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HOW TO

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Repair a pH Meter

Use a De-Q'er

AUDIO

Build a Crossover Network

Tape Recorder Tips and Techniques

(see page 60)

BUILD

Intermittent Filament Analyzer

BUILD

A Modulation Scope Monitor

(see page 54)

BUILD

IC Crystal Calibrator

(see page 32)

NOW

Measure 0.01 Ohm

(see page 41)

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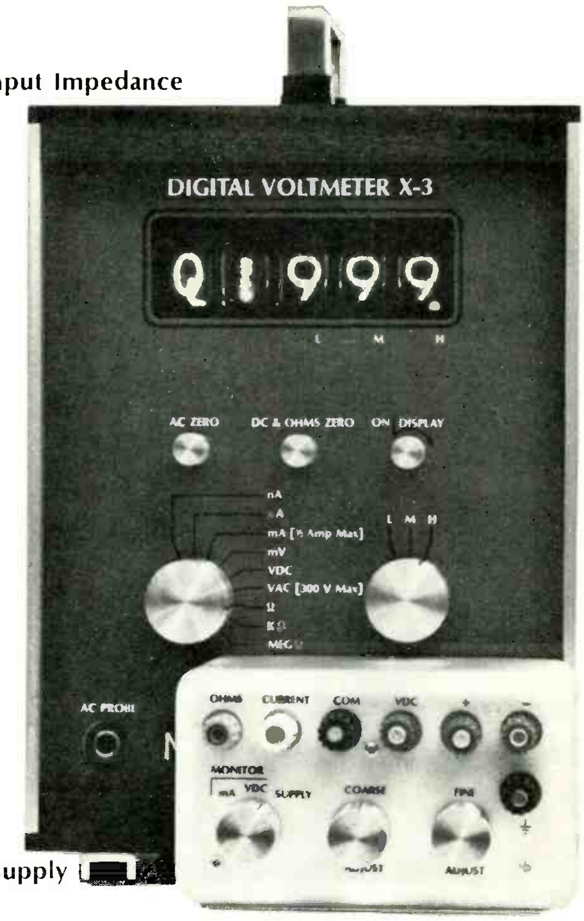

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Circle 7 on reader's service card

NEWS BRIEFS

FUTURE ELECTRET PHONE MIKES?

When Alexander Graham Bell invented the telephone, over 90 years ago, he produced a device which would transmit and receive the human voice. The transmitting function was improved by Thomas A. Edison in 1877 and by Henry Hunnings in 1878, but apart from these changes, the principles of the telephone have remained virtually unaltered to this day.

Meanwhile, the whole concept of a telephone system, of complex switching centers and vast transmission networks, has developed beyond Bell's wildest dreams. Only now does it appear likely that the carbon-granule telephone microphone may be replaced by a more efficient unit.

Researchers at Northern Electric Laboratories in Ottowa, Canada, have developed an experimental microphone using an electret—one of the least understood electronic developments of the past. The new microphone can reduce normal operating current by 90% while offering good quality reproduction. It is perhaps the first practical combination of a prepolarized electret with a semiconductor amplifier, to produce a useful telephone transducer with an attractive life factor.

The new microphone (see photo) consists of a lightweight electret film 0.0003" thick placed in direct contact with a roughened surface of a rigid backplate (to prevent wrinkles and consequent arcing and distortion). The polarized electret film is connected to a 20-dB solid-state amplifier which brings audio output up to line level, and matches the electret high impedance to the line low impedance.

Although an electret microphone can be made with flat frequency response over most of the audio spectrum, it was specifically designed to match the response of the carbon transmitter it replaces. Thus users will detect no difference in speech quality —except that the electret mike has lower noise and distortion levels.

