig. 8—When low-pass filters are used with pulses, they build up a waveform.

In Fig. 5-c, an irregularity can be noted in the base line. On the other hand, the waveforms illustrated in Fig. 6 can be called pulses only when the pulse component is of chief concern. Otherwise, they will be termed complex waveforms.

The waveform in Fig. 6-a is fully described as a peaked-sawtooth wave. You could also include mention of the residual video signal riding on the sawtooth component. Again, the waveform in Fig. 6-c is fully described as a pulse-and-sine wave: you could also state that the pulse appears near the positive peak of the sine wave. Distorted peaked-sawtooth waveforms are shown in Figs. 6-b and -d.

In each of these waveforms, the pulse has a certain amplitude relative to the sawtooth or other portion of the waveform. Furthermore, the peak-to-peak voltage is tied closely with circuit action. For example, a sync clipper does not operate as intended unless the input waveform has a peak-to-peak voltage that lies within certain specified limits.

Waveshaping circuits

To change a peaked-sawtooth waveform into a pulse (differentiate), a high-pass filter is used. A simple differentiating circuit is shown in Fig. 7. The pulse component of the waveform contains harmonics much higher in frequency than the sawtooth component itself. Hence, when suitable values of capacitance and resistance are chosen, the pulse is passed and the sawtooth is rejected. The simple RC configuration works best for peaked-sawtooth waveforms having comparatively narrow pulses.

Low-pass filters also are used as waveshaping circuits; Fig. 8-a shows a single-section RC integrating circuit. Integration is a process of addition or accumulation, and requires a storage device such as a capacitor. In a TV set the 60-Hz sync pulse is developed by a series of 6 relatively wide square wave pulses transmitted between the equalizing pulses in the composite video signal. The low-pass filter type of action prevents the relatively short duration pulses from building up a signal voltage at the output of the integrator. Figure 8-c is a 2-section network.

Another possible integrator circuit configuration is shown in Fig. 8-d. However, this circuit may not always work.

The RL circuit of Fig. 8-b is also an integrating circuit; if you choose suitable values of R and L, it offers the same waveshaping action as Fig. 8-a.

Practical difficulties in specific cases are due to the distributed capacitance of coil windings, which makes coils self-resonant at some frequency. If the input waveform contains strong harmonics near the resonant frequency, the output waveform will be distorted. Not only will the waveshape be different than anticipated, but "ringing" distortion can also occur.

Small pulse components

Familiar waveforms sometimes have comparatively small pulse components, which are nevertheless essential for normal circuit action. In an afc circuit, for example, the horizontal-sync pulse appears as a component of slight amplitude riding on the sawtooth comparison wave (Fig. 9-d). The pulse is halfway up the sawtooth wave, which corresponds to a picture that is split horizontally on the screen. If the pulse is weak or absent, there is a complete loss of horizontal locking. Another ex-

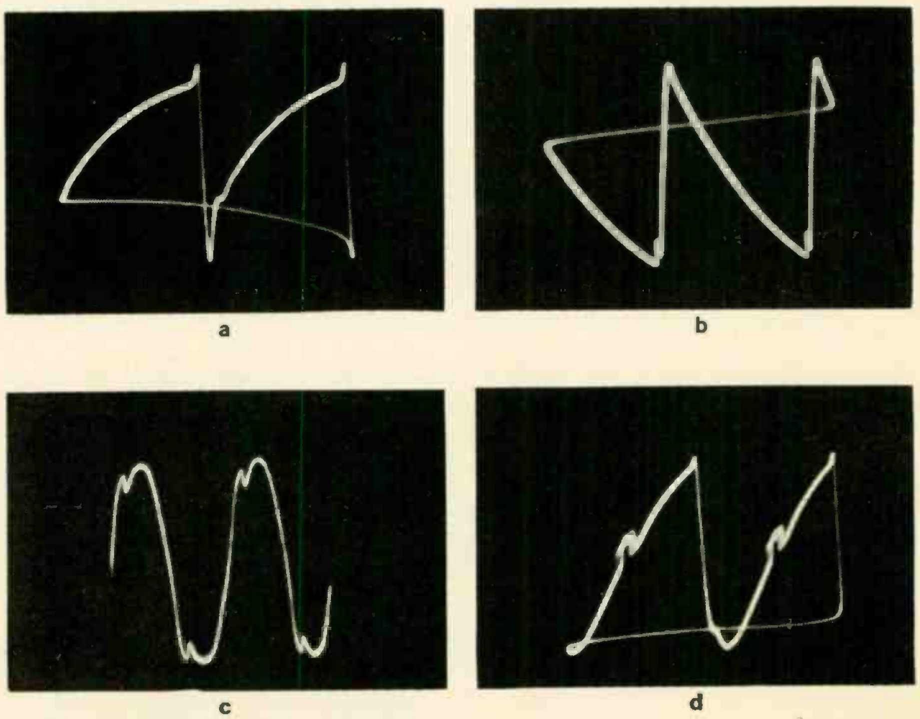

Fig. 9—Pulses can appear on various parts of a waveform. Sometimes they are hidden and sometimes they are very prominent. They can also increase or decrease amplitude.

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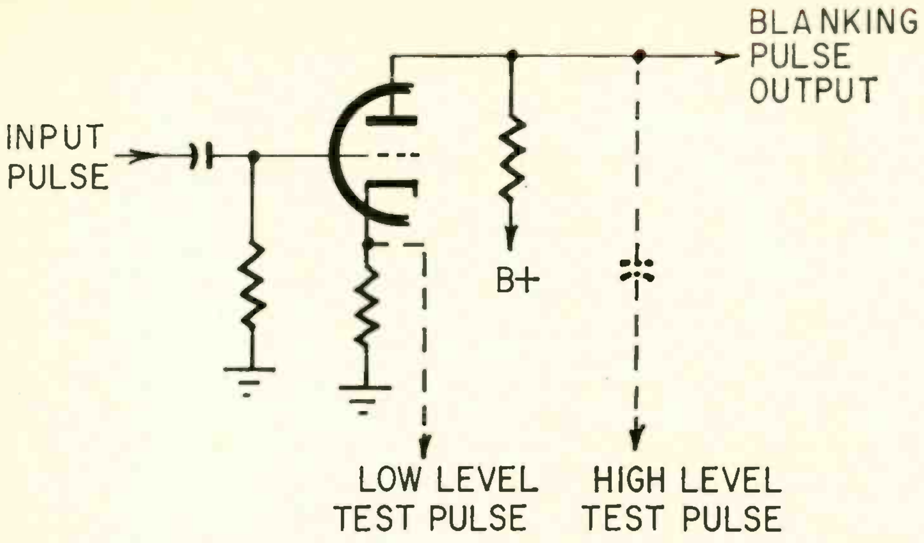

Fig. 10—Ringing-test pulse may be taken from blanking-amplifier output on scope.

ample of a minor pulse component is seen in Fig. 9-c; this is the voltage across the primary winding of a small 60-Hz transformer. Excessive current is being drawn, and the core is saturating during the pulse intervals. The pulse component is a clue to abnormal current flow. As saturation is approached, the sine wave becomes flattened.

In Fig. 9-b, the pulse starts at the negative peak of the sawtooth waveform, and its shape is obscured by the ensuing retrace interval of the sawtooth. The opposite aspect is seen in Fig. 9-a; here, the pulse is negative-going and increases the amplitude of the sawtooth component. A smaller positive-going pulse at the top of the waveform also increases the total amplitude. Various pulse-and-sawtooth waveforms are used in the horizontal-afc and sweep sections of many TV receivers, and analysis of waveform distortion with measurements of peak-to-peak voltages can be of considerable assistance in practical troubleshooting procedures.

Test-pulse source

Electronic technicians use pulse generators to make tests of coils and transformers as well as audio amplifiers and other equipment. A scope is a convenient source of test pulses. For example, most modern scopes have blanking amplifiers similar to that in Fig. 10. The output from the blanking amplifier is a pulse waveform used for retrace blanking, which can be tapped to provide a test pulse as shown in the diagram. If you use a trimmer capacitor in the pulse-takeoff circuit, you can adjust the trimmer for the sharpest pulse consistent with sufficient amplitude. If the pulse is differentiated, it becomes narrower and its amplitude will be decreased simultaneously.

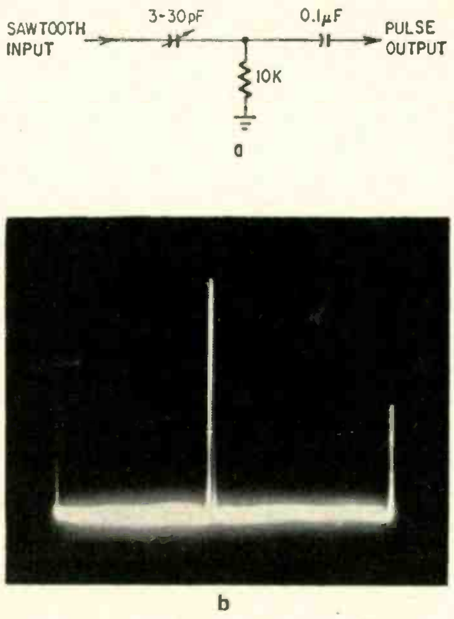

Fig. 11—Differentiating circuit used to shape the sawtooth taken from the scope. At (b), differentiator output waveform.

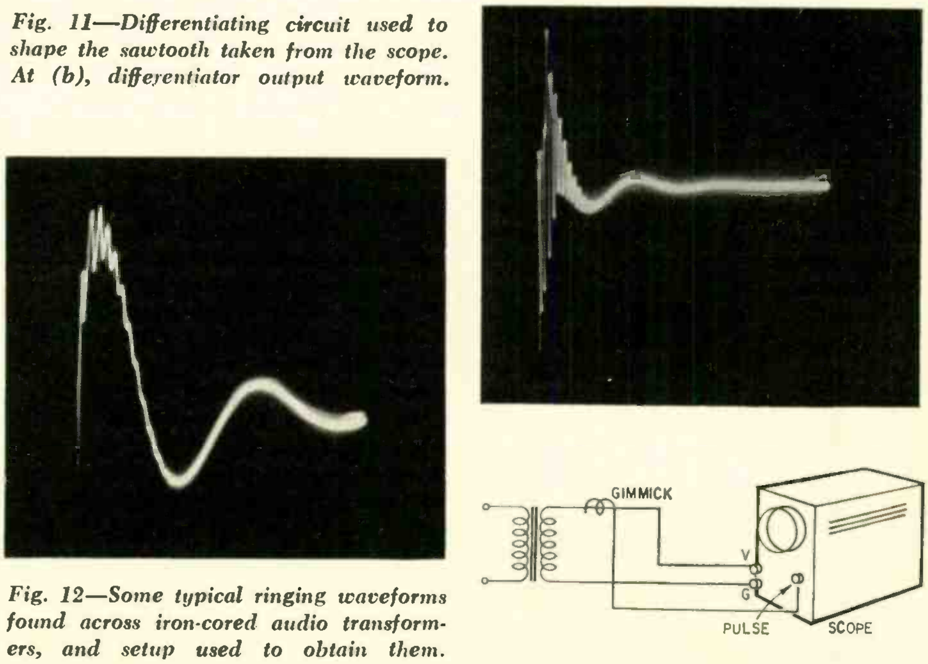

Fig. 12—Some typical ringing waveforms found across iron-cored audio transformers, and setup used to obtain them.

If your scope has no blanking amplifier, you still can obtain a test-pulse output. Simply couple the sawtooth sweep voltage through a small capacitor to a suitable differentiating circuit such as that in Fig. 11-a. If you use the horizontal sawtooth as a pulse source, the pulse amplitude will vary with the setting of the horizontal-gain control. However, this is not a disadvantage in most cases, because the gain control is usually set for nearly full screen width, and the pulse amplitude is ample.

This type of test pulse ordinarily is used for ringing tests of coils or transformers. Fig. 12 shows typical ringing waveforms, and the test setup. In case the pulse is too weak, connect the pulse lead directly to the vertical-input terminal of the scope. The ringing test is a comparison type in which the waveform produced by a known-good transformer is compared with the waveform produced by a transformer suspected of having any kind of defect.

Test pulses also are useful for checking the transient response of audio amplifiers. Some modern scopes have horizontal-sweep rates up to 500 kHz and will provide pulse repetition rates up to 500 kHz. While test pulses from a scope are less versatile than those obtained from a regular pulse generator, many useful applications are possible.

In just about every phase of electronics, pulses are an integral part of the operation of many circuits. When you know what normal pulse action is in a given situation, you will be able to recognize a faulty waveform. The trick then is to know what to do about it. **R-E**

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COVER STORY

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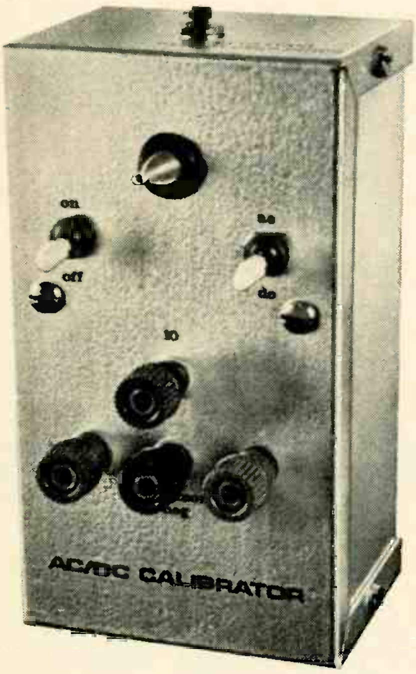
Inexpensive voltage reference sports 1% to 2% accuracy on 3 ranges



Panel Layout is designed for ease of operation. Neon lamp containing radioactive material serves as a 1% reference voltage standard and as a pilot light.

IT'S SURPRISING HOW MANY PEOPLE own several hundred dollars' worth of test equipment and use it daily—perhaps to make a living—and yet don't own a single item for calibrating all that stuff! Are you one of them?

I was. I have to laugh (or cry) at the amount of blind faith I used to have in my meter readings. When something was really in doubt, I would buy a mercury cell and use it to calibrate my dc instruments. But ac? Well, when I finally got a dc scope I evolved a tedious way of calibrating by using it. This method turned out to be inaccurate because the scope's response (unknown to me) was down some 3 dB at dc compared to the response at 60 Hz! That put my ac instruments about 30% high!

Imagine my delight when I discovered a 100-volt neon lamp, accurate to within 1 volt (that's 1%). The calibrator shown here is the result. It has one extra wrinkle—a chopper to make ac out of dc—for which credit is due Leslie Spaiser, a young technician in a neurology lab at Mount Sinai Hospital, New York City.

Peak to peak

I had been hunting around for some way to get an accurate 100 volts peak to peak for ac calibration. Signalite makes an ac version of the 100-volt 1% neon, but its waveform is tricky to use because it begins with a spike about 40% higher than the rest of the wave. Leslie suggested the simple chopper I used (Fig. 1)—it works.

From the 100 volts available across the neon lamp, you have to subtract the saturation drop across the transistor (about 0.25 volt), and to the zero you'd expect when the transistor is cut off you must add the voltage drop in the divider string due to transistor leakage (about 0.25 volt). These are small to begin with, making the peak-to-peak amplitude of the resulting square wave about 99.5 volts. It turns out that they are cancelled almost perfectly by the slightly increased drop across the neon under the lighter load caused by the action of the chopper.

The calibrator provides three voltages: 1, 10 and 100. The negative terminal floats (there is no connection to the case). The accuracy of the 100-volt output is ±1 volt, or 1%. The accuracy of the other taps is decreased, by the inaccuracy of the divider string resistors, to roughly 2%. These figures are good only when the current drawn from the divider is negligible.

The resistance of any device connected to the 10- and 1-volt terminals should be 100,000 and 10,000 ohms minimum, respectively, to keep the loading error to 1%. The load on the 100-volt terminal can be heavier; resistances as low as 10,000 ohms can be connected with less than 1% drop in terminal voltage as long as the neon lamp is not extinguished. This means that even 1000 ohms/volt vom's can be calibrated directly on their 100- or 150-volt ranges.

Construction

Parts placement is shown in the photo. The switches used in the original are little d.p.d.t.'s, with only the necessary terminals used. They are tiny and very attractive, but relatively expensive (about $1.50 each), and you may prefer to use less-expensive switches.

Don't try to substitute parts that are different electrically from the ones called for in the parts list. The transformer voltage, the values of C1, R2, R4, R5 and R6 and the transistor all affect the accuracy or stability of the output voltages. R1 and R3 are not particularly critical. Values within 20% of those shown will work as well.

A 2N398 or 2N398-A can be used in place of the 2N398-B shown, but the B version has lower leakage and lower saturation resistance, which makes it preferable.

Be sure to connect the lead of the Z100R12 neon lamp with the red dot near it to the positive side of the power supply.

The binding-post terminals on the front of the calibrator are all of the "jack-top" type and will accept bare wire, spade lugs, banana plugs or alligator clips. They are spaced so that

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By PETER E. SUTHEIM

Scope and Voltmeter

the 1-, 10- and 100-volt terminals are exactly ¾ inch from the common (negative) terminal. This permits the use of dual banana plugs, of which I have a great many. (The dual banana is sometimes called a "GR" plug, for General Radio Co., because they developed them. The plugs are also made by E. F. Johnson, Pomona; H. H. Smith and probably others.)

Nothing much needs to be said about using the calibrator for dc. Treat it as you would a battery: connect the device you want to calibrate and adjust the device to read exactly 1, 10 or 100 volts. Just be sure you don't connect heavier loads (lower resistances) than the limits mentioned earlier.

Operation

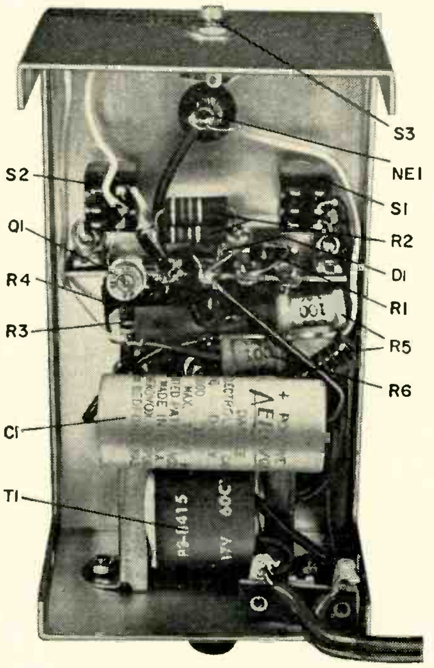
You need operate the START button only on dc. On ac, the "chopped" load of the divider string due to the action of Q1 is quite light. On dc the loading is twice as great, and the drop across R2 is enough to keep NE1 from igniting. A momentary push is enough. Don't hold the button down, because NE1 will be overloaded and eventually damaged.

On ac, remember that the values 1, 10 and 100 are *peak-to-peak* voltages. You should see exactly those figures on a peak-reading indicator such as a peak-reading vtvm or an oscilloscope. Average or rms instruments will *not* indicate 1, 10 or 100. An ac instrument calibrated to read rms values of sine waves (this includes the vast majority of service-type ac instruments, such as amplifier/rectifier type audio millivoltmeters and the ac ranges of vom's) should read 0.50, 5.00 or 50.0 volts, depending on which terminal of the calibrator is used.

The slight slope of the square waveform should give no trouble when the calibrator is used for an oscilloscope. Use the height of the leading edge of the trace as 100 volts.

Another way of checking instruments designed to indicate rms voltages is to set up a scope to display one or two cycles of the square wave from the calibrator on about ⅔ the screen height. Mark the height of the leading edge with a sharpened crayon or use appropriate graticule lines. Disconnect the calibrator and instead connect to the scope a sine-wave source. Adjust it so that the peaks of the sine wave coincide exactly with the marks. You now have a 1- (or 10- or 100-) volt *peak-to-peak* sine wave. Its rms value is very nearly 0.354 volt (or 3.54 or 35.4). Adjust an rms-reading instrument to indicate accordingly, when measuring the sinewave.

For the most accurate and stable readings, the calibrator should be left to stabilize at least 2 minutes before using it. Nothing will be gained by leaving it on permanently, although the life expectancy of the Z100R12 is around 30,000 hours (over 4 years). It is normal for the neon lamp to get too warm to hold comfortably. **R-E**



Center the neon lamp inside the grommet and cement in place. Observe lamp "polarity." Construction is not critical.

PARTS LIST

- C1—80-μF, 150-volt electrolytic capacitor
- D1—Silicon rectifier, 400 volts minimum, any current rating (1N1695, 1N3194, 1N4004, etc.)
- J1, J2, J3—Red jack-top ("5-way") binding posts
- J4—Black jack-top binding post
- NE-1—100-volt, 1% neon reference lamp, Signalite Z100R12, available only from Signalite, Inc., (Attn. Mr. Donald J. Furfaro) 1933 Heck Ave., Neptune, N.J., for $3.50 plus postage, and only if you mention this article and RADIO-ELECTRONICS.
- Q1—2N398-B transistor
- R1—100-ohm, ½-watt resistor
- R2—2400-ohm, 2-watt resistor (or two 4,700-ohm, 1-watt resistors in parallel)
- R3—330-ohm, ½-watt resistor
- R4—9000-ohm, 2-watt, 1% resistor
- R5—900-ohm, ½- or 1-watt, 1% resistor (100-ohm and 800-ohm resistors, in series)
- R6—100-ohms, ½-watt, 1% resistor
- S1—Miniature s.p.s.t. toggle switch
- S2—Miniature s.p.d.t. toggle switch
- S3—Momentary pushbutton, normally closed switch
- T2—Power transformer, 125-volt, 15mA primary and 6.3V, 0.6A secondaries (Stancor PS-8415, Knight 54 B 1410, or similar)
- Two-piece aluminum box, 2⅛ x 3 x 5¼ in. (Bud CU-3006-A or similar)
- Misc.—Terminal strips, grommets, rubber feet, etc.

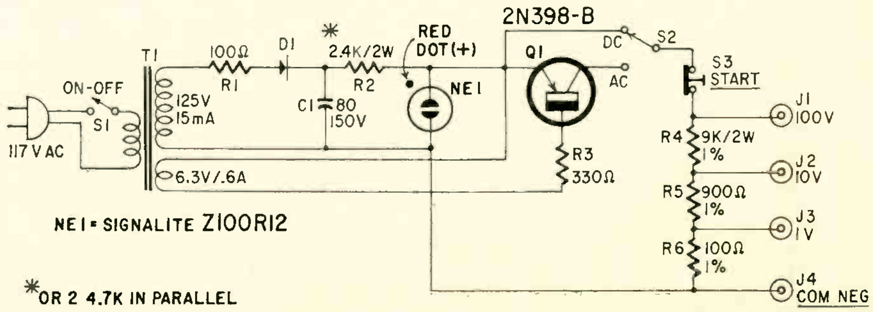


Fig. 1—Neon lamp (NE1) regulates output for 100-volts dc. Transistor Q1 chops this dc to develop the ac voltage. The resistor string sets up 2 more ac and dc ranges.

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QUIET NOISE LIMITERS AT WORK

You can cut some of the QRM without pulling the plug

By JOHN D. LENK

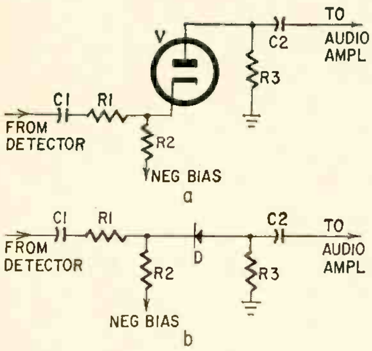

Fig. 1-a—Tube version; b—solid-state version of half-wave series limiter.

IN A RADIO RECEIVER A NOISE LIMITER reduces or eliminates rf impulses which interfere with desired signals. The operation of automatic noise limiter (ANL) circuits is based on the fact that undesired rf noise has two characteristics which make it different from intelligible audio modulation. Most rf noise is shorter in duration and greater in amplitude than the desired signals.

Most noise-limiter circuits are designed to *reduce* the noise pulses, rather than eliminate them. The circuits can be divided into several broad classifications, such as peak limiters and rate-of-change limiters. There is also the twin noise squelch (TNS) that blocks all sound during noise pulses.

Peak limiters are relatively simple. They "chop" off the tops of the noise pulses so that the noise is no louder than the signal. Rate-of-change limiters "chop" out noise, such as ignition pulses, which change polarity rapidly. The rate-of-change circuits are new compared to peak limiters.

Peak limiters

There are two types of series peak limiters—half-wave and full-wave. Both clip the peaks of noise pulses, to keep noise level from exceeding signal level. The full-wave noise limiter operates on positive and negative noise pulses, while the half-wave limiter restricts positive or negative peaks only.

A basic half-wave limiter circuit is shown in Fig. 1. The cathode is normally biased negative with respect to the plate —even during positive audio signals from the detector. Under these conditions, V (Fig. 1-a) or D (Fig. 1-b) conducts, allowing audio from the detector to pass to the audio amplifier in the normal manner. An abnormally large positive signal, such as a noise pulse drives the cathode of V positive with respect to the plate. Current can no longer flow, so V does not conduct the noise pulse to the amplifier. Usually, the noise pulse is of very short duration. As soon as it is over, the cathode again becomes negative with respect to the plate (or anode), V (or D) conducts, and normal operation is restored.

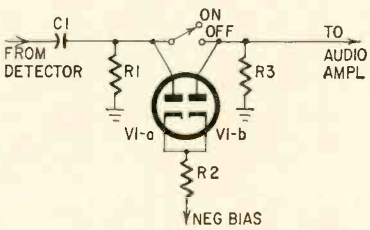

Fig. 2—The full-wave series limiter is more effective at removing the noise.

The basic series full-wave limiter circuit is shown in Fig. 2. Both cathodes are normally biased negative with respect to their corresponding plates, as long as the signal is less than a certain peak-to-peak voltage. Under this condition, audio passes from the detector to the amplifier without change. When there is a strong negative noise pulse across C1, the plate of V1-a is driven negative and it stops conducting, blocking the noise. As soon as the plate is positive with respect to the cathode, V1-a again conducts, permitting passage of audio.

Positive noise pulses are clipped in a similar manner by V1-b, since this half of the tube cannot conduct when a noise pulse drives the cathode positive. The two diodes in combination remove noise pulses from the audio output.

A series limiter breaks the audio path between detector and audio amplifier. A shunt limiter, on the other hand, shorts the noise peaks to the ground. This is the simplest form of limiting circuit and can be added to almost any receiver. The basic half-wave shunt limiter is shown in Fig. 3. Capacitor C1 charges to the average signal level through D2. At this point, the voltages on both sides of D2 are approximately equal, and the diode no longer conducts. Audio then passes from the detector to the audio amplifier. However, an abnormally strong signal biases D2 into conduction, and this pulse is absorbed by C1. The charge gradually leaks off C1 through R1 at a rate determined by the C1–R1 time constant.

It is possible to place two half-wave shunt limiters across an audio line with the diode polarities reversed, forming a full-wave shunt limiter. However, such a circuit can cause audio distortion if the capacitor values are not proper, or if the diode characteristics are not correct. Hence, full-wave shunt limiters

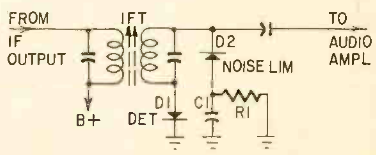

Fig. 3—Shunt limiter bypasses noise spikes without interrupting the signal.