DIODE-AMPLIFIED ANTENNA

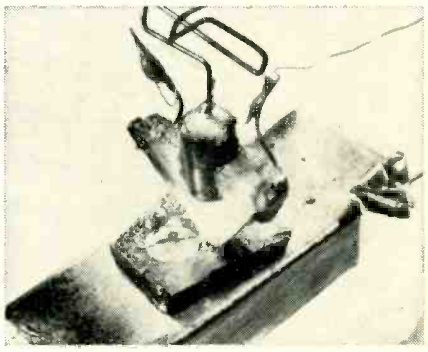
Powered by a single flashlight battery, a new active reflector antenna uses a tunnel-diode amplifier to bounce back a radar signal. It might be used as a tight-security locating beacon for aircraft, and messages may be added to the signal before it is transmitted back to the plane.

As shown in the photo, a metal spiral (antenna) is impressed on a circuit board at one end of a cup-shaped metal housing. Inside the housing are a tunnel diode, a capacitor and a piece of transmission line which resonates the device.

The spiral antenna has a broad-band characteristic that matches the wide frequency range of the negative-resistance mode of the tunnel diode. Thus the radiation resistance of the antenna is effectively cancelled by the tunnel diode, and the transponder has a reflection gain of about 20 dB. The prototype operates at about 8 GHz, but could work anywhere above about 500 MHz, depending on antenna size.

Sylvania engineers developed the new transponder while working on a research and development contract for the U.S. Air Force. Still experimental, the tunnel-diode amplifier is not currently in production.

TRANSISTORS INVENTED 21 YEARS AGO



On the afternoon of Dec. 23, 1947, a group of men at Bell Telephone Laboratories in Murray Hill, N.J., watched a demonstration of a crude device. Made of the element germanium and a few pieces of wire, the device (see photo) amplified a speech signal about 40 times. Thus the solid-state era was born; the crude device was the world's first transistor.

Bell Labs scientists had been interested in the physics of solid-state material for some time. In 1940 a modest research effort was begun, but it was interrupted by World War II. Following the war, a group at Bell Labs turned full time to semiconductor research. They concentrated on the two simplest semiconductors—germanium and silicon. Following one theory, physicist William Shockley proposed a semiconductor amplifier as a test. The device didn't work out as planned, so his colleague, John Bardeen, suggested a revision of the theory. During further experiments, Bardeen and coworker Walter Brattain discovered an entirely new physical phenomenon—the transistor. (It was so named for *trans*fer re*sistor*.)

The first transistor—a point-contact type—was patented by Bardeen and Brattain. (Two pieces of pointed metal make contact with a bar of ger-

(continued on page 44)

Radio-Electronics

March 1968 • Over 55 Years of Electronics Publishing

CONSTRUCTION PROJECTS

IC Crystal Calibrator .... **32** ..... Jack Althouse
Much precision with a few parts

Intermittent Filament Analyzer .... **37** .... Don Anglin
When it blinks, you've found the trouble

VOM Resistance-Scale Divider .... **41** ....J. F. Sterner
Split an ohm reading by a factor of 10

How to Use a DE-Q'er .... **45** .. Leonard E. Geisler
An old trick with a modern twist

FET Field Strength Meter .... **48** ..Lyman E. Greenlee
It's sensitive and tunable

Modulation Scope Monitor .... **54** ..... Robert J. Reed
Help clean the airwaves and improve your signal

SERVICING

In the Shop . . . With Jack .... **22** .... Jack Darr

How to Deal With RF Interference .... **35** .... Tom Jaski
No guarantees, but it should help

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Keep it clean

CB Troubleshooter's Casebook .... **84** .. Andrew J. Mueller
More case histories

AUDIO

Tape Recorder Tips and Techniques .... **60** ...... Earl E. Snader
Get the most out of your sound investment

How To Build A Crossover Network .... **46** . Max H. Applebaum
Nomograph eliminates math work

GENERAL ELECTRONICS

MATV—It's Simple .... **38** .... Eric Leslie
Now, a TV set in every room

Digital Computers At Sea .... **51** .. Clement S. Pepper
Today the world, tomorrow the universe

Bioelectronics and Life .... **57** ..... Allen B. Smith
Man amplifiers, eyeball controls, etc.