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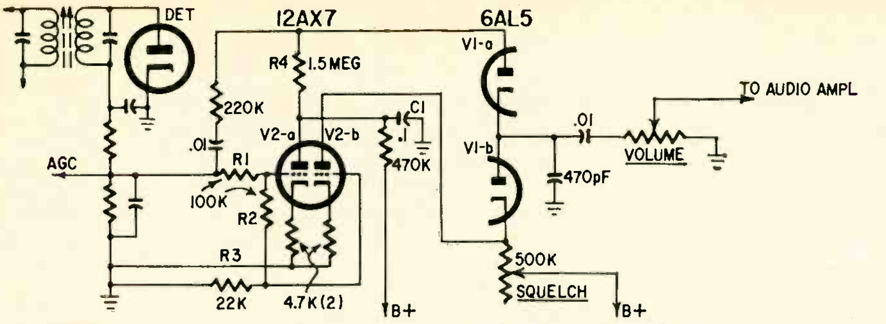

Fig. 4—Twin noise squelch has two actions. It keeps the receiver silent until a normal signal comes along, and cuts the receiver out again in the presence of noise.

are rarely used in audio stages, although they are sometimes found in i.f. stages of single-sideband receivers.

Twin noise squelch

This circuit is a combination squelch and noise limiter. As seen in Fig. 4, detector output consists of audio and a dc voltage produced by carrier rectification. This mixture is applied across voltage divider R1, R2 and R3. The divider is tapped so the grid of V2-a receives more detector output than the grid of V2-b. The audio signal is amplified by V2-b and goes through gating diode V1-a before it reaches the volume control and the audio amplifier.

A signal can pass through V1-b and V1-a only when each plate is positive with respect to its cathode. The voltage on the cathode of V1-b is controlled by the plate voltage of V2-b. Similarly, the voltage on the plate of V1-a is controlled by the plate voltage of V2-a.

Under no-signal conditions, the grids of V2-a and V2-b are zero-biased; both tubes are conducting. The SQUELCH control (supplying B+ to V2-b) can be set so the cathode of V1-b is sufficiently positive to cut off gating tubes V1-a and V1-b. When there is a signal from the detector, the grid voltage of V2-a drops faster than that of V2-b. Consequently, the plate voltage of V2-a rises faster than that of V2-b. This signal biases V1-a and V1-b into conduction, and the audio signal goes through the volume control.

When a noise pulse is received, it is applied to the grids of both V2-a and V2-b, causing their plate voltages to rise. However, the time constant of R4–C1 in the V2-a plate circuit slows down that plate's voltage rise, as well as that of the plate of V1-a. This means the plate voltage of V2-b (and the cathode voltage of V1-b) rises faster. Thus V1-a and V1-b are biased to cutoff, preventing audio from passing for the duration of the noise pulse. This hole is not audible, however, since the noise pulse is usually very short.

The TNS circuit is more effective than peak limiters. Its only drawback is distortion on very strong audio signals when the circuit is added to certain receivers. Even then the problem can be cured by a slight modification, described by the circuit manufacturer.

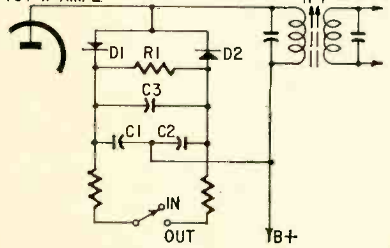

Fig. 5—Many single-sideband receivers use this special type of i.f. noise limiter.

I.f. noise limiters

In a single-sideband receiver it is desirable for the limiter to work on noise pulses before they reach the detector. This is because the beat-frequency oscillator (bfo) used for sideband reception produces an artificial carrier much stronger than the actual received carrier. If the limiter used the bfo carrier as reference, the limiter would have very little effect on noise pulses. A practical solution is to use a full-wave shunt limiter—similar to that shown in Fig. 5—in the *first* i.f. stage.

In this circuit, known as an IFNL, the plate current of an i.f. amplifier varies with the incoming signal; stronger signals produce greater variations. Capacitors C1 and C2 are charged to the average value of this varying i.f. voltage. Since D1 and D2 are reversed, C1 and C2 are charged by both positive and negative swings of i.f. plate current. C3 and R1 aid the voltage-averaging process.

When C1 and C2 are charged to the average value, the voltages on both sides of diodes D1 and D2 are approximately the same, and the diodes do not conduct. This allows the normal plate-current variations to appear across the i.f. transformer primary. When there is an abnormally strong signal (noise pulse), the voltage is considerably different from that of C1 and C2, creating a voltage differential across D1 and D2. One of the diodes then conducts and creates a virtual short across the i.f. transformer primary. This prevents any signal from passing though the i.f. stage. Once the noise pulse drops back to the average i.f. level, the voltage differential across the diodes is removed, and the circuit is restored to normal operation.

Rate-of-change limiters

Unlike peak limiters, rate-of-change limiters sense the speed at which the instantaneous detector output voltage is varying, not just the amplitude of change. In the presence of a rapidly changing detector output (such as a noise pulse), the rate-of-change limiter remains inactive up to a certain point. As the output swings above that point, the limiter substitutes its own output signal for that of the detector.

A typical rate-of-change limiter circuit is shown in Fig. 6. The base-emitter junction of a transistor is used as a diode. The voltages at the base and emitter of Q are determined by the audio signal. The base is connected at the junction of R1 and R2, and the emitter voltage is taken from the junction of R4 and C4. The values of R1, R2, R4 and C4 are chosen so the emitter is normally less positive (or more negative) than the base. This causes Q to pass audio from the detector to the volume control. With normal audio variations (no rapid changing of amplitude or polarity) both the base and emitter follow the audio signals.

When there is a noise pulse, or any signal that changes rapidly, the base of Q instantly swings negative. The emitter of Q also swings negative, but not as rapidly as the base, because of the time needed for C4 to charge. Therefore the base is more negative than the emitter during the noise pulse. This condition cuts off Q, preventing audio from passing to the volume control. The low charging voltage of C4 is substituted for normal audio.

When the noise pulse has passed, the base of Q returns to the normal voltage, Q starts conducting, and normal audio passes.

Most rate-of-change limiters obtain voltage from the detector load resistor (through a filter) and take the audio signal from a tap on this resistor. This makes the rate-of-change limiter self-adjusting for varying signal strengths. **R-E**

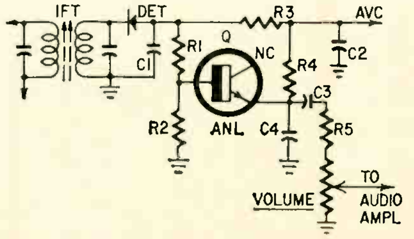

Fig. 6—Solid-state rate-of-change limiter.

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How To Measure Reverberation Time

Measuring reverb time is as important to the sound-system designer as selecting the equipment

By DON DAVIS*

MODERN HALLS ARE TOO BIG AND TOO expensive for architects and acoustics consultants to rely on hunches.

Designing or modifying the acoustics of a huge auditorium is a complex and fascinating job. It can be every bit as exciting and romantic as building a suspension bridge.

If you've ever strained to understand train announcements in the main waiting room of a city railroad station, you know that loudness alone is

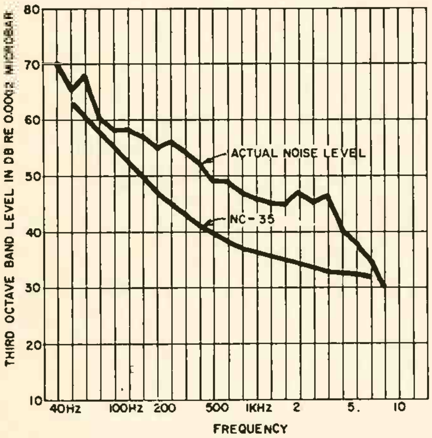


Fig. 1—Noise measurements of the hall.

not enough to make a sound system adequate. Why? If the *reverberation time* of the room is too long (or, as most people would say, if there's too much echo), the sound issuing from the PA speakers at any instant is blurred by earlier sound as it reverberates from the walls, floor and ceiling of the room. For a large, hard-surfaced room, 7 to 8 seconds is not at all uncommon for "echo" duration. With a reverberation time that long, loud speech becomes completely garbled. The louder the sound, the worse the situation gets, since the reflected sound increases with incident sound.

A method called Boner equalization (developed by Dr. C. P. Boner) permits the frequency response of a sound reinforcement system to be altered to suit particular reverberant-room characteristics. (See "Custom Equalization Enhances PA Sound," R-E, November 1966.) But that isn't the whole answer. It aids intelligibility, but it isn't suitable for high-quality sound assist in concert halls.

Basic terms. Reverberation time is defined as the time it takes for the rms sound-pressure level in a room to drop by 60 dB after having been allowed to reach a steady value. What this means in practical terms is simply the time it takes for one sound to drop to inaudibility (or very nearly so) so that it can't interfere with the next sound.

If no other frequency figure is given, one can assume that the measurement was made at 512 Hz.

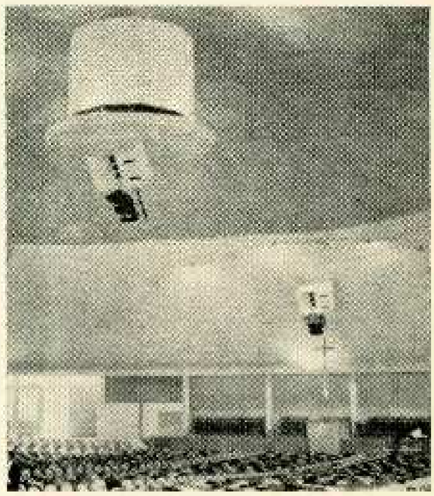
Wallace Clement Sabine, the father of modern architectural acoustics, was the first to reduce reverberation time to a workable formula. Around the beginning of the 20th century, in a series of brilliant experiments and deductions, he described reverberation time and plotted its dependence on the absorptive properties of the materials in the room.

By bringing cushions from an acoustically acceptable hall into an acoustically unacceptable hall he was able to plot the curve that characterizes reverberation time in a live hall:

$$T = \frac{.05V}{S\alpha}$$

where T = reverberation time in seconds, V = room volume in cubic feet, S = total surface area in square feet, and α = average absorption coefficient of the surfaces in the hall.

Sabine's work gave rise to a unit of acoustical absorption (now called the *sabin* in his honor): 1 sabin is the equivalent of 1 square foot of a perfectly absorptive surface. (Sabine's choice of a perfectly absorptive surface was a window opening out into free space.)



Hall after treatment. Dark area of dome is flocked for greater sound absorption. The nearer speaker is fed delayed audio.

It's obvious from the formula that reverberation time increases directly in proportion to room volume and inversely with absorptivity. Rule of thumb: Big room and hard surfaces mean trouble!

A typical case. A number of years ago a sound contractor and I were driving through a small city in the

*Author of **Acoustical Tests and Measurements**, published by Howard W. Sams & Co., Inc.

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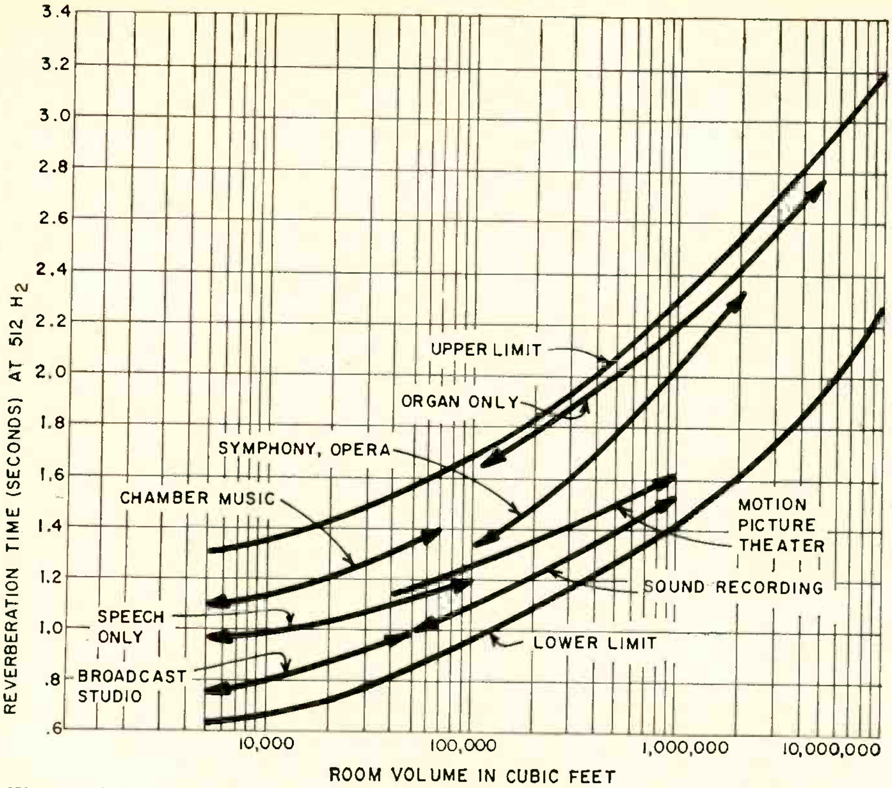

Fig. 4—An assortment of optimum reverberation times for various rooms and uses.

middle west when we noticed a large domed auditorium that had just been completed. Because of its size (over 370 feet in diameter) we were consumed with curiosity about its acoustical properties. Inquiries soon led us to the owners of the auditorium. When they heard we were in the sound-system business they unburdened themselves of an acoustical tale of woe. They had gone from cones to columns to confusion. It seemed that the auditorium had an interior volume of 1,500,000 cu ft, and not only were all surfaces hard but they were also concave. A handclap lasted a good ¼ minute, and stamping the feet created a roaring sound that rolled around and around the interior. The sound system was a "package deal" amplifier driving four low-cost column (line-source) speaker systems. Speech from the speaker's platform could not be heard clearly at any of the 7,600 seats.

We were taken to the architect's office. He asked us point blank if we could provide a sound system to correct the situation. We replied that at the moment we didn't know, but we could do a complete acoustical survey of the auditorium, and from the data we gathered we could give a definite answer.

A short time later the contractor and I arrived back in town with approximately $7,000 in measuring equipment. With this equipment we measured:

1. Ambient noise levels by frequency in the auditorium.
2. Reverberation time at ⅓-octave intervals from 40 to 10,000 Hz.
3. Frequency response and dynamic range of the sound system installed in the auditorium.
4. The harmonic distortion of the sound system at key frequencies in the speech range.
5. The reflection patterns in the auditorium when excited by the sound system.

The technique that's least familiar to someone who isn't a member of the club is the one used to measure reverberation time, and that's what this article is all about. So we'll concentrate on that.

The test apparatus was set up on an 8-foot table and allowed to warm up for an hour. Our big test speaker, used to excite the room with random noise, was aimed toward the center of the auditorium.

The first test run was a measurement of the ambient noise level in the auditorium. This we did, not only to analyze the noise sources in the room, but to let us know how high a sound-pressure level (SPL) we would need from our test speaker for enough dynamic range to guarantee a true picture of the decay slope (at least 20 dB of decay is highly desirable). At low frequencies in this large auditorium it was necessary to achieve at least 90-dB SPL of noise at the measuring microphone before the noise source is silenced. Fig. 1 indicates the result of the measurements in this large auditorium.

To make these measurements, we placed our sound-level meter (slm) in the center of the auditorium. The slm's output was connected by a long cable to the input of the ⅓-octave band analyzer. This analyzer can be read directly from its own meter, or its output can be connected to the input of the chart recorder for automatic plotting. All lights, fans, blowers, etc. normally on when the building is used were on for our tests. Our measurements were taken *without* an audience. An audience would have appreciably

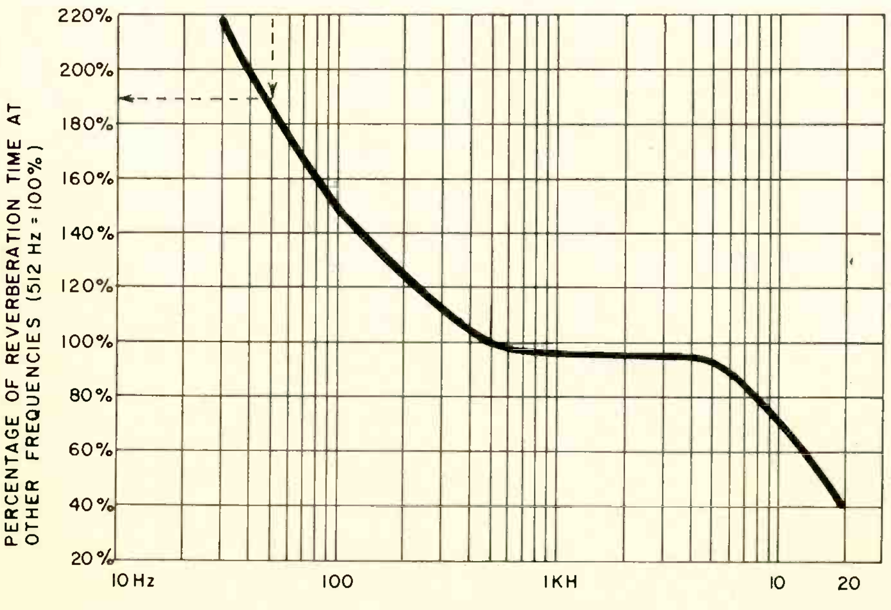

Fig. 5—Conversion chart for computing optimum reverb time versus frequency.

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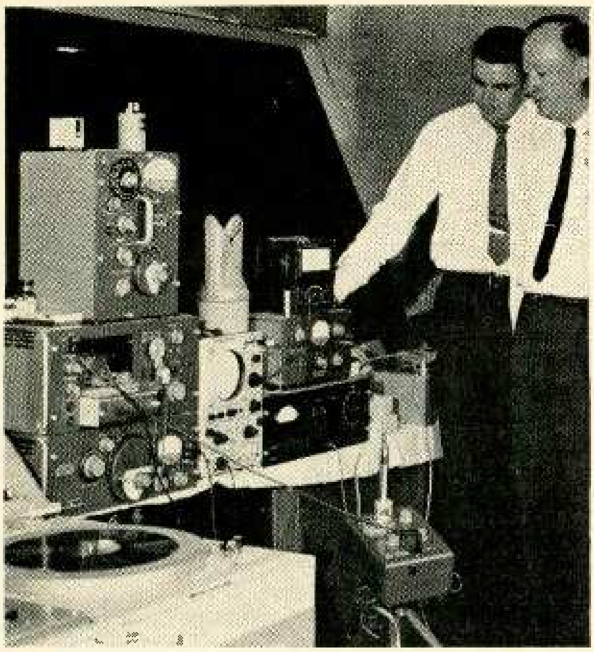

Quite an impressive table full of equipment is needed for professional measurement of reverberation. Permanent sound-system console at left is part of hall.

increased these noise levels.

After we were satisfied that the noise levels were overcome, we set our test speaker and its 175-watt amplifier to deliver a 126-dB SPL at 4 feet, or 96 dB at 128 feet. The hookup of the test equipment is shown in Fig. 2. We closed S1, tuned the ⅓-octave analyzer No. 2 to 40 Hz and started the graphic level (chart) recorder running at 75 in./min, or 300 div/min (5 div/sec) paper speed. We set the pen speed to its fastest setting (in this case 20 in./sec). Then we opened S1. The level recorder pen traced the decaying sound picked up by the slm's microphone.

Fig. 3 shows two decays, at 1,000 and 2,500 Hz. Here's how to read a curve like that:

1. Draw an average-decay-rate line through the decay slope.
2. Count off the number of horizontal divisions crossed by this average line in 20 dB of slope. (On this paper, 20 dB is 2 vertical divisions.)
3. Multiply the counted divisions by 3.
4. Each division represents 1 second.

This process is repeated for each of the ⅓-octave-band center frequencies. All the individual curves were recorded on the overall chart.

Criteria. Once you have a decay curve for each of the ⅓-octave bands on the chart, what do you do with them?

In the 60-plus years since Sabine's epochal work, literally thousands of rooms all around the world have been measured. Gradually people's subjective judgments of these rooms (good, bad, fair, etc.) have been compared with the reverberation curves they exhibited. While no one has found an absolute correlation between reverberation time and subjective opinion, it has been found that whenever a certain broad set of criteria is *violated,* listeners are invariably annoyed.

As room volume increases, slightly more reverberation time is usually tolerated. That works out happily: Remember V in the formula and how much surface absorption would be required to divide into it if it became a large number. Fig. 4 shows a chart that plots the optimum reverberation time against room volume and program type. There's a great difference of opinion about optimum reverberation, but most authorities agree that if you get beyond either of the two limit lines on the chart you can expect difficulties.

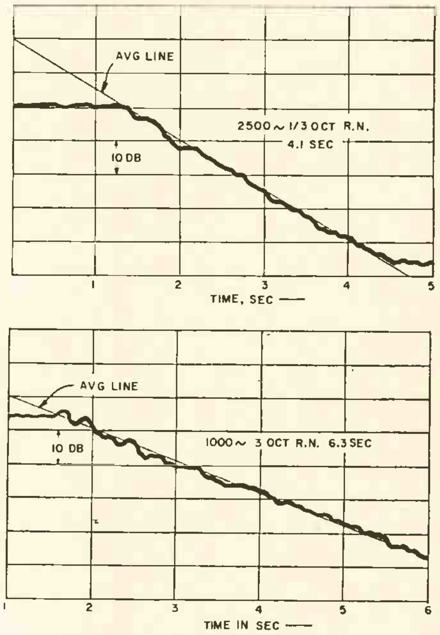

Fig. 3—Two sample decay-time measurements. Checks are made at several points.

Once you have a feeling for the range of acceptable criteria at 512 Hz, the chart in Fig. 5 gives the percentage of increase or decrease in reverberation time for other frequencies. It is important to note that, at very low frequencies, reverberation times often double compared with 512 Hz.

Data used for correction. When the measurements were concluded, the sound contractor was asked to install a sound system in the room. On the basis of the evidence from the tests he demurred until the builders engaged an acoustical consulting firm. All the charts and tests were made available

(continued on page 81)

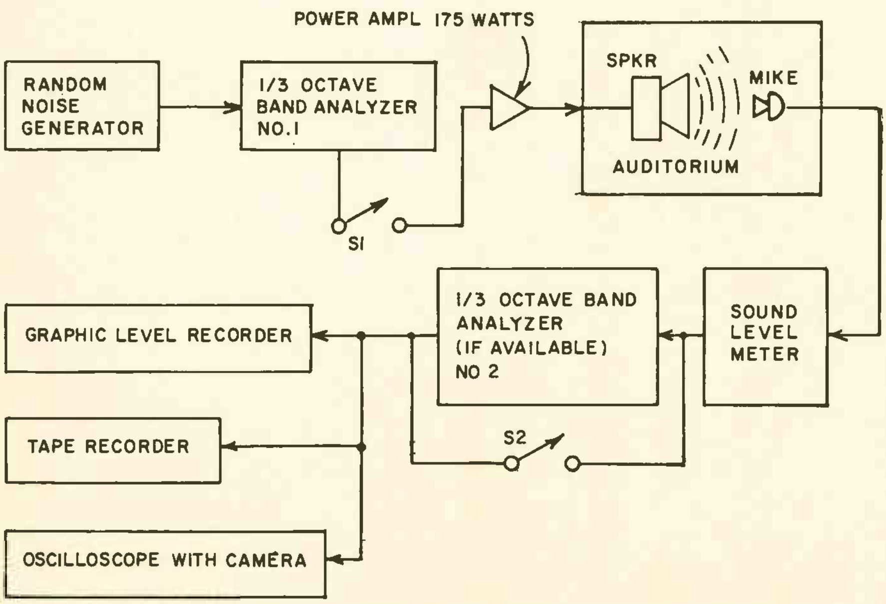

Fig. 2—Interconnection of the equipment used to measure hall reverberation time.

Build An Electronic Tremolo

Build this add-on unit for today's way out electronic music

By R. H. KEENAN

AN EFFECT COMMON TO MOST KINDS of classical and popular music is *tremolo*: periodic, fairly rapid variation in loudness. It is particularly common in wind instruments, even including the pipe organ. What it amounts to is amplitude modulation of the musical note by a low-frequency, subaudible signal (usually around 5 to 8 cycles per second). In conventional musical instruments it can be produced by varying the wind pressure applied to them.

Tremolo is *not* the same thing as *vibrato*, which is slow frequency modulation (FM) and sounds quite different. Pipe organs never have vibrato. The two words are often confused.

Tremolo (AM) is easy to add to an existing music source. The simple device described here can be used with electronic guitars, organs or other instruments, or with recorded music or noise to produce special effects for electronic music or sound-and-light shows. The circuit is simple and can be added quickly to any amplifier or tape recorder.

How it works

The subaudible tremolo signal is produced by Q1, a unijunction transistor, used in a simple relaxation oscillator (Fig. 1). Q2 amplifies the signal and drives lamp LM1, which flickers at the rate set by the oscillator. The varying light falls on cadmium-sulfide photocell PC1, causing its resistance to vary accordingly. The photocell is part of the series arm of a voltage divider (attenuator), so the audio level varies periodically as the oscillator swings. R3 is the tremolo RATE control; R5 controls the depth of modulation.

The photocell and lamp (see parts list) are placed end to end and rolled together into a strip of black plastic electrician's tape, making a single, lightproof unit with leads coming out the ends. Total current drain for the circuit shown, including the lamp, is about 20 mA. The circuit will probably work with other transistors; Q1 is a 2N2646, a common and inexpensive unijunction, and Q2 is a 4-watt npn 2N497, used because it was handy. The circuit could be rearranged for use with a pnp transistor as Q2. This transistor should have fairly high beta (h_{FE}) and be capable of dissipating at least 200 mW.

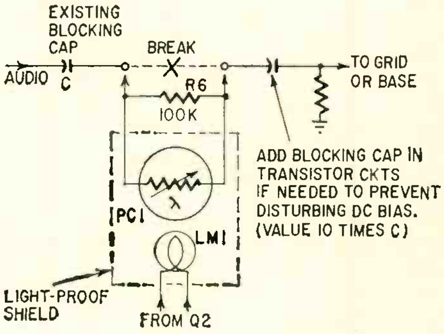

Fig. 2—Insert the photocell between amplifier stages as shown. Be sure to use blocking capacitors to avoid dc through the photocell and changing bias.

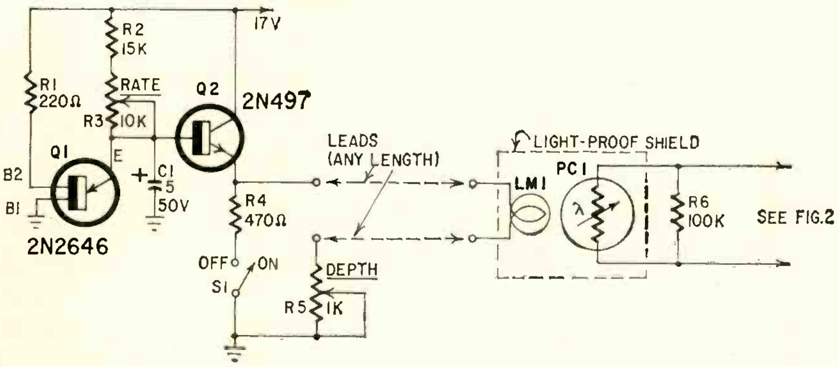

Fig. 1—Two 9-volt transistor batteries in series will power the tremolo nicely. You can install the lamp and photocell any convenient distance from controls.

PARTS LIST

C1—5-μF, 50-volt electrolytic capacitor
R1—220-ohm resistor
R2—15,000-ohm resistor
R3—10,000-ohm potentiometer (RATE)
R4—470-ohm resistor
R5—1000-ohm potentiometer (DEPTH)
R6—100,000-ohm resistor for shunting PC1 (you may need to select best value from 47,000 to 470,000 ohms)
PC1—Photocell (Clairex CL607)
LM1—Incandescent lamp, 28 volts, 40 mA (G-E 327 or similar)
Q1—Unijunction transistor (2N2646)
Q2—Large-signal npn transistor (2N497 or similar)
S1—S.p.s.t. switch of any convenient kind
Case and perforated board or other means for mounting Q1–Q2 circuitry.

Circuit connection

Connect the tremolo device between amplifier stages, either tube or transistor, as in Fig. 2 You may want

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dB The Useful Decibel

Everywhere in electronics you find dB's—now learn them the painless way—without logarithms!

By ERIC LESLIE

MUCH NONSENSE, AND WORSE—A LOT of incomprehensible sense—has been written about the decibel, probably the most useful unit of measurement in electronics. Yet in spite of that usefulness, too many technicians don't understand it. Why? Because most articles on the how and why of the decibel do more talking about logarithms than about decibels. That's fine, if you know logs. But if you don't, you have to learn logarithms *and* decibels, both at the same time.

Nonlinear measurement

How did the decibel come about? It was devised to measure nonlinear quantities. Did you know your ear does not have linear response to changes in sound volume? This is the reason you can hear a whisper across a quiet room, and also tolerate the blare of auto horns or the roar of a subway express train.

Suppose you're listening to an amplifier with a wattmeter across the output. First you hear a 1-watt sound; then you crank up the gain to 2 watts. Does the speaker output sound twice as loud? No—it just sounds a little bit louder. You have to turn up the gain until you increase power output 10 times—to 10 watts—before you hear twice as much audio as you did at the 1-watt level. That, briefly, is the way your ear works.

To describe this interesting system, the 10-to-1 power relationship was described mathematically and called a *bel* (in honor of Alexander Graham Bell). For more precise measurements, a tenth-of-a-bel unit—the decibel—was put in service.

The decibel, then, is a measure of power *ratio*. It doesn't matter whether you increase or decrease the power—dB's work both way. Double the power, and you've increased it by 3 dB. Cut the power in half, and you've decreased it by 3 dB. Check this with the table. In column B find the ratio of power increase—2.0. Opposite this point in column E you'll find 3—the number of dB's of change.

Decibels can also be used to measure the ratio between two voltages or between two currents. Since power equals voltage times current, though, voltage dB's come out differently than power dB's. Look at the chart again. Increase voltage by ratio of 2 (2.0 in column B) How many dB's of voltage increase? In column A you'll find 6.

Here's why: Put 1 volt across a 1-ohm resistor. Since $P = \frac{E^2}{R}$ or $\frac{1^2}{1}$, power is 1 watt. Now increase voltage 3 dB. The chart says that a 3-dB voltage increase is a ratio of 1.4 to 1. So now what's the power? $P = \frac{E^2}{R}$ or $\frac{(1.4)^2}{1}$, or about 2 watts. Power has *doubled*—and according to the chart, that is 3 dB of power gain. (The same figures work for current, by the way.)

How to use dB's

Using dB's to measure changes in power, voltage or current makes difficult jobs easy. As an example, suppose you want to install a master antenna system in a large 40-unit apartment building. You make a diagram—like Fig. 1—

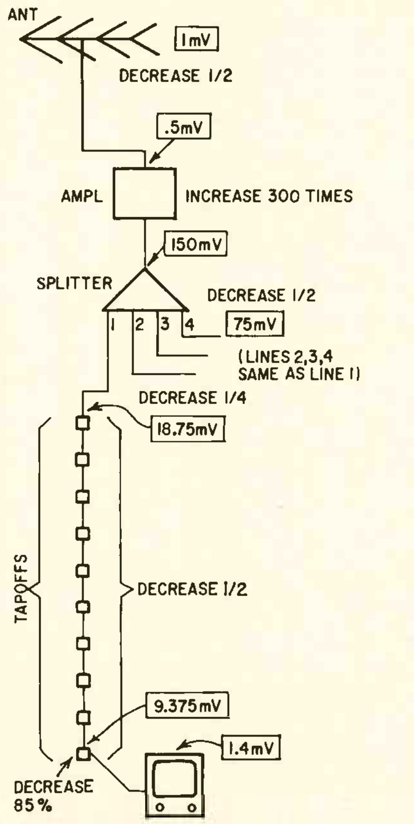

Fig. 1—Functional diagram of typical MATV system, with signal levels in volts. Boxed figures are absolute values.

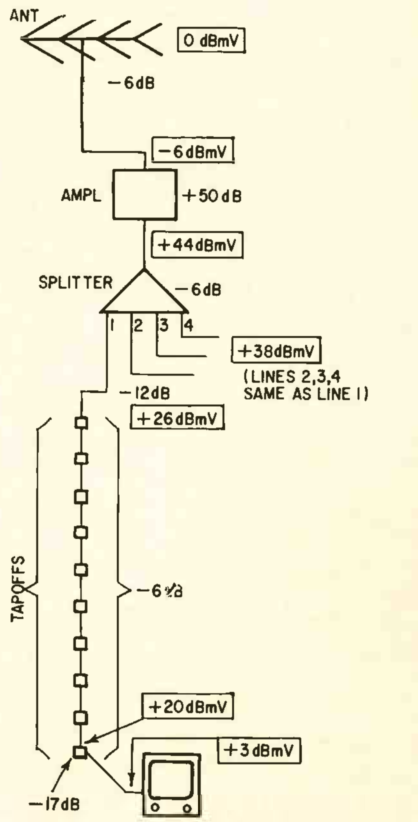

Fig. 2—Same system, using dB's. Again, signal levels are shown in boxes; gains and losses are not. See text for details.

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of the equipment. Then you figure how to get enough signal to each TV to furnish an acceptable picture.

Assume you've got a 1-mV signal at the rooftop antenna, and you want no less than 1 mV at each receiver. From the antenna, the signal goes through coaxial cable, dropping to half the voltage (½ of 1 mV is 0.5 mV) by the time it arrives at the amplifier, where it's stepped up 300 times (300 times 0.5 mV is 150 mV). From the amplifier, the signal divides at a four-way splitter, and each output has half the voltage of the input (½ of 150 mV is 75 mV).

Next there's more coax, dropping signal voltage to ¼ (¼ of 75 mV is 18.75 mV). The 10 receiver tapoffs in series cut the signal in half again (½ of 18.75 mV is 9.375 mV).

The last receiver is isolated from the line by the tapoff, and this isolation drops the signal again—to perhaps 15% of the line signal (15% of 9.375 mV is about 1.4 mV). That's what the last receiver gets.

If you *like* to multiply, as we've done, you're welcome to the method. There is an easier system, though—using decibels.

But first we've got to have a reference point. A dB figure is only a measure of the *ratio* between two power or voltage levels. It does not refer to an absolute value. In TV antenna work, 1 mV (or 1,000 μV) has become the reference point, because it is often the lowest signal that should be delivered to a receiver. Therefore, 1 mV is called "0 dBmV."

Now look at Fig. 2, where 0 dBmV is beside the antenna, to show that's the signal available there. Coax drops the signal in half, and from the table you'll find that's a 6-dB loss, so write that down and subtract it from 0 dBmV, getting −6 dBmV. (The minus sign here indicates the signal is 6 dB *below* 0 dBmV.)

Next convert the 300-times gain of the amplifier to the nearest value in the table, or 50 dB. Add +50 dB to −6 dBmV, getting +44 dBmV. (You can also do it by subtracting −6 dBmV from +50 dB; the result is the same. The plus sign here shows the signal is 44 dB *above* 0 dBmV.)

Continue through the diagram, using the table to convert voltage increases or decreases to dB gain or loss. Eventually you'll find you have about +3 dBmV at the last receiver. From the chart, you see that's about 1.4 mV.

Sure, you've had to do a lot of converting and using the table to work with dB's in this example—and it has been a nuisance. *But you don't have to do it in practice.* If manufacturers of amplifiers, splitters, tapoffs and cable told you only that their equipment would amplify a signal "300 times" or attenuate it "by 15%" you'd have to multiply and divide to lay out a master antenna system. They don't do that, however. They give you dB gain or loss figures, and all you have to do is *add and subtract* them.

Assume you've made a plan of the apartment building. From equipment catalogs, you obtain the following figures—all the losses in your system:

Cable (ant to amp)	−6 dB
Splitter	−6 dB
Cable (spltr to last rcvr)	−12 dB
10 splitters in series	−6 dB
1 splitter as isolation	−17 dB
Total loss	−47 dB

You determine the signal at the antenna is 0 dBmV. Since you also want 0 dBmV at the last receiver, it's obvious you need at least 47 dB of gain from the amplifier. You buy the nearest thing—a 50-dB unit. See how simple it is?

Other dB uses

Decibels aren't used solely in antenna work. Various reference levels are used in other areas of electronics. In broadcasting and recording studios, "0 dBm" is defined as 1 mW in 600 ohms of impedance. Years ago telephone companies and some radio stations used a 0-dBm reference point of 6 mW in 500 ohms. For higher-power applications, such things as "0 dBW" (1 watt) and "0 dBk" (1 kW) are used. There is even "0 dBV" (1 volt).

Notice that 0 dBm means 1 mW *only* in 600 ohms. Impedance is defined because radio, television and recording studios have standardized on 600-ohm inputs, outputs and lines. A similar situation exists in master-antenna computations involving voltage. Hence, 0 dBmV means 1 mV (or 1,000 μV) across 75 ohms of impedance, since that's the common type of coax used.

You can't use dB's to compare voltage differences unless the two voltages are across the same value of impedance.

So you see, the dB is really not too difficult to work with. As a stranger, it's an unknown, perhaps incomprehensible element. Once you get to know it, the decibel will become a valuable tool in your electronics work. **R-E**

Decibel Table

A dB of Voltage or current gain or loss	B Ratio of increase (to 1.0)	C Ratio of decrease (to 1.0)	D Attenuation or loss in %	E dB of Power gain or loss
0	1.0	1.0	0	0
1	1.1	0.98	11	
2	1.3	0.79	21	1
3	1.4	0.71	29	
4	1.6	0.63	37	2
5	1.8	0.56	44	
6	2.0	0.50	50	3
7	2.2	0.45	55	
8	2.5	0.40	60	4
9	2.8	0.36	64	
10	3.2	0.32	68	5
11	3.6	0.28	72	
12	4.0	0.25	75	6
13	4.5	0.22	78	
14	5.0	0.20	80	7
15	5.6	0.18	82	
16	6.3	0.16	84	8
17	7.1	0.14	86	
18	8.0	0.13	87	9
19	9.0	0.11	89	
20	10	0.10	90	10
21	11	.089	91.1	
22	13	.079	92.1	11
23	14	.071	92.9	
24	16	.063	93.7	12
25	18	.056	94.4	
26	20	.050	95.0	13
27	22	.045	95.5	
28	25	.040	96.0	14
29	28	.036	96.4	
30	32	.032	96.8	15
31	36	.028	97.2	
32	40	.025	97.5	16
33	45	.022	97.8	
34	50	.020	98.0	17
35	56	.018	98.2	
36	63	.016	98.4	18
37	71	.014	98.6	
38	79	.013	98.7	19
39	89	.011	98.9	
40	100	.010	99.0	20
42	130	.0079	99.21	21
44	160	.0063	99.37	22
46	200	.0050	99.50	23
48	250	.0040	99.60	24
50	320	.0032	99.68	25
52	400	.0025	99.75	26
54	500	.0020	99.80	27
56	630	.0016	98.84	28
58	790	.0013	99.87	29
60	1,000	.0010	99.90	30

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PART 3

Imaginary numbers are a cinch

Want a low- or high-pass filter? Find out how to design your own

By NORMAN H. CROWHURST

WHEN I NEXT DROPPED BY GEORGE'S lab, he'd been doing his homework on imaginary numbers. He'd made a neat tabulation of all the results he could find about the simple two-element low-pass filter we had been working with and started extending it to a three-element type. Now he wanted to know more.

"I think I could go ahead with more complicated low-pass filters, with a little trial and error," he said. "I suppose you can apply the same method to high-pass filters, but I couldn't see it."

"Let's just reason it out as we did for the low-pass." I sketched a high-pass circuit and started translating its performance into an equation (Fig. 1). "The output is an inductor in shunt with the terminating resistor, and its normalized value is unity. We let the inductive reactance be represented as b units at cutoff frequency, as we did with the shunt capacitor of the low-pass filter. Should these units represent reactance or susceptance really, at cutoff frequency?"

"That's what had me stymied," admitted George.

"You can use either, with the proper care," I went on. "I find it simpler to use *susceptance* for all shunt elements and reactance for all series elements. Then we show its variation with frequency and phase of the elements by where we write x and j."

"So the susceptance of the inductor will be jb/x?" queried George, who had obviously been thinking about this.

"Last week we set a standard about phase for this kind of calculation," I reminded him. "It was that a $+j$ means the quantity *leads* the reference quantity. Here, reference quantity is voltage across both the output resistance and the shunt inductor, so the j applies to the inductor current."

"And current lags voltage in an inductance," went on George, "so it should be $-j$, right?"

"Right. But an easier way is to just remember that the j and x always go together; this automatically takes care of the sign." I showed him that b/jx is the same as $-j(b/x)$. He was already figuring out the expression for this high-pass filter.

George was taking to the use of j like a duck takes to water. In short order, he had the phase and amplitude expressions figured out, as well as values for a and b for the constant-resistance type. He set these down alongside those he had tabulated for the low-pass unit.

"Hey," he said, "the values and, when you make $ab = 1$, the phase angles are the same for both, except for the sign. What does that mean?"

"Simply that the transfer phase of these two filters is 180° apart at all frequencies, when they use the same cutoff frequency as in a crossover."

"Can you also show from this that a crossover like these makes constant resistance and delivers constant total power?"

"For power, take the reciprocals of the amplitude-squared expressions, and add them," I suggested, which he did (Fig. 2) almost as quickly as I said it, and found the answer reduced to 1/1.

"Does that prove the constant-resistance property as well?"

"Not directly, you need to figure out the input admittance of each filter and then add the two together." I showed him step by step how to do this for the low-pass (Fig. 3). He did the same for the high-pass, converted to

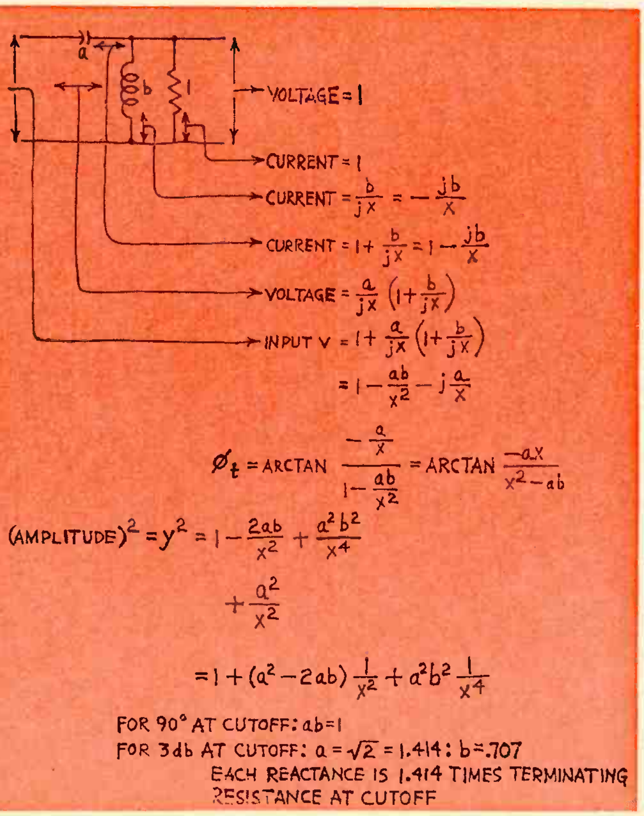

Fig. 1—Diagram of a high-pass filter, and what it does in simple math terms.

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x instead of 1/x as the variable in this case, added them, and found the sum was again equivalent to 1/1.

"Show me a three-element low-pass design," George asked. I drew the design (Fig. 4-a). I put in a, b, and c to represent the normalized reactance and susceptance of the elements at cutoff, and we started figuring.

"The voltage across the output inductor is jcx," said George, "so the total voltage at the mid-point capacitor is $(1 + jcx)$, isn't it?" I nodded, so he went on, "Then the current through the capacitor is . . ." and he wrote it out: $jbx\,(1 + jcx)$. "Now what?"

"What's the current through the input inductor?" I suggested.

"It's the current through the capacitor, plus that going to the output — is output current 1?" he asked. I nodded, so he wrote, for current in the input inductor: $1 + jbx(1 + jcx)$. "Then the voltage across the input inductor is . . ." and he wrote out:

$$jax\left\{1 + jbx\,(1 + jcx)\right\}.$$

"Now you just add the voltages together to get the input voltage," I suggested, sketching in the voltages on the schematic. By this time George was working it, to come up with the answer:

$$1 + jcx + jax\left\{1 + jbx\,(1 + jcx)\right\}.$$

"Yuk," he commented, so I took over and removed the parentheses, till we had:

$$1 - abx^2 + j(a + c)x - jabcx^3.$$

"Now what?" asked George. "Just solve for a, b, and c, I suppose you'll say."

"That isn't as difficult as you might think, for the constant-resistance or maximal-flatness case. First, let's figure out the amplitude-squared expression."

George squared the real and imaginary parts and added the terms in x^2 and x^4 to come up with

$$1 + \left[(a + c)^2 - 2ab\right]x^2 + \left[a^2b^2 - 2abc(a + c)\right]x^4 + a^2b^2c^2x$$

which evoked another "Yuk!" when he'd finished.

"Well, we can simplify that somewhat," I said. "First we want the rolloff asymptotic to cutoff, so the coefficient of x^6 must be one."

"Come again," said George, confused by the abstract math terms.

So I sketched out the response on log/linear paper (Fig. 4-b). I explained that the 1 of the amplitude-squared expression represents the horizontal part of the response in the passband, while the x^6 of the last term represents an 18-dB-per-octave slope, crossing the zero line at cutoff frequency.

"So that means abc must equal 1." George promptly made that substitution by crossing out abc and $a^2b^2c^2$.

"Next, for maximal flatness, the terms in x^2 and x^4 have to disappear," I told him.

"So the whole thing boils down to just $(1 + x^6)$?" asked George, and added, "Oh, I see now what you meant by its being asymptotic."

I nodded. "The curve approaches a straight line, but never quite gets there."

"That's negotiable," he said, writing out $(a + c)^2 - 2ab = 0$ for x^2 and $a^2b^2 - 2(a + c) = 0$ for x^4 (Fig. 5). Then he looked stumped.

"Because abc = 1, how about writing 1/c for ab?" I suggested, which he

(continued on page 71)

LOW PASS

$$y^2 = 1+x^4 \qquad \frac{1}{y^2} = \frac{1}{1+x^4}$$

HIGH PASS

$$1+\frac{1}{x^4} = \frac{1+x^4}{x^4} \qquad \frac{x^4}{1+x^4}$$

$$\frac{1+x^4}{1+x^4} = 1$$ CONSTANT TOTAL POWER CONDITION

Fig. 2—Power condition of the network.

LOW PASS

$\dfrac{\text{INPUT CURRENT}}{\text{INPUT VOLTAGE}}$ OR INPUT ADMITTANCE

FIG. 5 (PART 2)

$$\frac{1+jbx}{1-abx^2+jax} = \frac{1+j.707x}{1-x^2+j1.414x} = \frac{(1+j.707x)(1-x^2-j1.414x)}{(1-x^2)^2+2x^2} = \frac{1-j.707x-j.707x^3}{1+x^4}$$

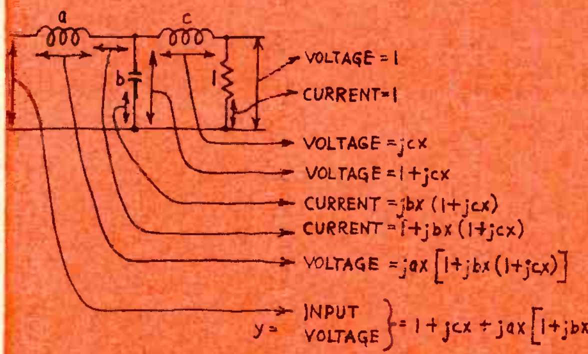
HIGH PASS

FIG. 1 (PART 3)

$$= \frac{1-\frac{jb}{x}}{1-\frac{ab}{x^2}-\frac{ja}{x}} = \frac{1-j.707\frac{1}{x}}{1-\frac{1}{x^2}-j1.414\frac{1}{x}} = \frac{(1-j.707\frac{1}{x})(1-\frac{1}{x^2}+j1.414\frac{1}{x})}{(1-\frac{1}{x^2})^2+2\frac{1}{x^2}} = \frac{1+j.707\frac{1}{x}+j.707\frac{1}{x^3}}{1+\frac{1}{x^4}} = \frac{x^4+j.707x^3+j.707x}{x^4+1}$$

$$\frac{1-\cancel{j.707x}+\cancel{j.707x}-\cancel{j.707x^3}+\cancel{j.707x^3}+x^4}{1+x^4} = \frac{1+x^4}{1+x^4} = 1$$

Fig. 3—Computing input admittance of the low-pass filter.



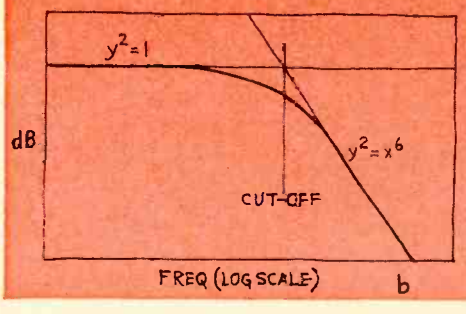
$$y = \text{INPUT VOLTAGE} = 1 + jcx + jax\left[1+jbx(1+jcx)\right]$$
$$= 1 + j(a+c)x - abx^2(1+jcx)$$
$$= 1 - abx^2 + j(a+c)x - jabcx^3$$

REAL PART: $1-abx^2$ IMAG. PART: $j(a+c)x-jabcx^3$

$$[\text{REAL}]^2 = 1-2abx^2+a^2b^2x^4$$
$$[\text{IMAG.}]^2 = +(a+c)^2x^2-2abc\,[a+c]\,x^4+a^2b^2c^2x^6$$

$$1+\left[(a+c)^2-2ab\right]x^2+\left[a^2b^2-2abc(a+c)\right]x^4+a^2b^2c^2x^6$$

a



b

Fig. 4—Design (a) of low-pass filter and the graph (b) of its performance.

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ULTRASONICS NEW TOOL FOR INDUSTRY

There are more technical applications for ultrasonics than you may realize

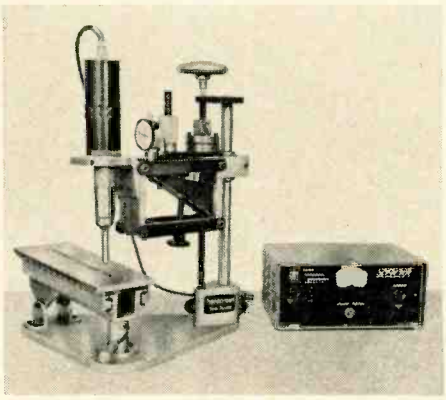
By PAT MCDONALD

MOST RADIO AND TV SERVICE TECHNIcians have some knowledge of simple ultrasonic devices. The remote-control channel changer supplied with many TV receivers, for example, is a very basic ultrasonic generator. Watchmakers and auto mechanics may have in their shops ultrasonic units designed for degreasing and super cleaning; most technicians and experimenters are at least aware that such devices exist. But do you know that other industrial applications employing ultrasonic waves include welding, atomizing, mixing, polishing, flaw detection in metals, and gas-and-liquid flow-monitoring devices, among many others? Because electronic circuitry is so much a part of ultrasonic devices (sound waves behave very much like electrical and radio-frequency waves) technicians will find much that's familiar in such equipment.

From frequencies as low as 20 kHz to an upper limit of several-hundred GHz or more, ultrasonic energy offers an expanded horizon for technicians and industrial engineers.

Ultrasonic devices fall into two principal categories: one employs sound energy directly as a power source to perform useful work; the other uses the high-frequency sound waves as a signal source for sensing, measuring, or carrying information.

In nearly every application, ultrasonic generators and transducers (devices which transform electrical energy into mechanical force) are part of a more complex electroacoustic system.



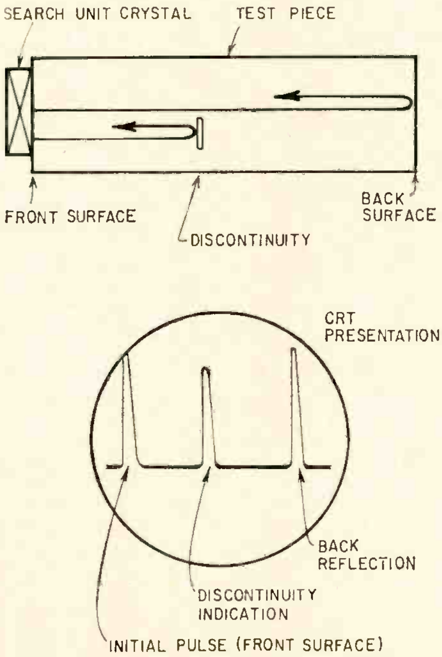
(Courtesy Branson Instruments)

An ultrasonic welder speeds fabrication of plastic containers, etc., providing a continuous welded seam at 100 ft/min.

Soldering and welding

Straightforward soldering techniques are used for joining many metals. Aluminum, however, cannot be soldered using familiar practices, because of the oxide film which forms a barrier to fluid-metal bonding. Abrasive removal of the oxide barrier and the use of corrosive fluxes generally are required to obtain a satisfactory metallic bond. Even then, the work is slow, the joints sometimes marginal.

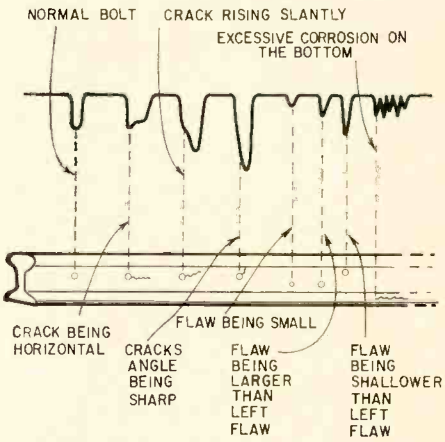
Ultrasonic soldering equipment, however, permits bonds to be made on difficult-to-solder metals such as aluminum, as easily as brass or tin can be soldered using conventional techniques.



Similarity of ultrasonic flaw detection to radar echo ranging is easily seen. Scope presentation also is much the same.

In ultrasonic soldering, vibrations are applied through a transducer to the tip of the iron or, as in the case of a dip-tinning bath, to the vessel containing the molten solder. The ultrasonic energy produces a violent agitation, the action of which removes the oxide film and allows a "wetting" action to take place, thus permitting a bond. No flux is required, and the danger of corrosion due to flux remaining in the joint is avoided. Fluxless soldering on delicate silicon and germanium surfaces in semiconductors can be accomplished readily.

Welding metal foils ordinarily is difficult, because thin-film metals are extremely delicate. An ultrasonic foil welder incorporated into automated foil-packaging machines, however, effectively eliminates foil damage and provides an hermetic seal. Such a welder may be added to systems using fixed or movable welding heads.



Plotted curve of signal current of track flaw detector indicates response to various types of commonly encountered flaws.

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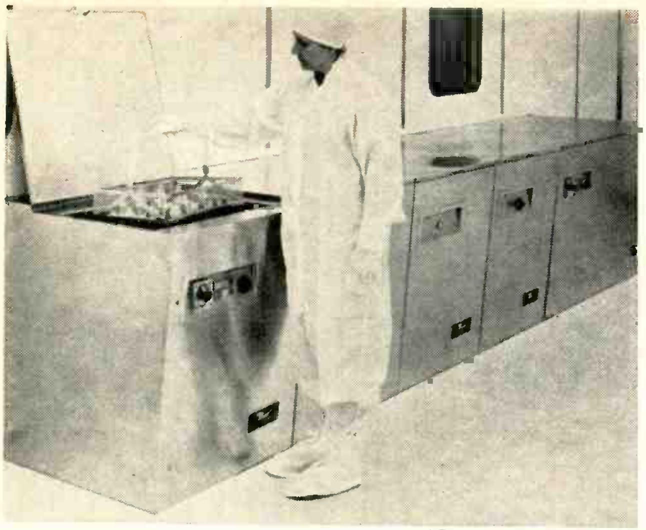


Industrial ultrasonic cleansing baths have become common in spaceage and defense work where absolutely clean parts are needed.

(*Courtesy Bendix Corp.*)

A similar technique also may be applied to most thermoplastic materials—Mylar, polypropylene, polyethylene, Nylon and Dacron. Here, as in metal bonding, the plastic material remains cool, regardless of how long the welder tip remains in contact with it. Continuous welding can be carried out at rates as high as 100 ft/min, depending upon the type of material and its thickness. Since there is no heat, flammable materials can be welded or encased in plastic containers without risk of fire.

Nondestructive testing

Ultrasonic material-testing techniques have given industrial quality-control and inspection technicians a valuable tool. Using ultrasonic inspection procedures, it's possible to detect flaws that cannot be uncovered by any other nondestructive method.

This testing technique uses short bursts of ultrasonic energy (sonic wave trains) generated by a piezoelectric element and transmitted by contact into the material under test. Any discontinuity in the structure of the material represents an acoustic barrier. Some of the sound energy will be reflected to the source, in a manner not at all unlike the echo responses obtained in various types of radar and sonar systems.

The piezoelectric transducer or "search" unit also may be used to convert the reflected ultrasonic energy into electrical energy, so that echo amplitude and return time may be indicated. The interval is proportional to the distance between the flaw and the entry surface.

Energy also will be returned from the opposite surface of the material and may be used to indicate the actual length of the part being examined. Such measurements obtained on calibrated instruments can determine the thickness of a wide variety of products; cathode-ray tubes and other electronic devices are used to display the information.

A thoroughly practical flaw-detection device has been designed to prevent train accidents due to rail fractures. The system is able to detect cracks and other structural flaws before they become serious enough to endanger passenger safety. To obtain an analysis of the rails, frequency-modulated ultrasonic waves are projected into the rail surface at right angles to the lay of the track. The frequency of the ultrasonic energy is resonant to the mechanical cross-section of the rail. Any change in the resonant frequency as a result of a structural discontinuity due to the presence of cracks or other flaws is detected visually by means of a meter and aurally by headphones.

Leak detection

The usual method of detecting pressure leaks in industrial gas systems is to apply a soap solution to various systems components and connections and watch for bubbles caused by a leak. A much more modern and effective technique is to use an ultrasonic translator to detect ultrasonic sound pressures created by the flow of gas molecules escaping from the system. Typical translators can detect pressure leaks at distances greater than 50 ft. This distant-detection capability, combined with the use of a directional probe, permits locating leaks without a minute examination of the entire system.

Ultrasonic sensing

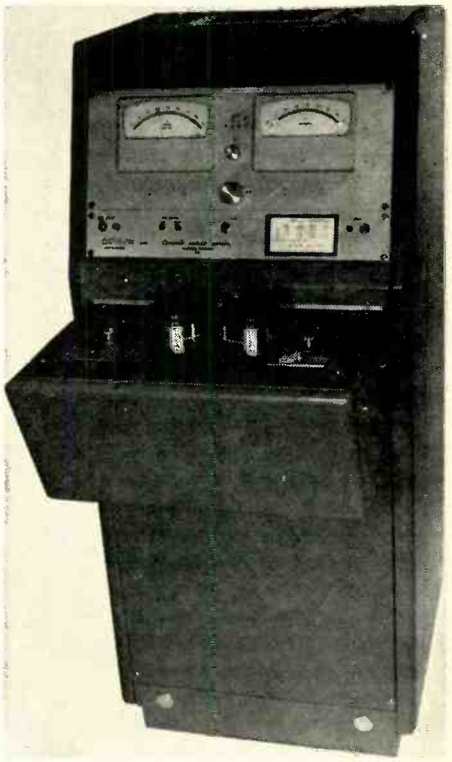
Ultrasonic transducers can be used in place of electric-eye sensing devices to detect a wide variety of objects. Since the ultrasonic beam can "see" in darkness and in spite of dust, smoke, steam, fog, high ambient light levels, humidity, vibration or contamination, most of the electric eye's shortcomings are thereby eliminated.

Using a direct beam, transmitting and receiving transducers (sensors) can be positioned to face each other for direct ultrasonic energy transfer. In cases where the sensors might be damaged or otherwise adversely affected when positioned near moving material (as in bin-leveling applications), reflective-beam operation is best. In either, a relay can be made to drop out or pick up upon beam interruption.

Cleaning

The "scrubbing" action of liquids agitated by ultrasonic waves makes it possible to use ultrasound to clean objects which otherwise would require extensive soaking, boiling, and scrubbing. The action of countless tiny bubbles in the cleaning solution literally "scrubs away" dirt, grease, and almost any other contaminant.

The intensive, deep cleaning obtainable through the use of ultrasonic techniques has proved especially valuable in medical technology and aerospace operations, situations where absolute cleanliness is required to avoid contaminating human life or a multimillion-dollar space probe that could infect an entire planet or stellar system.



(*Courtesy Chesapeake Instrument Corp.*)

Almost instantaneous readout of butterfat percentage and SNF percentage is possible using this dairy-industry ultrasonic unit.

Chemical action

Many chemical reactions are accelerated by ultrasonic energy, while others are inhibited. Solutions also can be mixed or homogenized efficiently through various high-frequency agitation procedures.

The vaporization of many liquids

(continued on page 82)

Audio Levels on Long Communications Lines

When several dispatch points are used in a two-way radio system and audio levels to the transmitter aren't the same, here's how to equalize them

By EUGENE AUSTIN

BACK IN THE OLD DAYS, INSTALLING A TWO-WAY SYSTEM meant plunking down a tin box and a mike on the sheriff's desk, hanging an antenna from the chimney, bolting a couple of boxes and a whip on his car, and then you were in business.

In recent years, I found myself ordering progressively more sophisticated equipment, and more of it. A short time ago, I loaded up a truck to the roof with mobile transceivers, and spent the next week installing them. In the meantime, the rest of the crew had loaded up a tin outhouse, carried it out on top of that big hill way out in the boondocks, and bolted it down on a cement pad at the foot of a 100-foot-plus tower.

Then they hooked up one end of a network of leased telephone lines and ran all over town hooking remotes to all the other ends.

And that's where we all came a cropper!

When they got done, I ran out and sent in a 0-dBm signal from all remotes, and thought we were ready for business. Trouble was the police dispatcher climbed down my throat because he could hear the sheriff's office perfectly, but the sheriff's house was so far down in the mud nobody could find him. If they turned up the volume to hear the sheriff's house, the first car that came on the air could be heard in the city clerk's office—seven doors down the hall.

Out in the cars it was even worse. If I set the modulation up for the police department, no sheriff's house. If I set up for the sheriff's house, the police dispatcher sounded like he had just swallowed a hot soldering iron. Also, we could hear every dog barking, every kid screaming, and every horn honking for two blocks around.

Having worked one summer on toll telephone systems, I took one look at a block diagram of the phone lines, and knew what I had on my hands. It was a network of bridged (paralleled) telephone lines that looked like it had been spun by a drunken spider. Every segment was a different length, and the loss figures varied over 10 dB from one to another. Einstein would have choked trying to figure out loss figures with a pencil.

I studied the thing for all of ten minutes, and threw up my hands. It looked like the best bet was to set up to deliver consistent audio to the transmitter—thus keeping

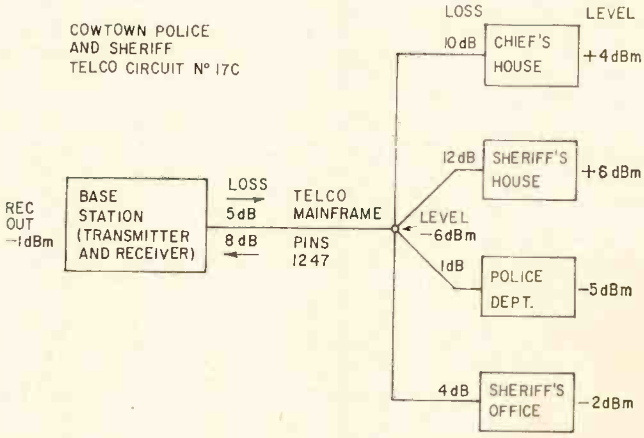


Fig. 1—Signal levels and line losses through typical system.

the FCC off the customers' backs. At the time, I was convinced that Satan himself couldn't control the blasting between remotes.

Soooo—I made sure all the equipment was connected, and stationed a man at the transmitter with a high-impedance dB meter. Then I went around to each remote and put 0-dBm into the line, at 1 kHz. The other man measured the loss, and noted it on a circuit card similar to that shown in Fig. 1.

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That done, I called the phone company, and learned that their maximum permissible level was +6 dBm (or 6 dB above 1 mW).

After studying the block diagram, I realized that, to deliver consistent levels to the transmitter, the remote on the end of the longest segment would have to transmit the highest level, because it had to overcome more loss than any other segment. Sure, that was a lot like signals in a CATV system—only backward.

I arbitrarily assigned the line segment with the highest loss—the sheriff's house—the maximum permissible level of +6 dBm.

I took my measured loss figures and figured what level

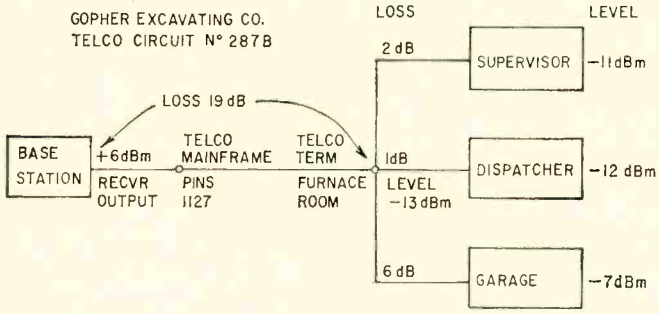

Fig. 2—Sometimes there are two common points within a single system. Levels at each should be maintained the same.

this +6 dBm from the sheriff's house would push through the transmitter. With a total line loss of 20 dB, the transmitter would receive −14 dBm.

I then figured backward and determined what level would be necessary for each remote to deliver −14 dBm to the transmitter. For the chief's house, with a loss of 18 dB, a transmit level of +4 dBm was necessary. For the police department, with only a 9-dB loss, a much lower transmit level of −5 dBm was necessary.

I set up each line in the system this way, adjusted modulation, listened to the various remotes on the monitor, and called it done.

I hadn't any more than hit the shop when the police dispatcher called. "Boy," he said, "this is more like it! I can't tell whether the sheriff's talking from his house or his office, they're that much alike. That's the way it ought to have been in the first place."

I mumbled something or other, hoping to convince him that I had planned it that way, and hung up quick. I sat down and asked myself: "What happen? What'd I do?" I got out the circuit card, looked at it for a while with a completely blank mind, then something snapped between my ears, and a great light dawned.

I had set up to deliver consistent audio to the base. Since all audio came together at a common gathering point on the telephone company's main frame and traveled down a common line from there to the transmitter, it followed that I had also unknowingly set up to deliver consistent audio to the common point. It came out to −6 dBm.

Look at it from the police department's viewpoint: If all three of the other remotes delivered a consistent audio to the common point at −6 dBm, this signal would travel down the common line to the police-department remote, losing about 1 dB on the way, and arrive there at a still-consistent level of −7 dBm. (Each remote station receives any audio on the network, whether from the base-station receiver or from another remote station.) All we had to do then was adjust the police-department input level to −7 dBm and we were set.

Or take the sheriff's house: If all three other remotes delivered a consistent signal of −6 dBm to the common point, this audio would travel down a common line to the sheriff's house, dropping about 15 dB on the way, and arrive there at the still-consistent level of −21 dBm. So all we had to do then was to adjust the sheriff's level for −21 dBm and his station received properly.

Realizing that all I had to do was set the receiver up the same way, I went back and measured the loss from the receiver to the common point. I got 5 dB loss, so I set the receiver to send −1 dBm down the line.

We did some later testing, and found that there wasn't the slightest sign of blasting anywhere. We decided we had somehow overlooked one key fact: The transmit level from any particular remote has no effect on blasting on that remote, because the receiving circuits in it are cut off during transmit. Obviously, blasting is strictly an incoming-signal problem. We could juggle transmit levels all over the place without causing local blasting.

Since that time, I've worked out a cut-and-dried setup procedure that works about 75% of the time. Specifically, it works on the 75% or so of all multiple-remote systems that have their lines tied together at a common point somewhere in the system.

Here's my technique:

1. Make sure all equipment is in place and connected. Two reasons: First, an unconnected end will not show working load, and will throw the whole system out of balance when finally connected. Second, the open end of a long telephone line will introduce all kinds of crosstalk and hum. If you absolutely must set up part of a system, have the phone company tie in the unused segments. Then, go out and connect a 600-ohm resistor across each end where a remote will eventually be installed. Leave it there until the equipment actually replaces it.

2. Make up a circuit card, like Fig. 1. Essentially, this is just a glorified block diagram, with telco circuit numbers and frame-connection locations added. You'd be surprised

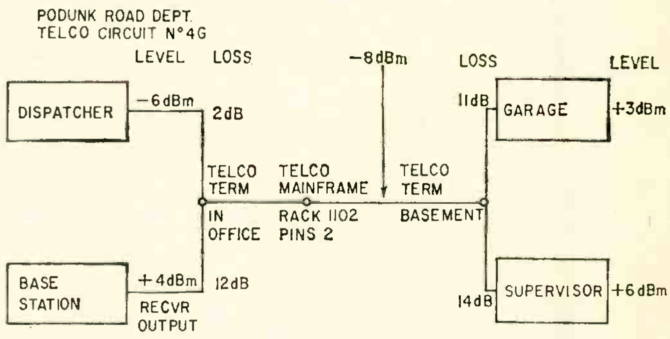

Fig. 3—If there's no actual common point in the system, you'll just have to set up for uniform audio level at the transmitter.

how much this information helps when you have to test a line in the middle of the night. I like to use the cardboard shirt stiffeners that come in my laundry. They are big enough to hold a lot of information without crowding, they just fit a file folder, and they are durable enough to lug around in the truck without getting dog-eared.

3. Send a man with a high-impedance dB meter (or audio vtvm) and the circuit card to the common point. Be sure the meter is high-impedance. Some dB meters, intended for toll telephone work, have a 600-ohm resistor across the input. Such a meter loads down the line and gives false readings.

4. Go around to every remote point and to the base, and put a 0-dBm, 1-kHz signal into the line for the other man to measure and note. Two precautions: First, always

(continued on page 73)

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BINARY COUNT DEMONSTATOR

Simple neon-lamp flip-flops demonstrate binary counting

By RUSSEL AYERS

AT THE REQUEST OF ONE OF OUR LOCAL teachers, I undertook to prove to his students that, believe it or not, 10 equals 2 and 100 equals 4.

No, there was nothing erratic about the request nor my immediate willingness to take on the project. In point of fact, I was being asked to develop a simple binary counter. And, in binary notation, as will be explained further in the article, these examples are correct.

When this neon-lamp counter was suggested as a classroom visual aid, I thought of the numerous articles on relaxation oscillators, flashers and such which would make the device comparatively easy for me to assemble. However, I quickly realized that there were a few more problems than I had anticipated, to say the least.

Certainly, flip-flops and triggering circuits employing neon lamps had been published by the dozens. But nowhere could I find a description of one that generated enough output power to trigger reliably another stage following. Only one or two even purported to. None actually did. And this is the one feature absolutely essential to a binary series or operation.

A hard look at the problem led me to see that what power there was being generated in the normal neon flip-flop tended to expend itself around its own internal loop. I divided the standard commutating capacitor in two, returning each half to the more stable midload point, and succeeded in getting more of the switching kick channeled out to trigger succeeding stages. Four well-demarked stages were constructed and tacked in series.

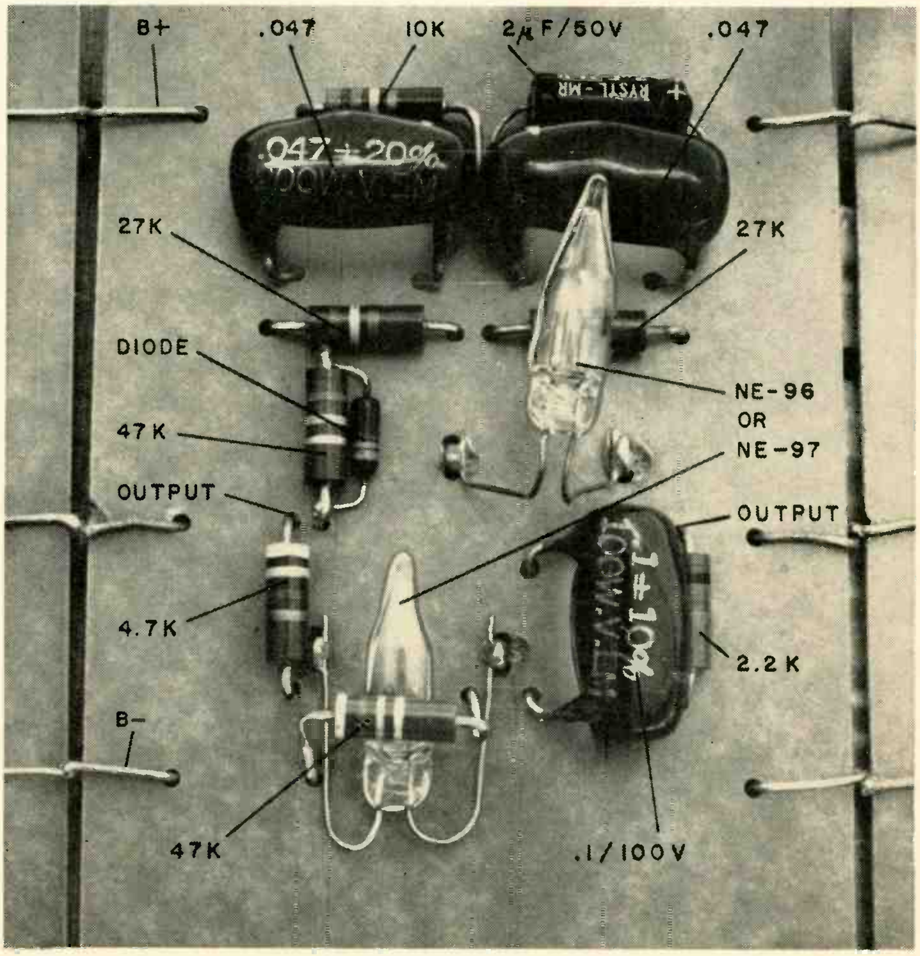
The results were unexpected and disappointing. The best stability I could get was with a Variac at the line input to the doubler supply. This showed that each stage tended to settle down at one certain voltage. None, however, were the same as any other. Pots were put in all four of the decoupling networks. This permitted each stage to be adjusted to its most stable point. Things did settle down considerably, but double-tripping took over as the general order. That is, a trigger was produced at the following stage on the flip as well as on the flop.

Some random single-excursion triggering did occur, though—enough to indicate that proper switching should be attainable. Matching lamps for ionization points and sustaining voltages had seemed an obvious precaution at the start. Now I found, confoundingly, that substituting lamps that did not match quite so well often produced better triggering action.

More pots were installed. This time in the common negative leg. They appeared to help. But it was only after more lamp substitutions—plus a few other experimentations, as a result of nothing in particular—that all at once a proper binary sequence began to click off. Through all four stages. From the first pulse, nicely right out through binary 15 (1111) and back to zero, or 16 if you prefer, it carried.

Five minutes later it quit. Perversely, it began double-tripping again. And it persistently avoided another correct sequence the rest of that session.

At the next session more lamp interchanging brought back periods of stable switching. Still, one lamp after another would fire out of sequence.



An experimental flip-flop mounted on a board (one of several sections in unit).

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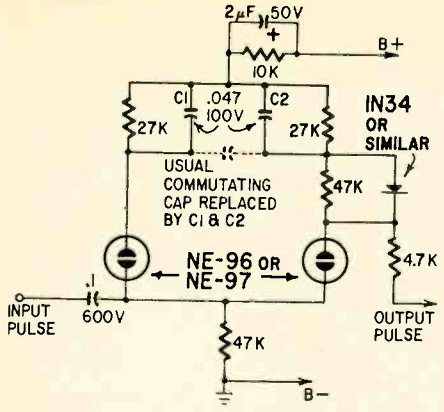

Fig. 1—One section of the flip-flop counter circuit which divides by two.

Then, and for no apparent reason, one of the lamps showed a very pale purple glow. This was quite different from the normal rich orange glint.

The oscilloscope showed that, not only was there high-frequency oscillation in this one lamp, but nearly every other lamp was producing heavy transients of the same sort. It was caused by the unbroken lineup of capacitors and lamps, bridged by other capacitors and lamps, that extended down through the entire string of flip-flops. That glut of reactances being stabbed by every voltage shift anywhere created the wild transients and ringing.

Isolating resistors were inserted to act as dampers. A 4,700-ohm resistor in the output pulse lead serves that purpose in the finished unit (Fig. 1). Now and then a very touchy lamp will need more than 4,700 ohms. The neon flip-flop shown in the photo also had 2,200-ohm isolating resistors in the input leads. You can omit either the output or input isolators in most instances.

With isolation, a much greater measure of reliable triggering could be maintained. Still, it held only within very narrow limits. And having a closely regulated supply for this simple little rig made no sense at all. Double-triggering kept creeping in. The trigger of undesired polarity was finally suppressed by a diode-resistor combination, placed just back of the isolating resistor.

Latitude and stability

Thus the circuit attained an appreciable degree of working latitude. So, at this juncture, the whole thing was gone over. All-round stability got a big boost. Even lamps stopped being so terribly critical. And the common circuit you see became feasible.

A number of interesting experiences deserve recounting: 1. Use NE-96's. Not NE-2's. They are 20 cents each against 10 cents. But you will hunt through 20 of the cheaper ones finding one workable lamp pair. 2. Put the easiest-to-ionize pair at the input. A safer way to do this is to connect the finished unit, except for the pulse leads. Then advance the power-supply pot (Fig. 2) slowly, and observe the order in which each flip-flop becomes a free-running multivibrator. Reconnect them in that order, the first going at the input. 3. Put a 200-volt zener diode across the power supply output (with a heatsink) to minimize adjusting the 10,000-ohm pot.

Fig. 3 is the circuit of a relaxation oscillator that you can use to drive the flip-flops when used as a demonstration counter. With the R-C values shown, the oscillator delivers one trigger pulse every 4 seconds. You can throw S1 to MANUAL and then use switch S2 for manual control.

Do not merely shift the lamps. Lamps that ionize on test a little before another pair may not do so when in the working circuit. Nor will lamps shifted from one working circuit to another hold their order. Even the best 5% resistors and capacitors have enough variance to effect these changes. Actually, closely matched pairs will interchange

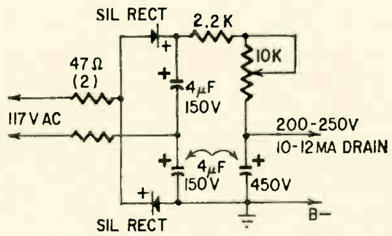

Fig. 2—Power supply for demonstrator.

without impairing switching. But a pair that ionizes 4 or 5 volts ahead of another might trigger right through a slower pair, which offers not a flicker.

Each flip-flop uses two neon lamps but only one is used as a count indicator. These are the ones visible in the photo. The other six are hidden behind the numbered plastic panels. The indicators are called "up" lamps.

Investigation of such things as optimizing frequency response would have been clearly immaterial as a training aid. As the counter stands now, even industrial applications such as batching counters would not tax it.

Say objects were coming off a production line too fast to count, but a record was to be kept of the dozen-per-minute rate. Watching for the "up" lights on the last two flip-flops ("4" and "8") would do it. A reset to zero would be needed, to keep the count from going on out to 16 each cycle. The "8" and "2" "up" lamps would obviously batch 10's. This is done all the time in automation, with standard transistor modules, though it is usually much too fast to see. A running count is always decimal, so binary-to-decimal conversion is done at every stage in automation. Computers do it only at the final readout.

Which brings us to those who may not yet have fully penetrated binary. This too-often-misrepresented, super-scientific system of counting can be cut down to size this way. Binary is cloven-hoof counting. People, having 10 fingers at hand, quite as naturally keep count in tens. They just do not group things in pairs or multiples of pairs.

High-speed computers

But computers do. And the flip-flop circuit is the element that forces them to do it. It kicks from this side to that side, and then back to this side again. And that is all. Trying to make it switch in some other fashion would tend to create confusion. Let it simply flip, and flop back, and it can rather easily be set to do this a million times in one second without a bobble. Moreover, setting either its flip or its flop to trigger another just like it is equally easy. One unit counts pairs. The next triggered unit counts pairs of pairs, or 4s. Then 8s. And we come out with a simple doubling progression.

The notation for binary is really simple. A zero is used to indicate a double. Start with 1. Add a zero and you double to 2. Add another, it is 4. It looks like 10 and 100. But it is actually two doubles. Add another and you are up to 8. It has grown to eight more counts and the input flip-flop would have to tick off to double again. You reach 16, and you have a five-figure term: 1 and 0000. But consider 1 and 000000. It looks like a million. It is actually only 64.

Very properly, the binary system can be regarded as a clumsy notation,

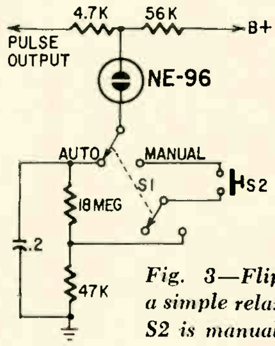

Fig. 3—Flip-flop driver is a simple relaxation oscillator. S2 is manual trigger switch.

and a clumsy way to count. But a computer can trip along to a million before you can jot down 64 in the normal way. By the time present-day second graders are grown, binary will be pre-eminent. But there is no real cause for alarm. Recently, a couple of second-graders, children of an old friend, had it down pat in 15 minutes, studying the rough little demonstrator in the photo. **R-E**

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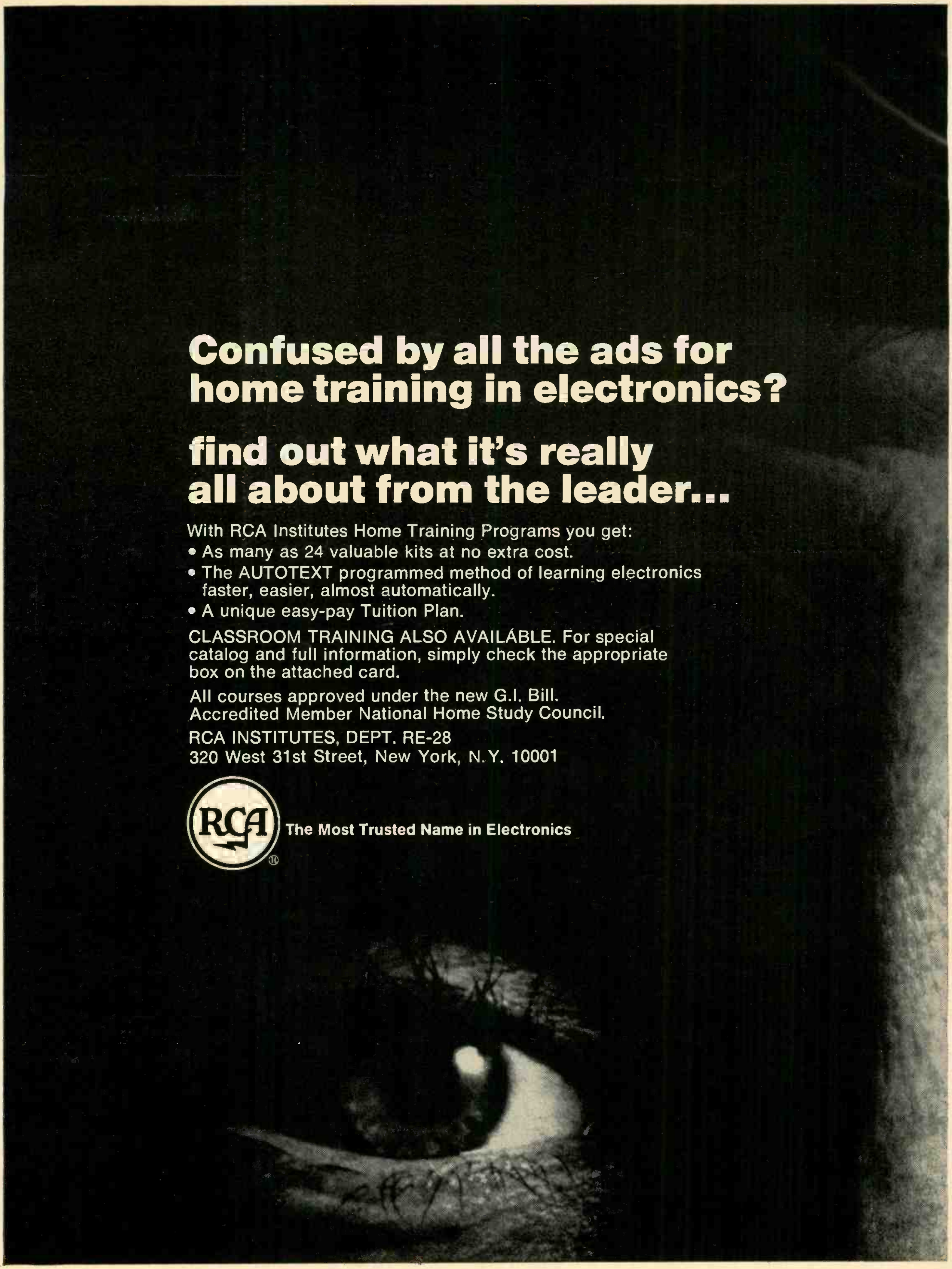

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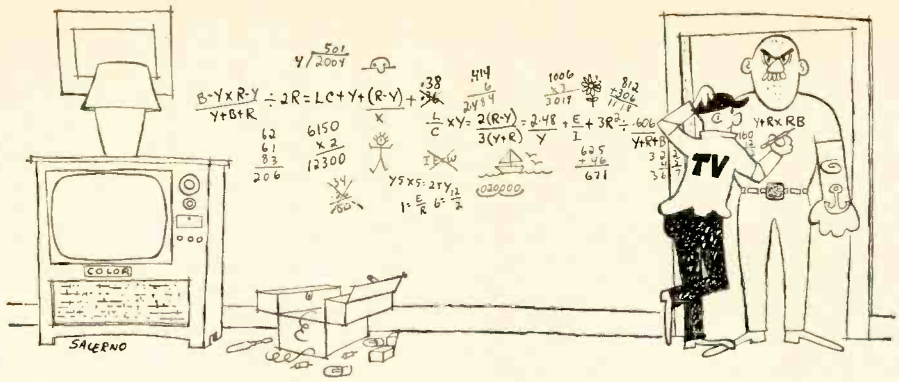

Illustrated by Frank Salerno

The Technician Who Knew Too Much

Or, don't sell the newcomer short

By WAYNE LEMONS

"IT COULD BE THE PICTURE TUBE," Jack said, "but I don't think so. It does have the characteristic blink that a black-and-white tube gets when the cathode opens intermittently, but since the color stays and since a color tube has three cathodes I'm pretty sure they're not open and certainly not all of them."

Jack Cline—a tall, almost skinny, red-headed TV technician—was talking to a customer. Jack is known as a good technician.

He belongs to a local civic club, takes part in the PTA, goes to church on Sunday and yells good-naturedly at the referees at ball games. But Jack has never forgotten that his chosen trade is electronic servicing and that he has to keep learning all the time.

And today, Jack would soon be wondering if he shouldn't go back to school to learn more about throwing stones in glass houses.

An old friend (or at least that's what he'd always thought) had taken his color set to the new technician in town. This guy had been a shop apprentice in the next county and had just opened a place around the corner from Jack's. And Jack, with more work than he could do, was happy for the competition.

Bad picture tube

The new man had diagnosed the trouble as a bad picture tube. Now Jack's "friend" wanted an expert diagnosis . . . "after all a picture tube costs a lot of money!"

Jack had stifled a natural inclination to sarcasm as to why he hadn't been consulted first and continued, half to himself, "The video, all of it, is dropping out and the only thing left is the color."

Jack turned down the color control to make a b-w picture; the picture blinked off and on but there was no change in color or brightness. Or, if there was, it was so slight as to go unnoticed.

"Can't you check the tube on your picture-tube checker?" his customer asked. "The other guy didn't have one."

"I could," Jack agreed, "and I will, but don't expect too much. When it's an intermittent condition you can't always depend on a test to find it. Mainly because a picture-tube checker just doesn't put the tube under exactly the same stresses that it gets in the circuit."

Jack got out the tester, set it up and made the checks on each gun. The tube checked okay. Tapping the tube produced not even a flicker on the short-indicating neons. The meter reading the emission of each gun held steady.

"Yes, I'd say the picture tube is good," Jack said. "Not just because of the tester but because it seems impossible to me that anything in the tube could cause all the video to drop out and yet the colored portions of the picture be okay. And especially since the screen background color doesn't change and the brightness stays normal. I'll get out the scope and see where we're losing the video."

Jack studied the circuit to decide where the best place to hook the scope would be. The set was a Curtis Mathes with an RCA-type video-amplifier circuit; it was dc-coupled all the way. This meant there just weren't too many things that could cause a loss of video without also affecting the screen brightness.

One thing that might cause it, Jack decided, was leakage—perhaps between the grid and cathode of a video amplifier. This would reduce the video level by reducing grid bias. Even

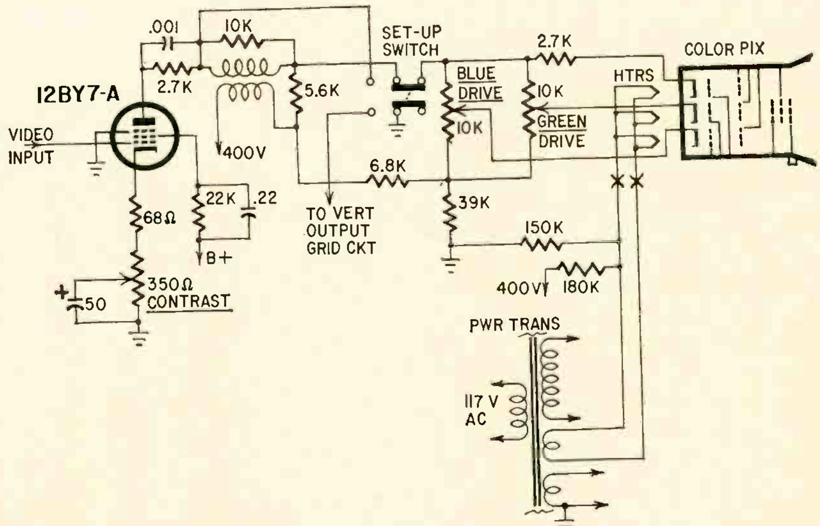

Fig. 1—Jack scoped the grid, then the plate, of the 12BY7-A. Signal on the grid was clean and steady; on the plate, it blinked. Could this be a bad CRT?

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this, Jack realized, was far-fetched. But he tried the tubes. The blinking continued intermittently.

Perhaps an open cathode-bypass capacitor? This would reduce the video without affecting the plate current of the tube. Maybe an open screen bypass?

Jack decided to start by connecting the scope to the third video amplifier grid (Fig. 1). The pattern was clean. When the blinking on the picture tube occurred, the grid signal did not change. The trouble was isolated to the last video stage or (heaven forbid!) the picture tube.

He moved the scope to the plate circuit of the third video amplifier. The trouble cleared itself suddenly, but Jack knew the whimsy of circuits; the hiding out of the culprit when the police get on the trail. He waited. The blinking returned and at the same time the scope pattern blinked, becoming reduced in size and distorted. What could cause the trouble? Perhaps it was a screen bypass. He bridged a new one in. No change. Ditto with the cathode bypass.

He checked voltages on the plate, screen and cathode of the 12BY7 third video amplifier. There was virtually no change when the blinking occurred.

Jiggle the switch

Jack pored over the schematic. Could it be trouble in the set-up switch? He reached over and jiggled it a couple of times. This seemed to have no effect on the blinking, except that the trouble would clear for several seconds; but that happened no matter *how* you disturbed the circuit. "And even if the setup switch was removing the video," Jack reasoned. "It shouldn't have much effect on the plate signal."

Something had to be causing a loss of video without affecting the circuit dc paths. A capacitor to ground somewhere? To probe this idea a little, Jack shunted a 0.01-μF capacitor from the plate of the 3rd video tube to ground. This nearly duplicated the symptom on the screen and the pattern on the scope. The video blinked off and the scope pattern took a distorted dive downward.

But where was the capacitive leakoff of the signal? He followed the video circuit from the plate to the picture tube. There was no wayward capacitor from some other circuit causing the trouble. No leakage paths. It was another dead end.

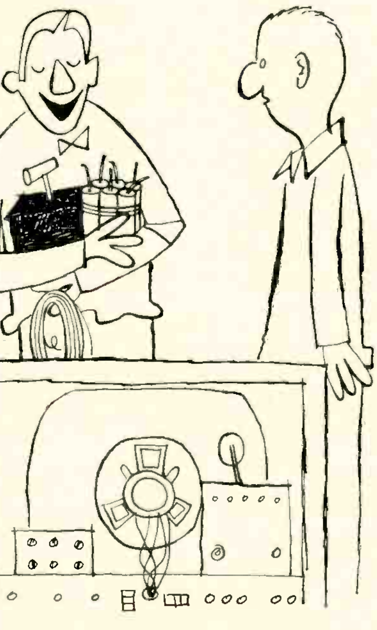
"Oh no," Jack groaned, half aloud. "It probably *is* the picture tube."

The picture was blinking off and on regularly now, sometimes staying off for several seconds. Jack eased the picture-tube socket off. The scope pattern on the plate of the 12BY7 returned to normal size and shape. It stayed that way for 5 minutes. The blinking was gone. Was it circuit whimsy or was it the picture tube?

He gently replaced the picture-tube socket. The picture stayed on 30 seconds after the tube warmed up—then started to blink again.

"It's *got* to be the picture tube," Jack concluded. "But how? How is it possible for a picture tube to lose all the video without losing the color or even changing background color?"

He studied the circuit—all of it. Then it came to him. That had to be it. He took a jumper and shorted two terminals going to the picture tube. It exactly duplicated the trouble. The question, dear reader, is: What did Jack do and what was the trouble inside the picture tube?



The cathode is shorted to the filament, and we've got to separate them.

Jack used a jumper to short one of the cathodes to the heater circuit. This recreated the trouble. There can be no brightness change because the heater is biased by a bleeder on the B+ line so that it is near the same voltage as the cathodes. But the video is skimmed off by the capacitance of the heater transformer windings to ground.

"Is there anything you can do, old friend?" his customer asked.

"I'll see if I can burn out the short, but I've never had too much luck with heater–cathode shorts," Jack said.

Jack looked at the circuit. Why not just ground the heater circuit? This would place quite a lot of voltage between the cathodes and the heater. Maybe the short would burn open.

Instead, something happened, but not what he had exactly hoped for. The short became permanent. You could even measure it with an ohmmeter. It was the green cathode shorted to its heater . . . now solid and tight.

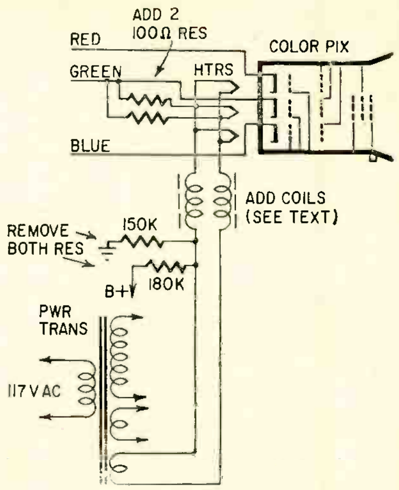


Fig. 2—Jack's solution to the green heater-cathode short; isolation coils.

"Not much I can do except put in a new picture tube," Jack said, "but for a really good friend who might have to tolerate just a little drop in video quality I can install a circuit that will make this old tube work pretty well, perhaps."

"Go to it," his customer said.

Jack wound two coils of No. 20 enamel-coated wire in a single layer on a ferrite core taken out of an old radio antenna circuit. Each coil was about 2¼ inches long. He inserted them in series with the heater windings at point "X" (Fig. 2). He removed the heater-biasing resistors and tied the green cathode though 100-ohm resistors to each side of the heater circuit. (He couldn't tie the cathode direct to the heater because the short inside the tube was not at the end of the heater winding. But the short might not be permanent. Should it remove itself the 100-ohm resistors would keep the heater winding biased.) The ferrite coils would pass the heater current and at the same time keep the video from being bypassed to ground.

The new circuit worked even better than Jack had dared hope. Jack thought about the new technician. He knew that the guy had instinctively but *accidentally* arrived at the correct diagnosis. He wondered if sometimes you "knew" too much for your own good. One thing was consoling though: Jack was pretty sure the new guy couldn't have salvaged the old tube.

And Jack, still a little rankled because his friend had gone to the new guy first, almost wished the jerry-built circuit hadn't worked. But then he smiled to himself . . . of such things are reputations made. **R-E**

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EQUIPMENT REPORT

Dynamic Instrument Plug 'N Play PNP-10

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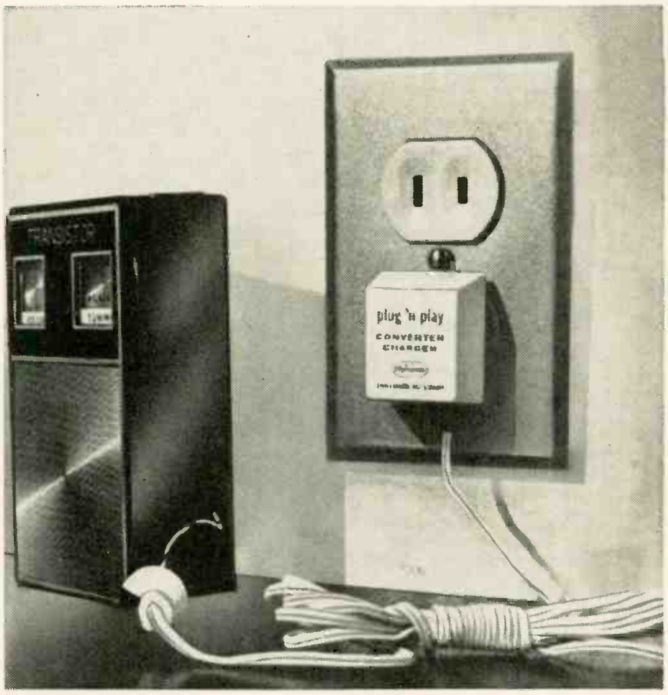


REPLACING BATTERIES IS A NUISANCE YOU TOLERATE IN transistor radios because you can use the radio anywhere. But, at a fixed location why not use the ac line and save money?

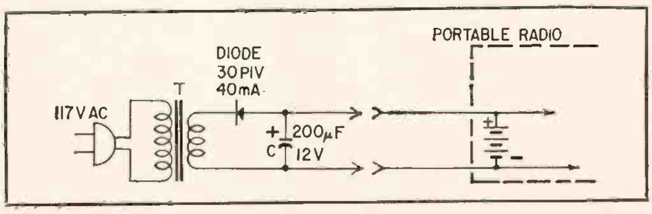
One device for doing this is the Plug 'N Play—a receiver accessory with two features. It converts ac to dc to run the radio off the line; it also recharges the battery and permits you use of the radio as a portable.

As the diagram shows, the circuit is simple—a step-down transformer, half-wave rectifier, and filter capacitor. Output voltage is 12.5 unloaded and about 6.5 across a 325-ohm load. You must leave the battery in the radio when using the PNP-10; thus the cell(s) limit voltage to the radio.

Whether a zinc-carbon or a mercury battery can be recharged is debatable. Call it recharging, rejuvenating, or depolarizing, I found the PNP-10 made a mercury battery last about 5 times longer than normal.

To experiment, I used 6 mercury cells—Mallory TR-146X (NEDA 1604M). They are rated at about 575 mA-hr, or about 48 hours to a 5.4-volt end point at 12 mA (which is what my AM-FM portable nominally draws). I ran batteries 1, 2 and 3 through normal duty cycles of a few hours each day, without recharging. Each began at a fresh terminal voltage of 8.0 under load, and each was retired at 7.0—the point where FM afc became touchy and audio peaks distorted. The three batteries averaged 46

(continued on page 86)



Numbers are a cinch

(continued from page 57)

immediately did.

"From the x^4 equation, $2(a + c) = 1/c^2$, so $(a + c) = 1/2c^2$, right?" he asked. I nodded. "So I can substitute this in the x^2 equation to find c?"

He was doing it and came up with the conclusion $c = \frac{1}{2}$, followed by $ab = 2$, then $a = 1.5$, and finally $b = 4/3$.

"Now we know the coefficients, let's

REDUCE PRODUCT OF Fig. 4-a TO $1+x^6$

① $a^2b^2c^2=1$

$abc=1$

$ab=\frac{1}{c}$

② FOR x^2 TO DISAPPEAR $(a+c)^2=2ab=\frac{2}{c}$

③ FOR x^4 TO DISAPPEAR $a^2b^2=2abc(a+c)$

$\frac{1}{c^2}=2(a+c)$ $\quad a+c=\frac{1}{2c^2}$

SO $(a+c)^2=\frac{1}{4c^4}=\frac{2}{c}$ $\quad \frac{1}{c^3}=8 \quad \frac{1}{c}=2 \quad \underline{\underline{c=\frac{1}{2}}}$

$ab=2$

$2(a+c)=\frac{1}{c^2} \quad 2(a+\frac{1}{2})=4$

$2a+1=4 \quad 2a=3 \quad \underline{\underline{a=1.5}}$

$1.5b=2 \quad \underline{\underline{b=\frac{2}{1.5}=\frac{4}{3}}}$

$y=1-2x^2+j2x-jx^3$

$y^2=1+x^6$

$\phi_t=\text{ARCTAN}\ \frac{2x-x^3}{1-2x^2}$

Fig. 5—How to make X^2 and X^4 disappear.

look at phase," I suggested. George had the expressions for y, y^2 and ϕt with values of a, b and c substituted to give a simple numerical result (Fig. 5).

"One element shifts 45° at cutoff, two elements make it 90°, does the third element shift it to 135°?" He crossed out the x's in the arctan expression and found it simplified down to -1, which is the tangent of 135°. Then he spotted that 90° would be where the denominator is zero, or $x^2 = \frac{1}{2}$ and $x = 0.707$, while 180° would be where the numerator is zero, or $x^2 = 2$ and $x = 1.414$.

"The whole thing looks easier by the minute," he commented. "Don't bother with the high-pass section, I'll work that some other time, for my own amusement. What I want to get to is that filter you designed that started us off on all this. Can you show me that?"

"Well, that's a little different," I admitted. "In the first place, all the filters we've discussed so far are 'ideal' designs: they are exactly what we want them to be — constant resistance, uniform total power. But there is no such thing as a perfect linear-phase filter, so we have to find what is the best we can do with a given number of components. Sometimes calculus will help, sometimes it's a matter for trial and error, with diminishing deviations. So I think we should look at that kind of problem first."

"Oh yes, you were going to show me how calculus helps," George commented. "Can you give me a quick example?"

"Calculus deals with slopes," I explained. "It's not too easy to work out for phase response, but it's easy with amplitude response and we use the same principles for phase. Suppose you have a response with rolloff something like this," and I sketched it out (Fig. 6). "Detailed analysis shows its amplitude expression is of the form $(1 + x^2 + x^4)$ which yields a 4.77-dB loss at the 90° point, where $x = 1$. Suppose we want to add a circuit that will reduce the loss to zero at this frequency, with minimum deviation up to this frequency."

"Sounds difficult. How do you go about it?"

"First step is to cook up the required overall amplitude-squared response, for which two requirements will set maximum flatness: boost equaling attenuation at $x = 1$ (4.77 dB for both); and, slope at the same point equal and opposite to that of the existing circuit, both measured on a dB/log frequency scale." I sketched in how this worked.

"As we're interested in frequencies up to the normalizing point of $x = 1$," I went on, "it's easy and useful to work in that reference, and find out how good the result is when we get through. The attenuation of 4.77 dB ($\log 3 = 0.477$) merely means that $1 + x^2 + x^4$ is 3 when $x = 1$ (which is fairly obvious). We use a two-reactance filter that provides a peak before rolloff, which means its amplitude response will be of the form $y^2 = 1 - ax^2 + bx^4$. We must solve for the two conditions: boost equal to attenuation, and equal, but opposite slopes; both at $x = 1$, to find a and b. Then we can convert this information into a designable filter circuit, by use of the *j* operator."

"I get the idea," said George, "but it's not all clear yet. For boost to equal attenuation, the amplitude-squared expression should be the reciprocal at $x = 1$, shouldn't it?" I nodded. "So $(1 - a + b)$ must have a value of 1/3," he went on. "But how do you figure out the equal-slope part?"

"That's where calculus comes in," I replied. "The slope we are interested in is plotted on log frequency and log amplitude (dB) scales, so the slopes we want are expressed by $\frac{d \log y}{d \log x}$, writing y for the amplitude. Because we use expressions for

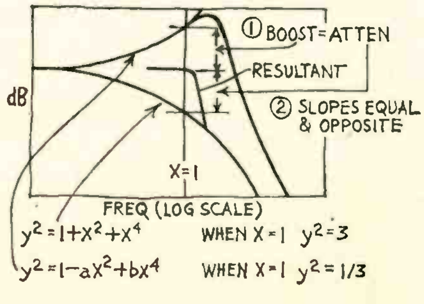
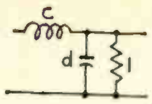


Fig. 6—Changing slope curve by calculus.



$y=1-cdx^2+jcx$

$y^2=1-2cdx^2+c^2d^2x^4+c^2x^2$

$1-(2cd-c^2)x^2+c^2d^2x^4$

$c^2d^2=1/3 \quad 2cd-c^2=1$

$\frac{2}{\sqrt{3}}-c^2=1 \quad c^2=\frac{2}{\sqrt{3}}-1 \quad c=\sqrt{\frac{2}{\sqrt{3}}-1}$

$=\sqrt{1.1547-1}$

$=\sqrt{.1547}$

$c=.395$

$d=\frac{.588}{.395}=1.461$

Fig. 7—Transform math into a filter.

amplitude squared, it's easier to work in y^2 and x^2 as variables, so we'll use that form." Showing him the standard differentials in a handbook he had, I wrote the conversion

$$\frac{d \log y^2}{d \log x^2} = \frac{x^2}{y^2} \times \frac{dy^2}{dx^2}$$

For the first expression, $y^2 = 1 + x^2 + x^4$. I figured this out to

$$\frac{x^2(1 + 2x^2)}{1 + x^2 + x^4}$$

Making $x = 1$ reduces this to a simple $3/3 = +1$. For the expression $y = 1 + ax^2 + bx^4$, the slope figures out to

$$\frac{x^2(-a + 2bx^2)}{1 - ax^2 + bx^4}$$

Making $x = 1$ in this expression reduces it to $\frac{-a + 2b}{1 - a + b}$, which needs to be -1. So the equation for equal slopes may be written: $a - 2b = 1 - a + b$, which rearranges to $2a - 3b = 1$. And the amplitude requirement equation reduces to $a - b = 2/3$.

George soon had these solved, to $a = 1$, $b = 1/3$. "But how do you make that into a filter?" he wanted to know.

"Assume it's of this configuration," and I drew it out (Fig. 7), using c and d as constants for the inductor and capacitor. "Then you solve for values of c and d that make the amplitude-squared equation come out to

$$y^2 = 1 - x^2 + \frac{1}{3}x^4."$$

George was glad of the exercise in using *j* and in short order had equations in c and d that made $a = 1$ and $b = 1/3$. Together we solved them, using a slide-rule to get approximate values of $c = 0.395$ and $d = 1.462$. Using the reciprocal of d, which is 0.685, we could use a reactance chart to design such a filter for any terminating resistance and cutoff frequency.

"How good is the correction this

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filter makes?" George wanted to know next.

"We can use calculus for that too. The maximum error will be a stationary point on the graph of the amplitude-squared equation, which means the slope of the graph is zero." I sketched this.

"Just a minute there," interjected George, "you've lost me, momentarily."

I showed him (Fig. 8) that a point moving along a curve can go up or down; or it can momentarily do neither, in which case it is stationary at the top of a peak or at the bottom of a dip. I pointed out that an amplitude-squared response with terms in x^2 and x^4 can have one stationary point (a peak) if the coefficient of x^2 is negative.

Thus, the combined response after "correction" can have three stationary points, one at zero frequency, followed

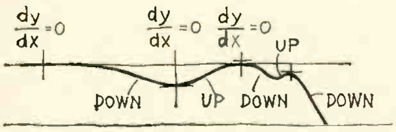

Fig. 8—Movement of point on a curve.

by a dip and a peak before final rolloff. "To find these points, we differentiate the amplitude-squared expression, for convenience using x^2 as the variable rather than x, and equate to zero (for zero slope).

$$y^2 = \left[1+x^2+x^4\right]\left[1-x^2+\tfrac{1}{3}x^4\right] = 1+\tfrac{1}{3}x^4-\tfrac{2}{3}x^6+\tfrac{1}{3}x^8$$

$$\frac{dy^2}{dx^2} = \tfrac{2}{3}x^2-2x^4+\tfrac{4}{3}x^6$$

$$x^2=0, \text{ LEAVING } \tfrac{2}{3}-2x^2+\tfrac{4}{3}x^4=0$$

$$2x^4-3x^2+1=0 \quad 2x^2=1\ \left(x^2=\tfrac{1}{2}\right)$$

$$\text{OR } \quad x^2=1$$

$$\text{WHEN } x^2=1 \quad y^2 = 1+\tfrac{1}{3}-\tfrac{2}{3}+\tfrac{1}{3}=1 \quad (\text{AS REQUIRED})$$

$$\text{WHEN } x^2=\tfrac{1}{2} \quad y^2 = 1+\tfrac{1}{12}-\tfrac{1}{12}+\tfrac{1}{48} = \underline{\tfrac{49}{48}}$$

Fig. 9—Overall amplitude-squared math expression.

"The overall amplitude-squared equation is . . . " George began, when he'd grasped this, and he wrote it out to

$$y^2 = 1 + \frac{1}{3}x^4 - \frac{2}{3}x^6 + \frac{1}{3}x^8.$$

I differentiated it (not bothering with log terms, because a stationary point has zero slope no matter which scale is used) and got (see Fig. 9)

$$\frac{dy^2}{dx^2} = \frac{2}{3}x^2 - 2x^4 + \frac{4}{3}x^6$$

Equating this to zero, x^2 must be zero, or 1/2, or 1. The point at which $x^2 = 1$ is the point for which we designed. s the point where $x^2 = \frac{1}{2}$, at 0.707 below cutoff, represents a dip. Substituting $x^2 = \frac{1}{2}$ into the amplitude-squared expression gives the fraction 49/48. Taking 10 times the logarithm of 49/48 gives the deviation in dB as .089.

George was impressed with how small a deviation this correction could achieve —less than 0.1 dB. Before I left, he wanted to know what else operator *j* could be used for.

I suggested it could be used to analyze anything that uses vectors. We had discussed vector analysis before.

George was convinced his new knowledge of how to use operator *j* was going to prove a very useful tool. **R-E**

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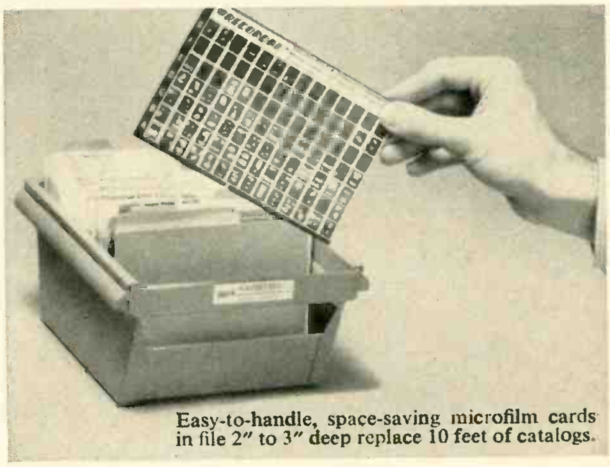

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Audio Levels on Long Communication Lines

(continued from page 61)

send the signal from the remote to the common point. These systems typically show different loss figures with direction of transmission. Second: All dB meters, and the line math on which they are based, are designed around a 1-kHz signal. There are capacitive effects on long phone lines that will cause any other frequency to give misleading readings.

5. Call the phone company, and ask for their maximum permissible level. This could be anywhere from 0 dBm to maybe +10. It will vary from town to town, depending on the age and condition of the cable system. Your best authority is normally the wire chief. However, in larger places, you will have to run down somebody from the engineering department.

6. Select the line segment with the highest loss figure and arbitrarily assign that remote a transmit level equal to the maximum level. Reasons were given earlier. In Fig. 1, this would be the sheriff's house, with a loss of 12 dB, and an arbitrarily assigned level of +6 dBm.

7. Figure what level that remote, transmitting at its assigned level, will deliver to the common point. In Fig. 1, the sheriff's house, transmitting at +6 dBm, will drop 12 dB getting to the common point, and arrive there at −6 dBm. Note this figure on the card at the common point.

8. Figure backward and determine what level is necessary for each remote to deliver this same level to the common point. In Fig. 1, the base receiver will drop 5 dB getting to the common point, so it has to put out −1 dBm. The police department, with a loss of only 1 dB, only needs an output of −5 dBm. Continue like this around the system.

Variations of the leased-line systems have common points at places other than the telephone company's main frame. Fig. 2 illustrates; setup is exactly the same as before.

There are some systems—about 25% around here, to be exact—that have no common point (Fig. 3). In these systems, you will have blasting among the remotes no matter what you do. I set them up to deliver consistent audio to the transmitter. At least the FCC traveling monitors don't hear stinky signals.

There is also one special case, the repeater system, which requires additional work.

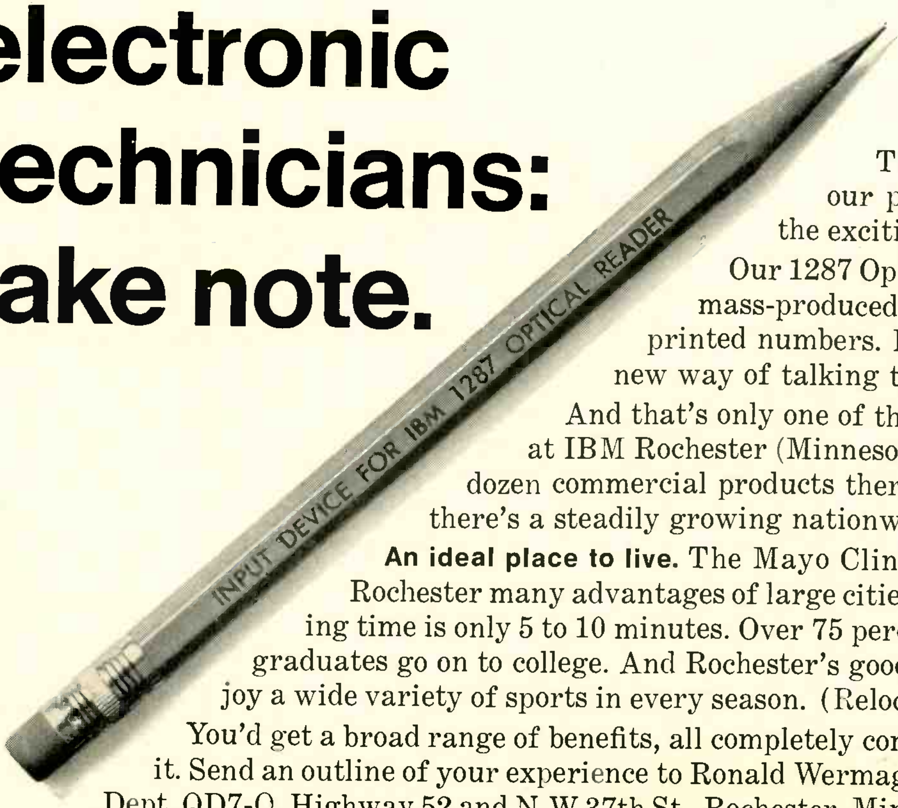
Repeaters feed receiver audio to the transmitter for retransmission, as well as down the phone line to the remotes. All the repeaters I've worked on have receiver-to-receiver attenuators, put there specifically for adjustment to prevent local blasting.

To set them up, you begin by making one additional loss measurement, from the common point to the transmitter. Do this in repeater mode (not remote-transmit mode).

Add together the two loss figures from the base-station segment of the line. In Fig. 1, this would be 13 dB.

Set the receiver-to-transmitter attenuator to this figure. I replaced the fixed resistors that come with these rigs with an adjustable wirewound resistor; the size depends on the particular equipment. That way, I don't have to spend an hour or more fooling with a box of resistors, and I got a more exact setting. **R-E**

electronic technicians: take note.



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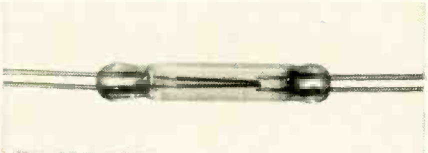

bounce have been reduced and voltage break-down level increased. The multi-element design eliminates need for several switch types.—**Caton Industries, Inc.**

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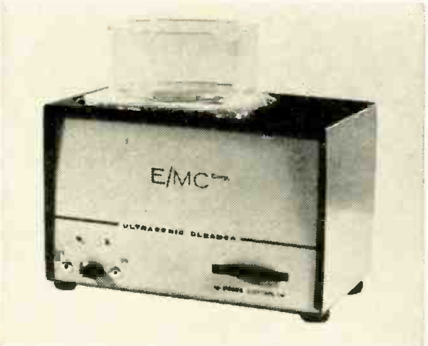
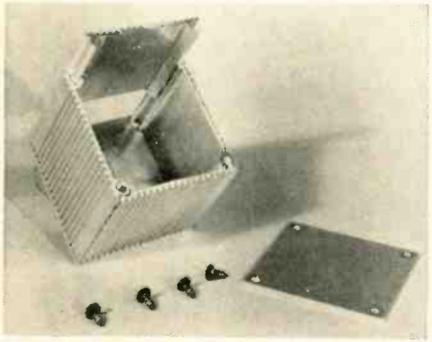
ULTRASONIC CLEANER, *Model LP-2.* Operates at 90,000 Hz on 115 volts. Turns off automatically before it can overheat. All metal and stainless steel cabinet



with crystal beaker. Can be filled, emptied, and objects rinsed without moving the cabinet. $39.95—**Electromation Components, Inc.**

Circle 47 on reader's service card

ELECTRONIC CIRCUITRY ENCLOSURES, *MINI-COOL.* Constructed to contain cable junctions, plug boxes,



control modules, transformers, circuitry, solid-state devices, meters and amateur radio gear. Can withstand a force of 3 tons. The six flat sides are made of lightweight extruded aluminum. Features a lock joint at each corner, which tightens when the screws are installed. Also available with integral heat sink walls. 21 sizes range from 2" x 2" x 1½" to 2.6" x 2.6" x 10". Price from $ .62 to $2.40, depending on size and quantity ordered.—**Sarex Corp.**

Circle 48 on reader's service card

ROSIN FLUX REMOVER, *Spray-on No. 2009 Freon T.M.C. Cleaner.* Removes rosin flux from printed circuits, electrical relays, and semiconductors

without harming plastics and elastomers. Nonflammable and non-toxic, it comes in the 16-oz. size can with an extension tube for delicate work.—**Industrial Supply Div./Sprayon Products, Inc.**

Circle 49 on reader's service card

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streamlined with no exposed wires or gears, the wall-mounted radio receiver is accessible for ready maintenance. Instant-stop control automatically stops the door when an obstacle is encountered and when started again it reverses direction. Additional information available. —**Perma-Power Co.**

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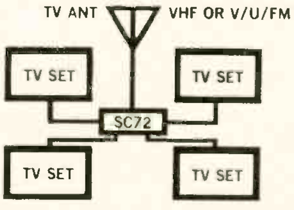

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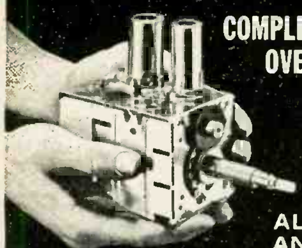

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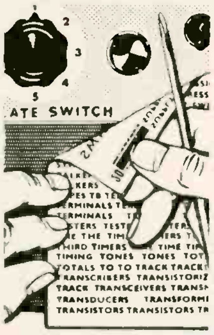

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FIELD-EFFECT VOM, *FE14.* With 15-megohm input resistance on dc and 10-megohm input impedance on ac, measures voltages with a minimum of circuit loading. Has ac and dc voltage ranges from 1.0 to 1000-V full scale. An optional high-voltage probe extends the dc range to 30 kV. Frequency response is up to 10 MHz. A zero center scale of 0.5 volt simplifies testing of transistor circuits. Direct current ranges are 0 to 100 μA, and 1, 10 and 100 mA. Operates on small 9-V and 1.5-V batteries. Complete with test leads, less batteries. $59.95—**Sencore**

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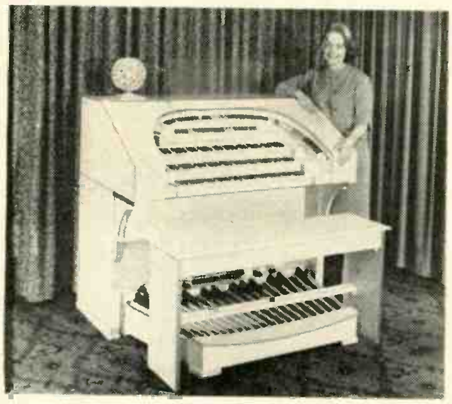
NEW AUDIO EQUIPMENT

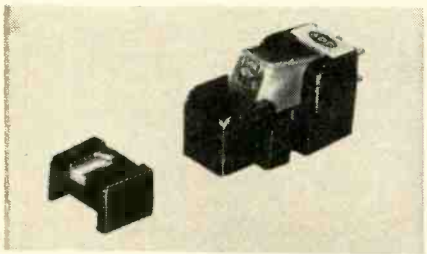
IMPERIAL KIT ORGAN. Theater-type organ is designed to look and sound like the consoles of the silent-movie era. The actual tone of theater pipes is reproduced by employing many sets of transistor oscillators plus special voicing filters.



This is one of 12 models now available for home builders. No previous kit-building experience is required. The *Imperial* is available in several woods and optional finishes; custom-built or in kits at 50% savings.—**Artisan Organs**

Circle 53 on reader's service card

MAGNETIC PHONO CARTRIDGE *10/E-Mark II.* Increased resiliency, greater stylus deflection and greater shock absorbency. Uses elliptical stylus, tracks at up to 1½ grams. Moving mass is far below



record groove yield for clean tonal rendition. Replacement stylus will fit both 10/E and 10/E-Mark II cartridges. Three-year free inspection service. $59.50—**Audio Dynamics Corp.**

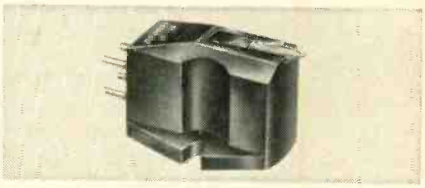
Circle 54 on reader's service card

STEREO RECEIVER, *SX-300T.* 40-watt AM/FM/FM-multiplex receiver with 41 transistors and 26 diodes. Channel

separation is better than 35 dB at 1 kHz. *FM Section:* 3 μV sensitivity, 52 dB image rejection at 1000 kHz, signal-to-noise ratio of 55 dB. *AM Section:* 28 μV sensitivity, 33 dB image rejection, built-in ferrite loopstick antenna, transistorized protection circuit to insure against damage to output transistors. Rear of chassis has standard terminals and switches. Coded plugs are provided for the speaker leads. Additional details and specs available. Oiled walnut cabinet optional.—**Pioneer Electronics U.S.A. Corp.**

Circle 55 on reader's service card

PHONO CARTRIDGE, *SL-15.* Small size, 7 grams, output impedance 2 ohms, stylus pressure 1–2 grams, output 0.04 mV/cm/sec., channel separation 20–30



dB. Fits all transcription pickuparms, mounts easily in all better quality automatic turntables. $60.00 without external transformers, $75.00 with external transformers—**Elpa Marketing Industries, Inc.**

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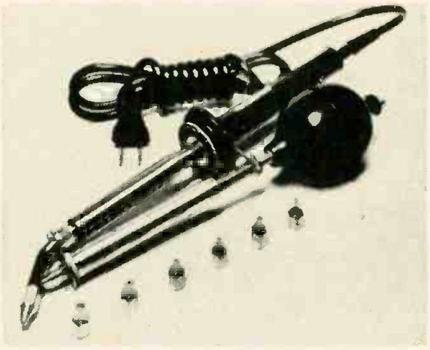

nections to remove all solder. Tip openings are 0.046" and 0.067". Packaged in clear plastic, they come 3 of each size to a package, or 6 sizes for both model irons.—**Enterprise Development Corp.**

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NUTDRIVER SET *No. HSC-1* features drilled handle. By passing an 8-inch or longer round-shank screwdriver blade through the center of the handle and the

hollow nutdriver shaft, you can quickly and easily set the combination locknut and screw adjustments. Eight interchangeable shafts with hex openings from 3/16" to 9/16" are included.—**Xcelite Inc.**

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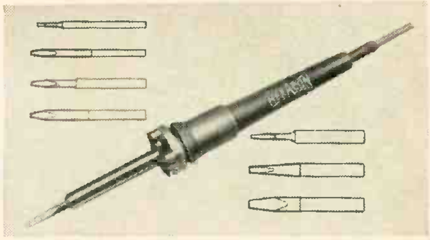

scaling and nonfreezing. Wattages range from 15 to 60 watts.—**Hexacon Electric Co.**

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METAL MARKING KIT, *Lectroetch.* Permanently marks identification on any clean, bare metal surface. Complete with 110-volt power supply which is transformed to 2 amps–10 volts. Marks

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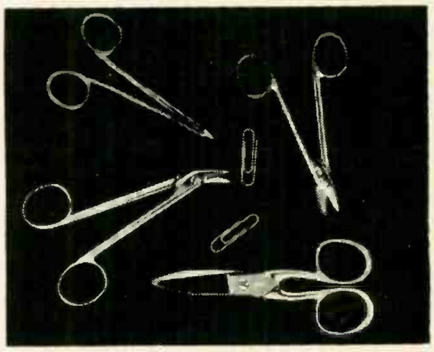
ELECTRONIC SCISSORS come in five styles and are helpful in a variety of ways for electrical and electronic work. Assemblers, production workers, model-shop men, technicians, research and de-



velopment people find them ideal for cutting fine wires, springs, foil, insulation, gaskets, etc. Small size lets them get into tight places. Specs on each of the five models are available.—**Telvac Instrument Co.**

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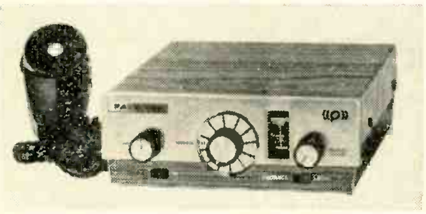
New Communications Equipment

CB TRANSCEIVER, *PACE 200.* A 12-channel unit designed to complement the decor of modern cars. Meter indicates relative incoming signal strength in S-units and dB over S9. Transmitter rated



at 5 watts and operates at 100% modulation. Receiver has a single-crystal tolerance of 0.0033%. Brackets provided for mounting on car or boat. $159—**Pace Communications**

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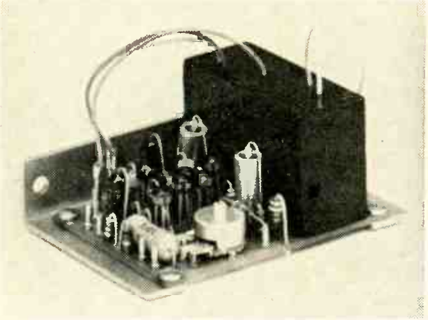
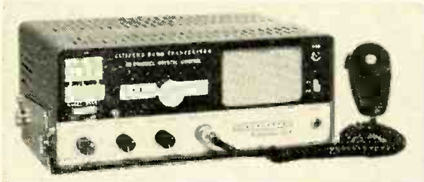
TONE SQUELCH ENCODER, *Series 260 SUB-TONE.* Generates between 67 and 250 Hz without use of a mechanical resonant reed. Easily adaptable to almost any two-way radio, the silicon, solid-



state circuit withstands severe mobile conditions. Six tunable plug-in frequency control networks. Dc supply is 10 to 18 volts and output level adjustable from 0 to 2 volts.—**Mu-Western, Inc.**

Circle 63 on reader's service card

CB TRANSCEIVER, *Comstat 25A.* 23-channel transceiver has a 5-watt transmitter, dual-conversion receiver and 2.5-kHz fine-tuning control. Features S/PRF meter, public-address switch and external speaker jack. Has a built-in TVI antenna



trap, 117 Vac and 12 Vdc transistorized power supply. 11 tubes, 2 transistors and 11 diodes. All crystals are supplied. Comes with mounting bracket and ceramic push-to-talk microphone.—**Lafayette Radio Electronics Corp.** **R-E**

Circle 64 on reader's service card

How to Measure Reverberation Time

(continued from page 52)

to the firm. They recommended spraying the domed ceiling with absorptive asbestos flocking. The second plotting in Fig. 6, made after treatment, shows the change in the reverberation time as a result of the flocking.

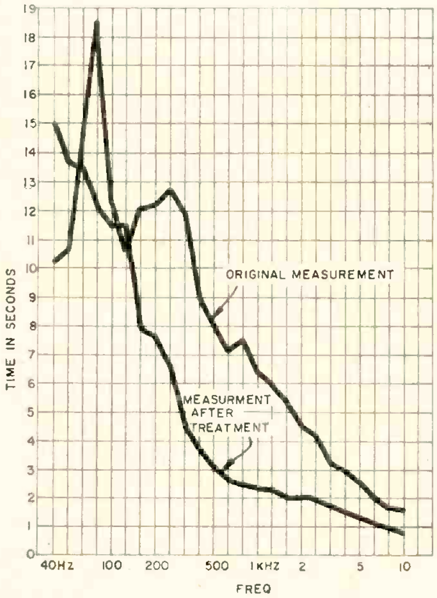


Fig. 6—"Before" and "after" curves of the hall described in this article.

After this correction was made it was possible to install two large speaker arrays carefully designed to distribute high-level sound reinforcement evenly to every seat in the hall. The array mounted in the center is time-delayed to allow for the fact that sound travels far more slowly than electric currents to a speaker. Otherwise, the amplified sound would reach the listener before the direct sound.

The acoustical tests and measurements in this case were useful to the architects in another way. They were able to use them to prove to the ceiling-material supplier that the results he had guaranteed had not come about. The material had failed to reduce reverberation time properly.

Once a sound engineer has measured a number of auditoriums he finds that he gradually develops a feel for the kinds of spaces that are going to cause troubles. Eventually he can recognize them at the drawing board stage. Then he becomes very valuable. If you're a sound contractor, you'd be well advised to look into acoustical tests and measurements. The professional jobs of the future will fall to the professional who starts today. **R-E**

have you any idea how many ways you can use this handle?

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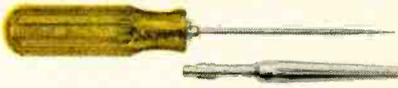

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ULTRASONICS

(continued from page 59)

ordinarily is very difficult; it is even more difficult to generate droplets of a desired size. This job is accomplished easily using ultrasonic waves, since this type of energy can be controlled precisely so that the particle size of the vaporized liquid is determined by the frequency and amplitude of the ultrasonic wave used.

Typical applications of such ultrasonic vaporizing include control of fuel-burning rates, carburetion, agricultural-chemical dispersion, and painting. The efficiency of heat exchangers used to heat and refrigerate closed areas also is greatly increased by applying ultrasonic waves to the interface between fluids and the heating or cooling surface.

The strength and other working properties of metals are directly dependent on their grain structure. Ultrasonic waves applied during crystallization are capable of altering basic grain orientations, creating entirely new classes of alloys and improving existing metals.

Ultrasonics in the dairy

In the dairy industry, ultrasonic testing obsoletes the laborious methods of determining butterfat content and the percentage of other solids or solids-not-fat (SNF). One instrument includes a computer section that gives rapid, automatic, and simultaneous measurement both of solids-not-fat and butterfat in samples of fresh milk.

The time required for an ultrasonic pulse to travel through a typical milk sample is approximately 50 μsec; the exact speed of the pulse depends on the concentration of suspended and dissolved substances and on the temperature. The presence of butterfat lowers the speed, while that of solids-not-fat raises the speed. The exact time is measured electronically and fed to the computer which determines the effect of either variable on the pulse speed. Computed values of butterfat and solids-not-fat are then displayed on meters in direct percentages.

In this introduction to a few of the present uses of ultrasonic energy, the wide range of possible applications remains largely unexplored. Certainly ultrasonic technology today is in its infancy—perhaps as much so as was electronics when de Forest was perfecting the vacuum tube. Look for new and unusual uses of ultrasound to improve existing methods of measurement, cutting, heating, cooling, and many other areas of industrial- and consumer-oriented interest. Ultrasonic devices may turn up where you'd least expect to find them. **R-E**

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Versatile Electronic Tremolo

(continued from page 53)

to trim the 100,000-ohm resistor, depending on the values of the resistors in the circuit. Keep the leads on the photocell short, else they may pick up hum. The leads to the lamp may be any length; this means that the unit containing Q1 and Q2 can be put in any convenient place.

When the tremolo is used with an electronic organ, it is usually desirable to keep tremolo off the pedal tones (tremolo in low bass notes just doesn't sound right). Thus you may want to insert the photocell in the lead that carries signals from one or more manuals only, before the pedal tones are mixed in (Fig. 3). For more specific information, consult the diagram of your organ.

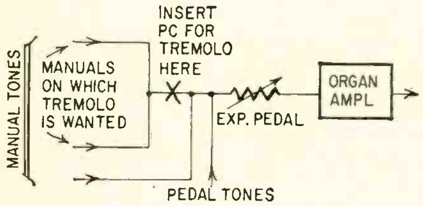

Fig. 3—You may want to split-feed an electronic organ, adding tremolo to only certain manuals, and not to others. See organ manual before attempting this.

Pipe organs generally do not have tremolo on all manuals. The *great* almost never has it, the *swell* does frequently. You may want to arrange your electronic organ similarly.

Controls

Potentiometer R3 is for rate, R5 for depth. Although electrically the two controls are quite independent, psychologically there seems to be some interaction between rate and depth adjustments. You may want to rig up a switch with two or three values of fixed resistance so that you can select quickly, while playing, different rates or depths of tremolo.

To check out the circuit, connect an ohmmeter across the leads of PC1. If the circuit is oscillating and the lamp is glowing, the needle should fluctuate.

The 2N2646 is fairly easily damaged by heat, so use heat-sink clips when soldering, and solder quickly. Its case is connected internally to base 2, so be sure the case doesn't come into contact with any alien wires. A one-turn wrap of tape or a tight-fitting plastic tubing will prevent mishaps. R-E

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MISS-Q

"A Modern FM Stereo Adapter" (August 1967) schematic on page 32 should show that the collector of Q6 is also connected to the 14-volt supply. The printed circuit board (see Correspondence Column) is correctly wired.

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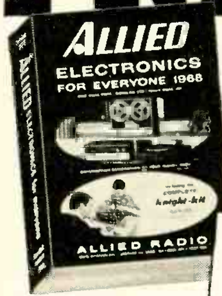

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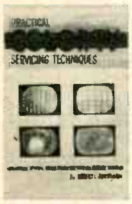

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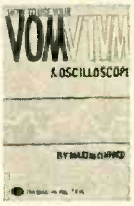

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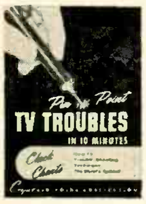

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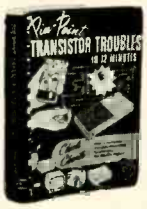

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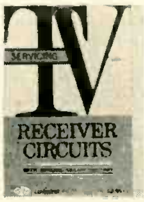

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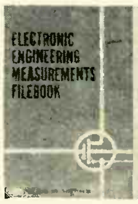

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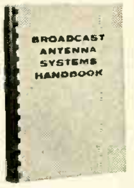

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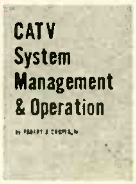

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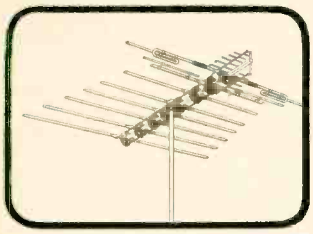
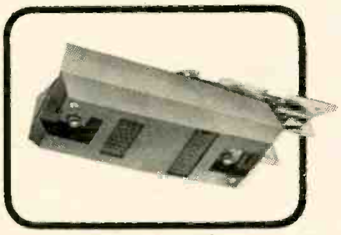


Outdoor antennas



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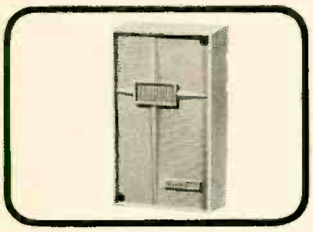

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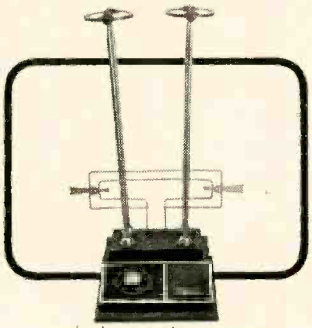

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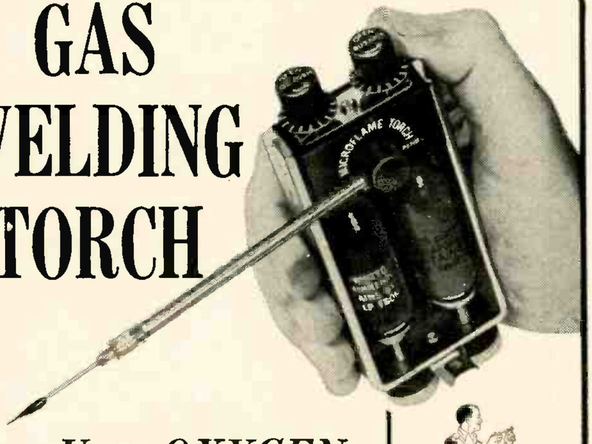

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Circle 119 on reader's service card

EQUIPMENT REPORT

(continued from page 70)

hours of useful life. (Of course, current varied with volume setting.)

Then I ran battery 4 several hours per day in the radio, and recharged it equal time with the PNP-10. Out to 50 hours battery voltage remained constant at 8.0. After that. it would drop after a few hours of use, and I had to limit playing time to about 5 hours—followed by recharging. Otherwise the voltage might have fallen so far the battery couldn't be recharged. I reached the point of no return at about 200 hours, when the battery died. I got similar life from batteries 5 and 6.

I paid $1.31 for a TR-146X. Without recharging, each battery lasted 46 hours for a cost of 2.86 cents per hour. With recharging, life was 200 hours, for a cost of 0.655 cent per hour.

I pay 4 cents per kilowatt-hour to the power company and, allowing for 50% charging efficiency, the PNP-10 probably doesn't draw more than 0.2 watt. Hence I paid all of .0008 cent per hour for the current the recharger drew. To recharge a TR-146X for 200 hours costs $0.0016, which you can just about forget.

The actual battery cost had thereby dropped 1/5—from $1.31 to $0.26—for a saving of $1.05 on each battery. Considering the PNP-10 cost, I figure that after using and recharging 6 batteries the device will have paid for itself.

Of course, if you want to run your radio off the ac line exclusively, your battery life will equal shelf life. And the cost of the ac will never break you!

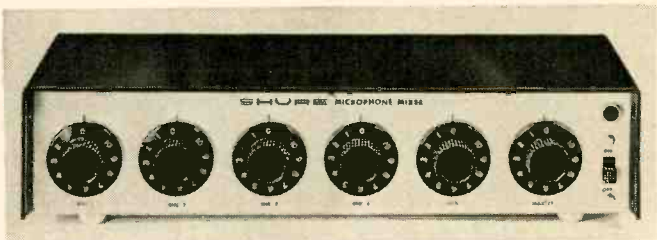
I didn't try zinc-carbon cells, so I don't know what savings you'd get with them.—*Thomas R. Haskett*

Price: $5.95

Shure M68 Microphone Mixer

Circle 21 on reader's service card

THIS EXCELLENT MIXER FOR PUBLIC ADDRESS AND SERIOUS amateur recording work meets or exceeds all its specs. I found distortion at rated output somewhat lower than specified: 0.2% for 1 volt output into high impedance at 1 kHz, rising to 0.4% at 20 kHz, and to 1% at 3.5 volts, 1 kHz. This last figure was measured with 50 mV input—roughly a hundred times the voltage produced by a low-impedance mike.



The M68 has four mike-input channels, all switchable from high-impedance unbalanced to low-impedance balanced or unbalanced with a tamper-resistant switch over each input connector on the back. All mike connectors are male Cannon XLR-3-14's, the three-prong positive-locking types used in almost all broadcast and recording studios.

An additional input accepts signals at a slightly higher

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level, from a tuner or tape or phono preamp. Its input impedance is fixed at 50,000 ohms. (The input may be somewhat too sensitive for many applications, but that can be taken care of by inserting an extra resistor of 150,000 or so ohms in series with the input right at the jack.)

Control interaction was low enough, I found, for noncritical speech or music mixing. With any one control at midposition, turning any other control from zero to full on produced a 1-dB drop in output. Interaction is worst at low settings of each control, and decreases as the control is turned up.

Three kinds of output are available from the M68. The output Cannon connector can be switched to produce an average output of about a millivolt for feeding to the low-impedance mike input of a recorder or console. The same connector can be switched for unbalanced high-impedance feed (typically about 20 mV) for the high-impedance mike input of a recorder or amplifier.

Third, an ordinary phono jack provides a level on the order of a volt or two for feeding "high-level," "line" or "auxiliary" inputs of recorders or amplifiers. This output can also be connected to the auxiliary input of another M68, giving a stacked mixer good for eight microphone channels and one high-level auxiliary input.

The noise level of the M68 is low enough for all PA work, and for all but highly critical serious recording. The mixing circuitry is relatively conventional. Each mike input, after going through a matching transformer, is amplified by one transistor, which feeds a current-divided mixer control through an isolation resistor (to reduce interaction).

The controlled outputs are "collected" along a mixing bus. The AUX input feeds the bus directly, unamplified, through a 47,000-ohm resistor. A two-transistor amplifier feeds the outputs, via the MASTER gain control.

The M68 is about as small as it can be made without making the knobs too small to get hold of. Professionals who are accustomed to 2- and 3-inch knobs are going to be annoyed with these, but most people will find the compactness of the M68 a joy.

It's pretty rugged inside and out, and should take quite a bit of banging around in the back of a sound truck. Nothing about the unit is delicate. Inside, all transistors, resistors and capacitors are rigidly mounted to terminal strips. The channel-form chassis and its cover brace each other when assembled.

A device like this should never need servicing, but if it does, everything is instantly accessible by removing the cover (four screws).

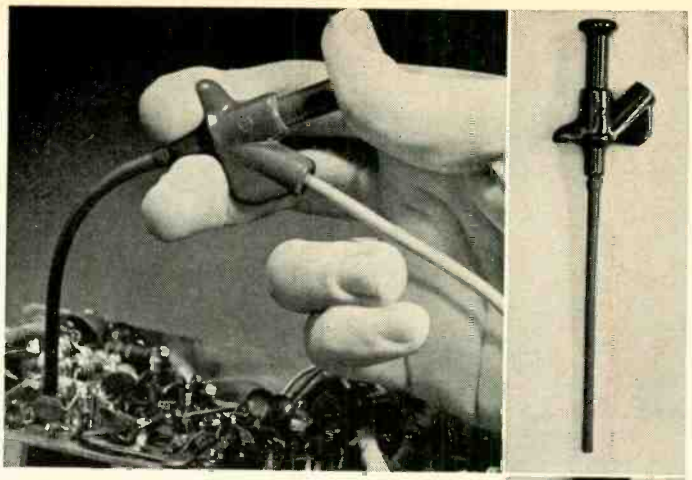
Finally, the M68 can be powered from the ac line (built-in transformer power supply) or from an external 22- to 28-volt supply. An export model, the M68-2, offers a choice of 155- or 230-volt power-line inputs.

A lab prototype of this unit which I saw about a year and a half ago had a steel cover that fitted over the control panel and could be padlocked in place. This production model doesn't have that. It seemed a good idea, since the mixer then becomes quite safe for unsupervised operation. The controls can be set by the sound man, then locked behind the cover beyond the reach of people of the twiddling kind. Perhaps Shure will decide to make such a cover available as an option.—*Peter E. Sutheim*

MANUFACTURER'S SPECIFICATIONS

Frequency response: ±2 dB, 30 to 20,000 Hz
Hum, noise: 70 dB below rated output
Equivalent input noise: 123 dB below 1 volt, 150-ohm source
Output clipping levels: 60mV at low-Z mic. output; 850 mV at hi-Z mike. output; 4 volts at AUX hi-Z output
Distortion: less than 1% total harmonics when low-Z mic output is 20 mV, hi-Z mike output is 200 mV, AUX output is 2 V.
Weight: 4 lb
Price: $75.00

R-E



Clever Kleps 30

Push the plunger. A spring-steel forked tongue spreads out. Like this ☞ Hang it onto a wire or terminal, let go the plunger, and Kleps 30 holds tight. Bend it, pull it, let it carry dc, sine waves, pulses to 5,000 volts peak. Not a chance of a short. The other end takes a banana plug or a bare wire test lead. Slip on a bit of shield braid to make a shielded probe. What more could you want in a test probe?

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20,000 Ω/v DC sens. 10,000 Ω/v AC sens. 4½", 40μa meter. High impact bakelite case. 5 DC voltage ranges: 0-6-60-300-600-3000v. 5 AC voltage ranges: 0-12-120-600-1200-3000v. 3 DC current ranges 0-6-60-600ma. 3 AC current ranges: 0-30-300ma; 0-3A. 3 resistance ranges: 0-20K, -200K,-20 megs. 5 db ranges: −4 to +67db. With carrying strap. 5¼" W x 6¾" H x 2⅞" D.

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Model 103A Factory Wired & Tested **$20.75**
Model 103AK Easy-to-Assemble Kit **$16.80**
4½", 2% accurate, 800μa D'Arsonval type meter. One zero adjustment for both resistance ranges. High impact bakelite case. 5 AC voltage ranges: 0-12-120-600-1200-3000v. 5 DC voltage ranges: 0-6-60-300-600-3000v. 5 db ranges: −4 to +64db. 5 AC current ranges: 0-30-150-600ma. 4 DC current ranges: 0-6-30-120ma; 0-1.2A. 2 resistance ranges: 0-1K, 0-1 meg. 5¼" W x 6¾" H x 2⅞" D.

POCKET SIZE VOLOMETER
Model 102A
Factory Wired & Tested **$16.95**
Model 102AK Easy-to-Assemble Kit **$14.40**
3½", 2% accurate 800μa D'Arsonval type meter. One zero adj. for both res. ranges. High impact bakelite case. 5 AC voltage ranges: 0-12-120-600-1200-3000v. 5 DC voltage ranges: 0-6-60-300-600-3000v. 3 AC current ranges: 0-30-150-600ma. 4 DC current ranges: 0-6-30-130ma; 0-1.2A. Resistance: 0-1K, 0-1 meg. 3¾" W x 6¼" H x 2" D.

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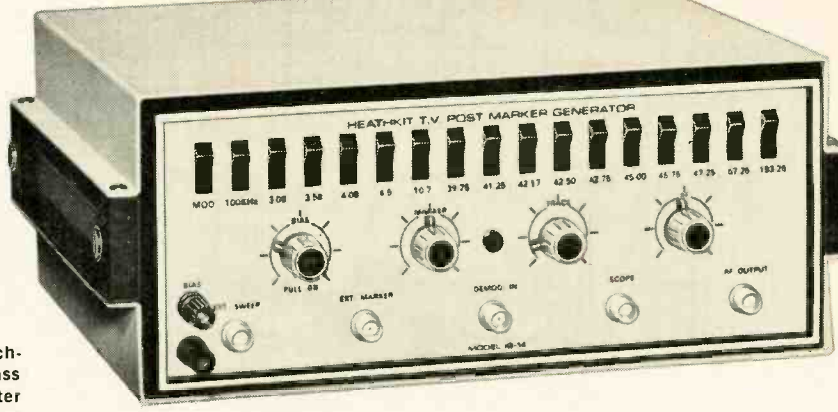
8 NEW KIT IDEAS FROM HEATH . . .

Attention TV Servicemen! Introducing The All New Heathkit Solid-State Crystal-Controlled Post Marker Generator . . . The Most Important Instrument You Can Own For Color TV And FM Alignment . . . Now At A Fraction Of The Usual Cost



IG-14
$99.95
no money dn., $10 mo.

• 15 crystal-controlled marker frequencies • Switch-select picture and sound IF frequencies, color bandpass and trap frequencies, 6 dB points, plus FM IF center frequency and 100 kHz points • Use up to six markers simultaneously for faster TV alignment • Birdie-type markers • Trace and Marker amplifiers and size controls • 400 Hz modulator • Variable bias supply • All solid-state, 22 transistors, 4 diodes • Circuit boards

Fast, Accurate Color Alignment. Speed and accuracy are important in today's service work . . . important to your customers, important to your profits. Speed and accuracy are what the new Heathkit IG-14 gives you . . . plus features usually costing five to ten times as much.

Just Push A Button. That's all it takes to set a frequency . . . no dial to twiddle, no searching, no resetting problems. Fifteen switch selected crystal-controlled markers. Nothing could be easier or more accurate. The IG-14 has input and output connections so that it can be used with any sweep generator and scope. Also an external marker input. BNC connectors are used throughout.

No Trace Distortion. One of the big values to using a post marker generator like the IG-14 is that markers are injected after the sweep signal passes through the set being tested, thereby eliminating the 'scope trace distortion usually found when injection or absorption type marker generators are used.

Crystal-Controlled Markers For Any TV Alignment Task. Four marker frequencies are provided for setting color bandpass, one marker for TV sound, eight at the IF frequencies between 39.75 and 47.25 MHz, and markers for channel 4 and channel 10 picture and sound carriers for checking tuner RF response. With the ability to use up to six markers at once, such as picture and color carriers at 6 dB points, corner marker and trap frequencies, alignment is fast and precise. Trap alignment is just a matter of selecting the appropriate trap frequency, applying the 400 Hz modulation, and tuning the trap for minimum audio on a scope or meter.

Easy FM IF and Discriminator Alignment. The IG-14 provides *visible* markers at the 10.7 MHz center frequency plus 100 kHz markers on each side . . . visible because they are applied to the trace after detection and so are not attenuated by the discriminator. Use of harmonics, fully explained in the manual, provide tracking markers as well.

Trace and Marker Amplitude Controls . . . on the front panel permit using a regular service type 'scope instead of a wide-band, ultra-sensitive model . . . and stage by stage alignment is easier.

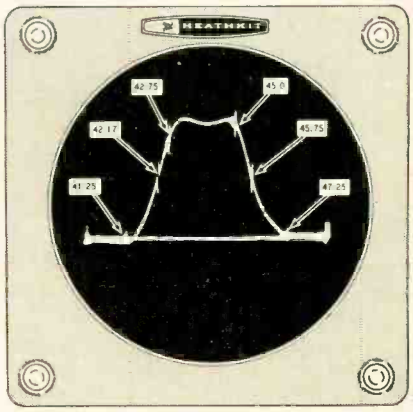
Variable Bias Supply . . . 0 to 15 VDC @ 10 milliamps is isolated from chassis so you can use positive or negative bias.

New Look . . . Circuit Board Construction. Handsome low profile, "stackable" cabinets in the new look of Heath instruments . . . finished in beige and black. Easy-to-build layout with two circuit boards.

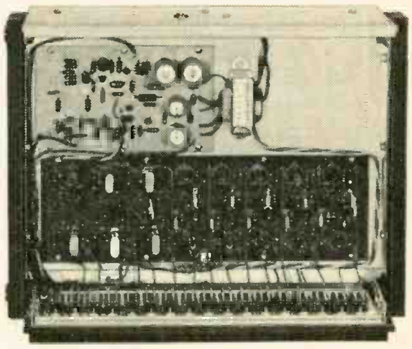
Save Hundreds of Dollars. Until now, an instrument with these features cost much more. Order the IG-14 now . . . it's the best investment in alignment facilities you can make.

Kit IG-14, 8 lbs., no money dn., $10 mo. **$99.95**

IG-14 SPECIFICATIONS—Crystal Marker Frequencies: 3.08, 3.58, 4.08, 4.5, and 10.7 MHz @ .01%; 39.750, 41.250, 42.170, 42.500, 42.750, 45.000, 45.750, 47.250, 67.250, and 193.250 MHz @ .005%. **FM Bandwidth Marker:** 100 kHz. **Modulation:** 400 Hz. **Input Impedance:** External sweep, 75 ohm; External marker, 75 ohm; Demodulation input, 220K ohm. **Output Impedance:** RF output, 75 ohm; Scope output, 22K ohm. **Bias Output Voltage:** Variable from 0 to 15 VDC @ 10 MA. Isolated from chassis for either negative or positive bias. **Type of Marker:** "Birdie." **Controls:** Bias voltage with AC on/off; Trace size; Marker amplitude; RF output; Modulation on/off; Markers, individual switches for each frequency. **Semiconductors:** Transistors: (16) 2N3692; (6) 2N3395; (3) Silicon diodes; (1) Zener diode, 13.6-V. **Power requirements:** 105-125 volts, 50/60 Hz AC @ 7.5 watts. **Net weight:** 8 lbs.



SIX MARKERS SIMULTANEOUSLY. The scope trace above shows how six markers can appear at the same time. Note the trap markers, 6 dB points, and picture and sound carriers . . . all on one trace with the IG-14.



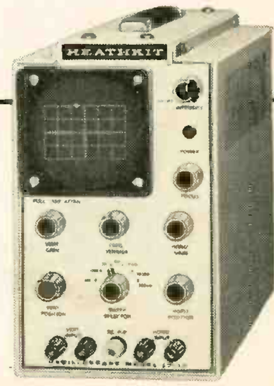
EASY TO BUILD. Note how everything except the front panel switches and controls mount on two circuit boards . . . even the crystals.

NEW Heathkit 5 MHz 3" Compact 'Scope – Only $79.95

Destined To Set The Value Pace . . . the new Heathkit IO-17 with its superior response and sensitivity, professional features, compactness, handsome new styling, and low cost . . . will find its way into shops and labs the world over. It's your best wide-band 'scope buy!

Kit IO-17, 17 lbs., no money dn., $8 mo. **$79.95**

IO-17 SPECIFICATIONS — VERTICAL CHANNEL: Input impedance: 1 megohm shunted by 25 pF; x50 attenuator position 1 megohm shunted by 15 pF. **Sensitivity:** 30mV P-P/div. (uncalibrated). **Frequency response:** 5 Hz to 5 MHz ±3 dB. **HORIZONTAL CHANNEL: Input impedance:** 10 megohm shunted by 15 pF. **Sensitivity:** 300 mV P-P/div. **Frequency response:** 2Hz to 300 kHz ±3 dB. **HORIZONTAL SWEEP GENERATOR: Sweep generator:** Recurrent type. **Frequency:** 20 Hz to 200 kHz in four overlapping ranges. **Retrace:** Blanked by a pulse from blanking amplifier. **Synchronization:** Automatic type. **GENERAL: Tube complement:** (1) 3RPI cathode ray tube, medium persistance, green trace; (3) 12AU7; (1) 12AX7; (1) 6GHB; (1) 6BH6; (1) 6BQ7. **Power requirements:** 105-125 volts 50/60 Hz or 210-250 volts 50/60 Hz. **Power consumption:** 60 watts. **Overall dimension:** 9½" H x 5½" W x 14⅛" L. (Dimensions include handle, knobs, etc.). **Net weight: 12 lbs.**



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

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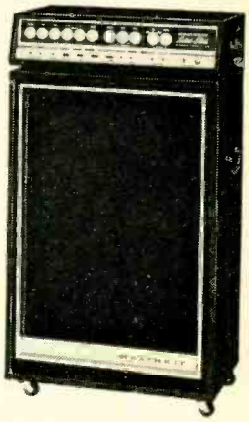

All the "big sound" features every combo wants . . . tremolo, built-in "fuzz", brightness, reverb, separate bass and treble boost and more. Delivers a shattering 120 watts EIA music power (240 watts peak power) through two TA-17-1 speakers . . . or 90 watts through one TA-17-1 speaker. Features 3 independent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

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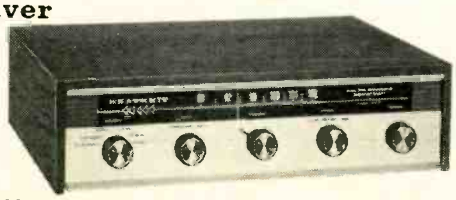
NEW! Lowest Cost Solid-State Stereo Receiver

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



Features wide 18-60,000 Hz response @ ±1 db at full 5 watts RMS power per channel . . . 14 watts music power . . . inputs for phono and auxiliary . . . automatic stereo indicator . . . outputs for 4 thru 16 ohm speakers . . . adjustable phase for best stereo . . . flywheel tuning . . . and compact 9¾" D. x 2⅞" H. x 11¾" W. size. 12 lbs. Optional factory assembled cabinets (walnut $7.95, beige metal $3.50).

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Professional 10-Band Shortwave Receiver

Kit SB-310
$249
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Covers 49, 41, 31, 25, 19 & 16 meter shortwave . . . 80, 40 & 20 meter ham . . . 11 meter CB Includes 5 kHz crystal filter for AM, SSB and CW listening. Features selectivity that slices stations down to last kHz; 11-tube circuit; crystal-controlled front-end and more. 20 lbs. SB-600 8 ohm 6" x 9" speaker in matching cabinet $18.95.

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

Kit IM-17
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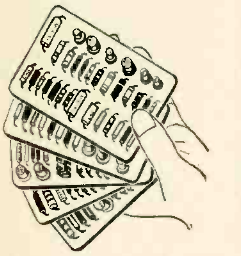

COMPUTER BOARDS from IBM. Ten boards have over 35 transistors, plus over 135 parts as diodes, caps., resistors, chokes. 10 for $1.00 . . . CLOCK MOVEMENTS: *Westclox* 115 VAC includes *Auto-on-off*, also doze light, complete with face and clock hands (no case) $2.25 . . . TELECHRON, complete with face and clock hands, includes *on-off-auto* and *sleep-switch* $2.30 . . . WESTCLOX *Cordless Alarm Clock*, battery operated, in high impact, white case 5" long, 3" wide x 3" high. Shatterproof crystal, clear bell alarm, *7 Jewels* quiet tick, sweep alarm indicator, raised gold numerals, padded base. Operates *one year* on "C" flashlight battery. Regular 90 day factory guarantee by Westclox $8.45 . . . TRANSISTORS: RCA 2N404, Syl. 2N229, UST 2N43A, UST 2N44 & IBM 015 (PNP-40 MHz) each 25¢ . . . SPEAKERS, Jap. 2"—2½" diam., 8 or 40 ohm, includes safety screen to protect cone 50¢ . . . HARNESS Battery Cable and clips for 9 V. Battery, 10¢ ea. $1 doz. . . . 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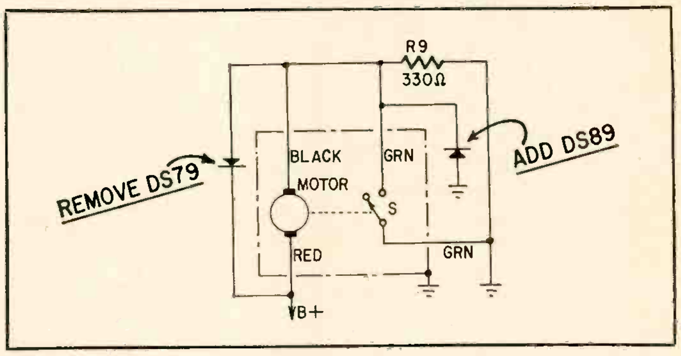
TECHNOTES

MOTORS IN AUTO TAPE PLAYERS



A slow tape-player motor doesn't necessarily have to be replaced. If it runs slow at 10.5 volts but is OK at 14.5, don't replace it. Cure it this way (see diagram).

1. Remove diode DS79, shunting the motor.
2. Operate the player on 16 volts dc for 5 to 15 minutes. (Applying 16 volts with spike suppressor diode DS79 removed cleans the contact points.)
3. Check the player operation periodically by listening to a tone such as Program 2 on the Delco test tape and applying between 10.5 and 16 volts. The contacts are clean when the tone is constant as the voltage is varied.
4. Install a 24-volt Zener diode (DS89). The Zener diode provides "point-cleaning" voltage and permits the player to operate at lower voltages.

(Note well that this repair is not required on all tape-player motors.)—*Delco Testing Tips* **R-E**

COLOR TV AGC ADJUSTMENTS

Always readjust the AGC control after installing or repairing a color TV set. You must make this adjustment while receiving the strongest station on the customer's antenna. Improperly adjusted AGC can cause poor sync, overloading, insufficient contrast, sync buzz or horizontal pulling and results in complaints and callbacks. The correct procedure for adjusting the AGC control is:

1) Turn set on and warm up for 5 minutes.
2) Tune in strongest station in the area.
3) Turn CONTRAST control fully clockwise and turn BRIGHTNESS control clockwise until picture is bright but not blooming.
4) Slowly turn the AGC control counterclockwise just to the point where the picture weakens and begins to lose contrast.
5) Adjust vertical and horizontal hold controls for a steady picture. Vertical lines must not bend at the top.
6) Turn the AGC control clockwise very slowly until the picture bends, tears or shifts or until buzz is heard in the sound. Then, turn the control counterclockwise slowly until bending, tearing, shifting and buzz stop.
7) Turn the control an additional 10 degrees counterclockwise.
8) Check the picture at maximum contrast on all channels. Picture should not overload and should reappear immediately after changing channels.—*Admiral Service News Letter* **R-E**

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Solid-State TV Servicing

(continued from page 37)

regulator (preregulator) and 14.5 at the base of the upper regulator.

Note the extremely high capacitance of the filter capacitor at the output of the rectifiers. A 3000-μF capacitor is used, and an additional 800 at the output of the supply. These assure substantially ripple-free dc for minimum hum transistor operation. In some receivers, transistors are used in ripple-filter networks to permit use of lower-value capacitors.

The circuit used in the Sears-Silvertone model 7122 solid-state receiver is shown in Fig. 9. Any ripple

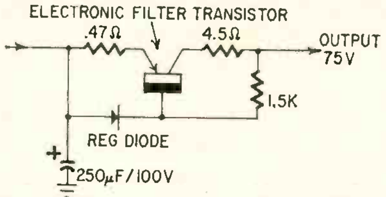

Fig. 9—The value of filter capacitor is multiplied by transistor current gain.

voltage behaves as a signal input to the base–emitter junction of the filter transistor. The collector signal that develops is out of phase with the input signal. This out-of-phase signal is applied to the output line and partially cancels the ripple from the rectifier.

Excessive ripple in the power supply will produce hum from the speaker (even with the volume control turned down) as well as hum bars on the screen. If such symptoms appear in a solid-state TV set, make sure you check filter transistors and regulator circuits in addition to the usual filter capacitors.

Standard precautions

When working on transistor sets, keep in mind the standard precautions for all circuit testing. If you are using probes with the set turned on, watch out for possible shorting of transistor collector to base by the probe tip. Avoid temporary shorting of low or high voltages. Don't shunt in-circuit capacitors with test external capacitors while the power is on.

Keep the yoke connected all the time the set is in operation to prevent damage to the sweep output transistors. (This also applies to the speaker—keep it in the circuit whenever the set is turned on.)

As a final "don't"—don't believe the old adage that rules are made to be broken. If you don't follow the rules in solid-state TV servicing you might end up with more damaged components than you had when you began. Respect transistors and other solid-state devices. They are physically rugged, yet electronically delicate. **R-E**



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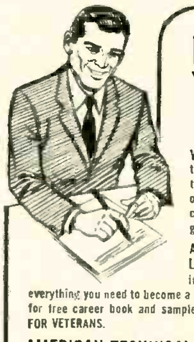

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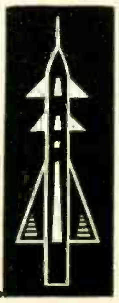

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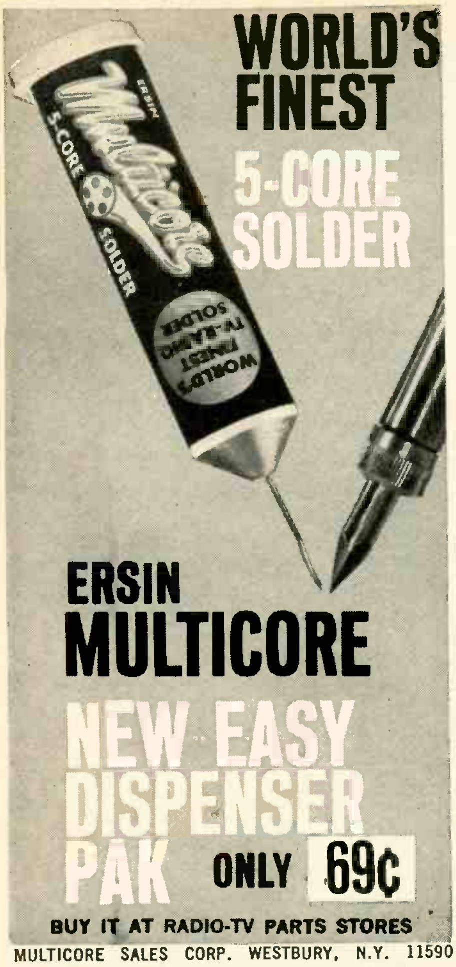

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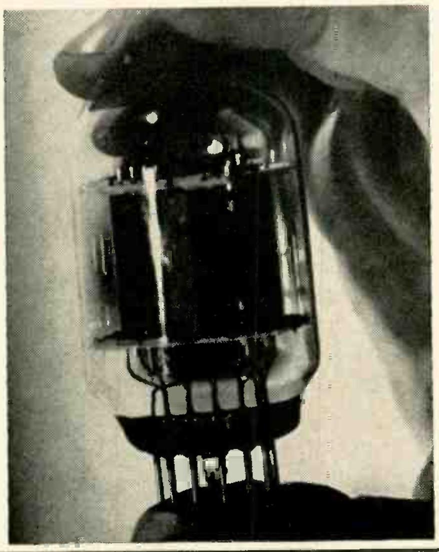

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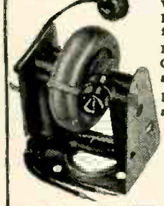

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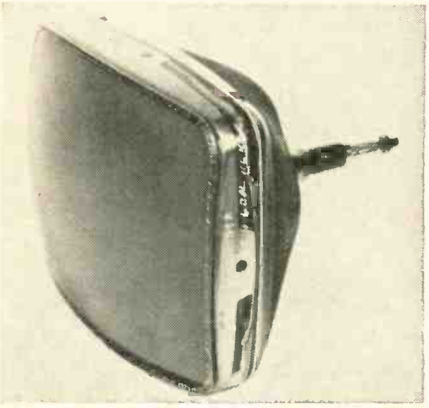
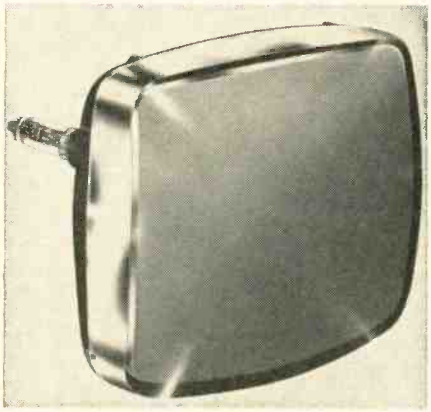
integral faceplate and requires a separate safety glass as implosion protection. Further details on these two



tubes can be obtained from Westinghouse Electronic Tube Division, Elmira, N.Y. 14902.

The 15LP22 (right) is an RCA 14-inch diagonal 90° color picture tube featuring improved rare-earth



red phosphor material and sulfide red and green phosphors to provide equal cathode currents. An added feature is the einzel-lens focusing system (see "How We See Color", January 1966, page 35) that eliminates the need for a separate focus rectifier. The tube is designed for operation with the blue gun down (anode contact on top) to provide the best freedom from pincushion distortion. **R-E**

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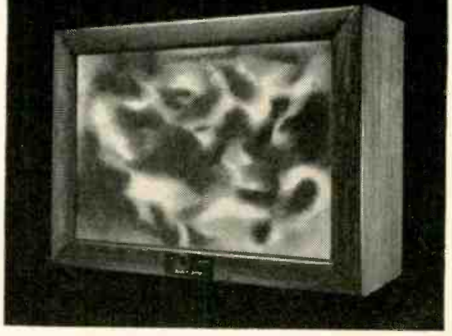

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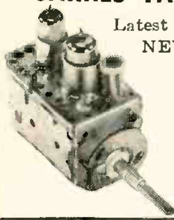

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7"	— 1800'	.99
7"	— 2400'	1.59
7"	— 3600'	2.97
CASSETTE 1 hr		1.00

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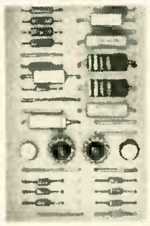

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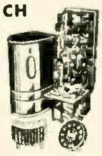

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NOTEWORTHY CIRCUITS

FUZZ BOX FOR ELECTRIC GUITARS

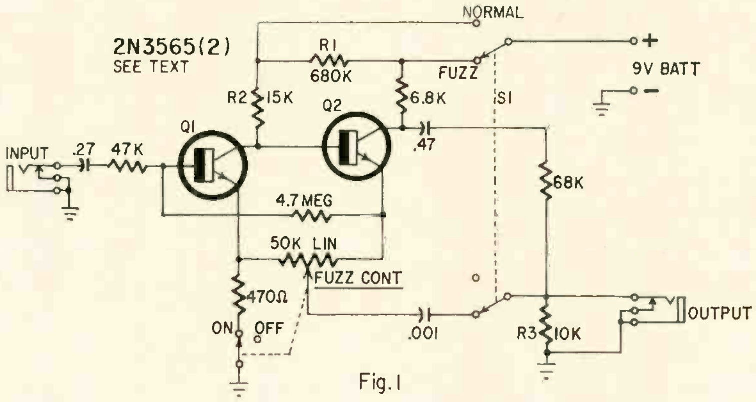
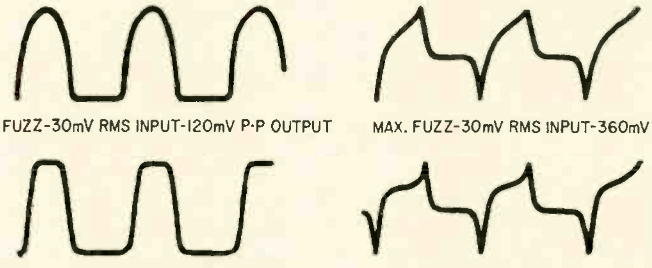


Fig. 1



MIN. FUZZ-30mV RMS INPUT-120mV P-P OUTPUT

MAX. FUZZ-30mV RMS INPUT-360mV P-P OUTPUT

MIN. FUZZ-60mV RMS INPUT-120mV P-P OUTPUT

MAX. FUZZ-60mV RMS INPUT-520mV P-P OUTPUT

Fig. 2

A number of readers have asked for the circuit of a "fuzz box"—a device used with electric guitars to produce strident tones similar to some reed instruments. Generally, fuzz tones are produced by clipping the positive and negative peaks of the signal waveform. This generates multiple harmonics which intermodulate the original tone to give it the distinctive "fuzz".

The diagram in Fig. 1, taken from *Electronics Australia,* shows a fuzz box designed to be connected between the guitar and the amplifier input. The circuit consists of a pair of 2N3565 (Raytheon) or MPS6514 (Motorola) npn transistors connected as a direct-coupled amplifier.

When switch S1 is in the FUZZ position, Q1's load resistor consists of R1 and R2 in series. With this value of collector load resistance and forward bias, the first stage is near current saturation. The base of Q2 is direct-coupled to Q1's collector so it is held near cutoff. The positive peaks of the incoming signal are clipped by Q1 as it is driven to saturation. The negative peaks are clipped as Q2 is driven to cutoff. This results in out-of-phase square waves appearing at the collector and emitter of Q2.

The high-frequency components of the distorted signal at the emitter are taken off through the .001 μF capacitor and added to the signal from the collector appearing across output resistor R3. This produces an output waveform with spikes on the trailing edges of each square wave. The FUZZ control determines the amount of the emitter signal that is fed to the output. Fig. 2 shows the waveforms available.

When S1 is in the NORMAL position, R1 is switched to the collector load of Q2, the emitter-signal circuit is disconnected and both transistors operate as linear amplifiers. Circuit gain is about 1.5 for both modes of operation.

The original unit was built into a small metal box which resembles a sloping-panel meter case laid on its back. The foot-operated FUZZ–NORMAL switch—a heavy-duty d.p.d.t. pushbutton type—is mounted on the sloping surface that rests under the player's foot. The ON–OFF switch is on the top, and input and output jacks are on the rear.

You can also construct the fuzz box on a small circuit board and mount it on the body of the guitar. **R-E**

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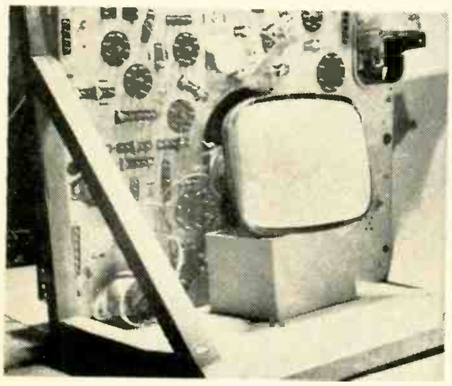
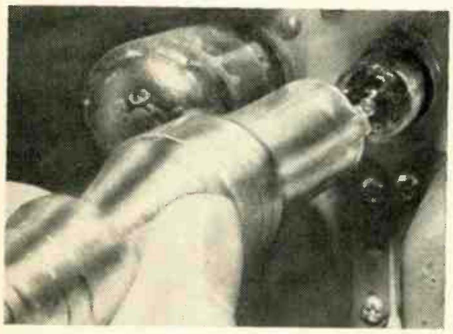
Many vertical TV chassis are difficult to hold upright for repairing. From wood, construct a large "L" bracket and platform. The TV chassis rests against the "L" bracket and on the



wooden platform. A small CRT can be plugged in and the chassis can be checked from either side. Not only is it easy to check voltages and locate defective parts, but small parts will not be bumped and accidently broken by laying the chassis down.—*Homer L. Davidson*

TUBE PULLER PULLS SHIELDS

A 9-pin tube puller fits a 7-pin tube *shield!* This can be useful when you work with crowded aircraft equipment, where the shield is almost as hard to re-



move as the tube. I have tried a 9-pin puller on various types of 7-pin shields, and it fits them all. This idea is handy for radio and TV sets too. When replacing a shield with the puller, it is necessary only to twist the puller to remove it from the shield.—*Robert E. Kelland* **R-E**

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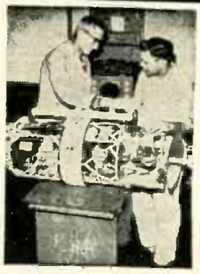
Circle 130 on reader's service card

1968 Consumer Electronics Show has been scheduled for June 23 to 26 in New York City. Exposition will include new exhibits from manufacturers of television, radio, phonographs, magnetic tape gear, and accessories for these products.

Show will occupy space in four hotels in New York—Americana, City Squire Motor Inn, New York Hilton, and Warwick Hotel.

ELECTRONICS



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• Obsolete Tubes: #UX200, $1.69; #80, $1.20; #10Y, 69¢ etc.

• 7 inch 90 degree TV bench test Picture Tube with adapter. No ion trap needed. Cat. #7BP7, $6.99.

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• OZ4 Silicon Rectifier replacement, octal based. Cat. # Rect 2, 99¢ each.

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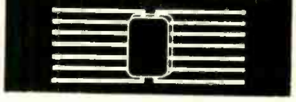

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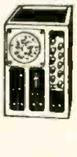

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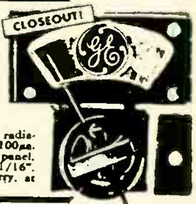

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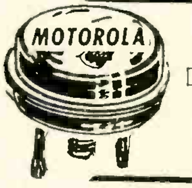

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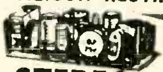
☐ **3 for $1**

PNP 100Watt/15 Amp HIPower TO36 Case! 2N441, 442, 277, 278, DS501 up to 50 Volts

G.E. 1 AMP MICROMINIATURE SILICON RECTIFIERS

PIV	Sale	PIV	Sale
50	☐ 5¢	600	☐ 19c
100	☐ 7¢	800	☐ 27c
200	☐ 9¢	1000	☐ 39c
400	☐ 13¢		



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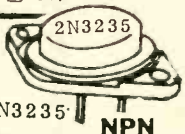
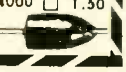
- ★ Ready to Play thru tape Amplifier, radio, TV
- ★ Volume, Tone, Controls sw



2N3235 NPN SILICON
(Watts) 115
BV_{CBO} 100
(AMP) 15
$2.25

1 AMP TOP HAT AND EPOXIES

PIV	Sale	PIV	Sale	PIV	Sale
50	☐ 5¢	800	☐ 21¢	1800	☐ 75¢
100	☐ 6¢	1000	☐ 32¢	2000	☐ 1.10
200	☐ 8¢	1200	☐ 45¢	4000	☐ 1.50
400	☐ 11¢	1400	☐ 55¢		
600	☐ 17¢	1600	☐ 65¢		



TERMS: add postage Rated, net 30 days. CODs 25%

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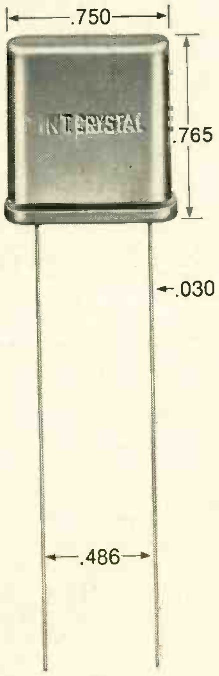
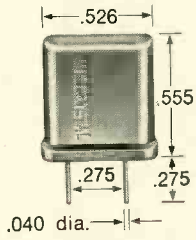
70 KHz to 160 MHz

HOLDER TYPES

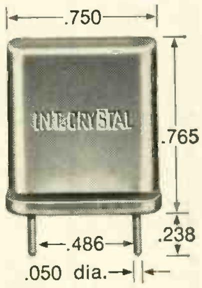


F-700

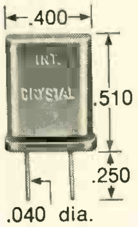
F-609



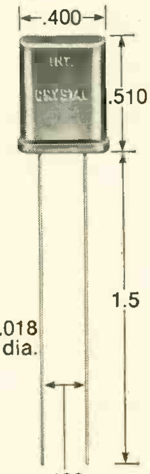
FI-4



F-605



FM-2



FM-1

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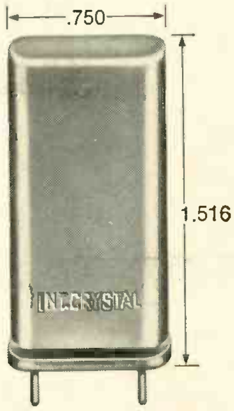

F-13

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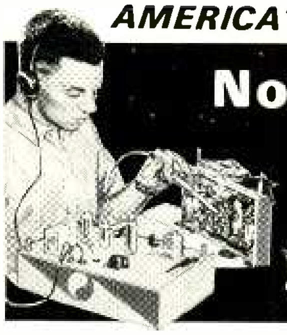

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AMAZING KIT-A-MONTH CLUB

You Get ALL the following in nine monthly kits!

NO EXPERIENCE NECESSARY
Everyone will enjoy the easy-to-use equipment and exciting, learn-by-doing courses. It's easy — it's fun!

DEVELOPED BY TOP SCIENTISTS
The ABSClub program is a real science course developed with world famous Southwest Research Institute — a non-profit public service organization, nationally recognized as the center of scientific research in the Southwest.

EQUIPMENT IS GOOD QUALITY
These kits are not toys. They consist of standard components by Centralab, General Electric, Strobelite, Leviton, Precision Tube, Cinch-Jones, Mallory, Lancaster Lens, General Instrument, Trim, RCA, Stackpole, Eastman Kodak and other reliable manufacturers.

NO SPECIAL TOOLS REQUIRED
All you need are a screwdriver and pliers. You get an electric soldering iron FREE with your second kit. Also included: hardware, solder, wire, etc.

FUN FOR THE WHOLE FAMILY
This program offers such a variety of activities that every member of the family can find a field of interest. In many homes, working with the kits is a family affair enjoyed by all.

INVALUABLE FOR STUDENTS
Makes school science fascinating and easy. Gives students a real head start. The kits are a valuable source of ideas and equipment for school projects.

MONTHLY CLUB BULLETIN
The $1 membership fee covers a year's subscription to the ABSClub Bulletin which carries news of interest to members, plus ideas submitted by members for additional projects with the kits.

ELECTRICAL LAB
All the equipment for basic electrical experiments with **Wheatstone Bridge** (measures resistance), **Magnetizer** and **De-magnetizer, Thermocouple, Mystery Shock Box, Continuity Tester, Extinction Voltmeter, Solenoid Coin Tosser, Electromagnetic Relay, Neon Lamp, Galvanometer, Induction Coil, Resistors,** Chemicals and Electrodes for Plating and Electrolysis. **FOR SAFETY** a step down **Isolation** Transformer provides required current.

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YOU BUILD A SHORTWAVE AND BROADCAST RADIO. 3 tube regenerative [illegible] **CARBON MICROPHONE** [illegible] **AUDIO AMPLIFIER. RADIO TRANSMITTER** for code or voice. **RIPPLE TANK WAVE GENERATOR** with variable frequency. [illegible] **CODE PRACTICE OSCILLATOR** with manual **"Steps to a Ham License."** All you need to pass the FCC Ham License Exam.

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ATOMIC CLOUD CHAMBER WITH PROJECTOR ILLUMINATOR. See the vapor trails of alpha and beta particles, and of cosmic rays. **SPINTHARISCOPE.** Shows exploding atoms. **ELECTROSCOPE** — metal housed with **Scale** and **Magnifying Viewer.** Measures background radiation and tests sample sources. **SAFE RADIOACTIVE MATERIALS.** Alpha Source in handy container and Uranium Ore. **Full instructions and explanations open up the fascinating field of nuclear physics.**

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STROBE LIGHT
A **Neon** Lamp that flashes at intervals you can synchronize with the speed of rotating or vibrating objects in order to "freeze" their motion to permit close study and checking frequencies and RPM. Flashes are timed by a variable frequency oscillator with a range of 20 to 600 cycles per second.

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Signal Tracer
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SIGNAL TRACER. [illegible] probe [illegible] **CONTINUITY TESTER.** [illegible] **"Simplified Radio and TV Servicing."**

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Analyze spectra of glowing gases. See and identify the Fraunhofer Lines. A quality instrument featuring an **easy-to-read built-in scale and a powerful condensing system** for a bright spectrum. Equipment includes **Alcohol Burner** and a **2 Watt Neon Spectral Lamp. Full instructions cover theory and use.**

PHOTOELECTRIC RELAY
Crystal Photocell, Electronic Amplifier, Relay, large Condensing Lens in Cabinet Mount. Features automatic on or off or holding circuit operation. Sensitivity Control, Plug-in Outlet for controlled circuit. Use for alarms, counters, etc. Operates on 115V AC. **A basic unit for many exciting experiments.**

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Changes regular 110-120V AC to the direct current required for electronic projects and experiments. [illegible] **Power Transformer, Vacuum Tube Rectifier, 20/20 MFD Capacitator Filter Circuit, and a potentiometer Voltage Selector.** A Safe Isolated Power Supply eliminates the need of expensive multi volt batteries.

ULTRAVIOLET LAMP
140 watt filter type UV LAMP. [illegible] metal cabinet, 6 Foot Cord, Rotary Switch. Produces dazzling color effects with invisible black light. Has many uses in the Fields of Mineralogy, Crime Detection and Science. Accessories include **Invisible Ink, Tracer Powder, Fluorescent Crayons.**

ANALOG COMPUTER
Electronic Computer multiplies, divides, calculates powers, roots. Set up the problem on the scales of two potentiometers and find the answer on the scale of third potentiometer as indicated by a sensitive meter. Instruction Manual covers computer theory and practical use. Over 150 sample problems and answers [illegible] fractions, trigonometry, logarithms, physics formulas, ballistics, etc.

MICROCRAFT LAB
Microprojector shows microscopic subjects enlarged with brilliant detail on wall or screen. Has sturdy Steel Cabinet, large Condensing Lenses for extra brightness [illegible] **Microscope** features Ramsden Eyepiece for wide field viewing, [illegible] **Slides, Cover Glasses** and **Microscopy Manual.**

SURVEYOR'S TRANSIT
A practical Transit. **6X erect image telescope with Range Finder Reticle for measuring remote distances and heights.** Vernier reading for both horizontal and vertical [illegible] Leveling Head with Thumb Screw Adjustment and Spirit Level. Clamps under head hold wooden legs of Tripod (Legs not included.) **Instructions cover elementary surveying, range-finding.**

LIGHT AND OPTICS LAB
Exciting optical projects for the study of light. Equipment includes five **Precision Lenses, Prism, Polarizing Filters, Diffraction Grating, Mirror, Telescoping Tubing, Lens Mounts, Tube Holders and Brackets.** All the parts and instructions to build a Camera Obscura, Camera Lucida, Polariscope, and many other optical devices.

Measuring Wavelength of Light

PHOTOMICROGRAPHY CAMERA
Photographs subjects mounted on microscopic slides. Enlarges up to 100X. Takes clear sharp pictures of specimens too small to be seen with the naked eye. **A fully self-contained unit** [illegible] Uses standard roll film, either 120 or 620, black and white or color. Make a photographic record of your project, with microscopic subjects.

TELESCOPE AND MOUNT
30X erect image. Extends to 30" length. Five ground and polished Lenses. **Ramsden Eyepiece. Sturdy Equatorial Mount** makes it easy to follow the movement of heavenly bodies. Mount [illegible]

PHOTOGRAPHY LAB
A PRECISION 35MM ENLARGER ... horizontal type with twin condensing lenses and 3" F/L projection lens. Produces quality enlargements up to 8"x 10". Contact Print Frame takes negatives up $3\frac{1}{4}$"x$4\frac{1}{4}$". **3 Plastic Developing Trays, Neon Safelight, Tray Thermometer, Film Clips, Developing Chemicals, Printing and Enlarging Paper and Darkroom Handbook.** Make quality enlargements for 6¢. Make prints for only 2¢. Full instructions included.

LIGHT TRANSMITTER-RECEIVER
The **TRANSMITTER** consists of a **Light Source, a Modulating Reflector Diaphragm** and an Optical Projection System. The **RECEIVER** is a **Two-Stage Audio Amplifier,** controlled by a Photoelectric Cell that catches the projected light beam and causes the original sound waves to be reproduced in the headphone.

Talking on a Light Beam

WEATHER STATION
A REMOTE READING ANEMOMETER AND WIND-VANE . . . Flashing Neon Lights on indoor indicator board show wind speed and direction. Operates **on less than 1 cent per month. Safety Power Cord** makes all connections safe. 100 ft. of Lead in Wire. Plus — **Air Tank Barometer** with 4 ft. indicator column. **Sling Psychrometer** measures relative humidity. **Rain Gauge** measures rainfall to 1/100 inch. ALSO Cloud Chart, Weather Map and Forecasting Manual — a complete set up for amateur meteorology.

MEMBERS ARE ENTHUSIASTIC
Over 50,000 members have successfully used and enjoyed these kits. All the projects are proven and practical.

"Every kit is very complete in explanation, illustrations, materials, hardware and extras. This is what I like."
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"I have enjoyed every kit. I wish I could give them to all my students."
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"Hard-to-get equipment at a great price. Thanks to your kits I am enjoying new fields of science."
J. Allemong, White Springs, Illinois.

"I have immensely enjoyed every minute with the kits, and eagerly await the postman every month."
Fred Carter, Sanford, Florida.

"The ABSClub kits are very practical, interesting and educational . . and the projects always work."
Larry Schutts, Eden, New York.

"A wealth of information presented in an easy-to-learn manner."
Tom Webster, Vidor, Texas.

"It is incredible that we can obtain so much material for such a price. The manuals alone are of great value."
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"I am an electronics student in the Air Force. We have not covered anything in school that your kits have not covered."
John G. Dill, Keesler Air Force Base, Biloxi, Miss.

"When I started your program I knew little about any of the topics that you presented. I now am repairing radios and photography is my main hobby."
Bruce Russell, Denver, Colo.

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SEND ONLY **$1.00** TO ENROLL — PAY ONLY **$4.75** FOR EACH KIT THAT YOU RECEIVE

Take as few as you wish—or get all nine . . . it's up to you!

SOME QUESTIONS ANSWERED

Q. How is it possible? It seems incredible to be able to get all the equipment shown above in just nine kits — at only $4.75 per kit!

A. The direct-to-you "no middleman" club plan is just part of the answer. The other key is ABSClub's especially designed multi-use equipment. For example: the Microprojector quickly and easily converts into the Spectroscope, Photo Enlarger and Cloud Chamber Illuminator. Similarly, the Transit doubles as a Telescope Mount. Such multi-purpose design . . . plus club plan economy . . . makes possible this all-science program at a price everyone can afford.

Q. May members choose the order in which they receive their kits?

A. Yes. With the first kit members receive a list of the equipment and projects contained in each of the remaining eight kits. With this information they are able to choose the kit sequence that best suits their particular interest.

Q. Can members get their kits all at once instead of one-a-month?

A. Yes. At any time members can have the balance of their kits sent in one shipment. We recommend that you start on the kit-a-month plan because the monthly spacing will give you time to get the full measure of knowledge and enjoyment that each kit has to offer.

NO EXPERIENCE NECESSARY — IT'S FUN! IT'S EASY!

NO OBLIGATION—NO RISK!

- ★ **$1.00 is the full cost of membership.**
- ★ **You take only as many kits as you wish.**
- ★ **Two weeks approval on each kit you take.**
- ★ **You may return any kit for full refund.**

Send coupon today—get your first kit on its way!

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I wish to try the Kit-a-Month Program:

☐ I enclose $1.00 to enroll and $4.75 for the first kit postpaid.

☐ I enclose $1.00 to enroll. Send first kit COD. I'll pay COD fee.

I understand if I am not satisfied with the first kit I may return it for a complete refund including the $1.00 membership fee.

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