Battling Bollworms With Ultrasound .... **69** James A. Gupton, Jr.
Batlike sounds make 'em run for their lives

Horseflies, Tractors and Mr. Kirchhoff ...... **70** .... Wayne Lemons
Vectors count

Equipment Report: Heathkit **67**
Solid-State Vom
Model IM-25

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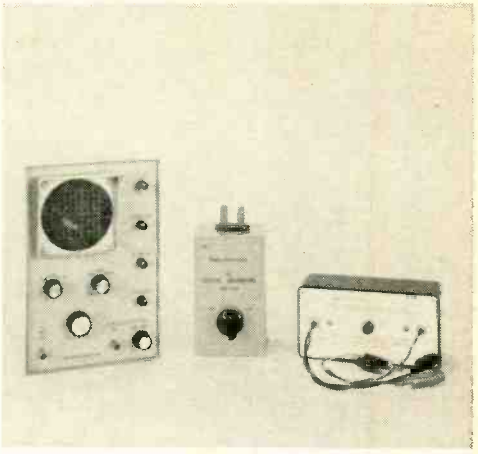
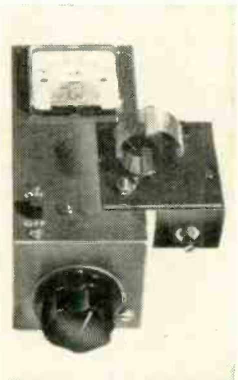


Modulation Scope Monitor has relatively few parts, is easy to build and lets you see your signal's waveform. Simple, low-cost 100 kHz crystal calibrator, useful for troubleshooting and alignment work, has 0.0001% accuracy. With the R-Scale Divider you can check ground connections, switch contacts and other low-resistance devices.

Improve your tape recorder techniques and get more mileage out of your tapes. Norelco's Carry-Corder 150 portable Cassette tape recorder shown here is typical of the newest generation of popular type of battery-operated units. See page 60.



Join the FET set with this sensitive field strength meter. You can tune it to a specific frequency and gauge the output of most any CB, ham or commercial transmitter. See page 48.

RADIO-ELECTRONICS, MARCH 1968, Volume XXXIX, No. 3.
Published monthly by Gernsback Publications, Inc., at Ferry St., Concord, N. H. 03302.
Editorial, Advertising, and Executive offices: 200 Park Ave. S., New York, N. Y. 10003. 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, $6. Pan-American countries, $7. Other countries, $7.50. Single copies: 60c.

POSTMASTER: Notices of undelivered copies (Form 3579) to Boulder, Colo. 80302.

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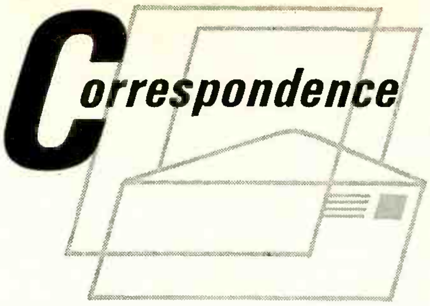
Radio-Electronics is indexed in *Applied Science & Technology Index* (formerly *Industrial Arts Index*)



Correspondence

SOLID-STATE MAN

Keep those good IC articles coming. How about more like the one in the December 1967 issue, "30 Basic IC Projects"? Also, keep up the good work in the New Semiconductors and Microcircuits column. Can you tell me where I can get sockets for integrated circuits? I have checked the local distributors and several mail-order companies but have drawn only blanks.

JIM PERLBERG
Racine, Wis.

More IC projects are in the works. Jim, these sockets are available from the industrial electronic parts distributors. The mail-order distributors do have sockets for IC's listed in their industrial catalogs. Allied has a package of 5 sockets for TO-5 type IC's for $6.70 . . . stock number is 47E-6080.

DIESEL TRUCK NOISE WANTED

Is there anyone who can supply me with a tape recording of the sound of a diesel highway truck, starting from idle and roaring through the gears shifting up to full speed? A 5" reel recorded at 1⅞ or 3¾ ips is desired.

MIKE RAYMER
Blaine Lake
Sask., Canada

LIKES MILLIVOLT COMMANDER

Your recent article "Amphenol Model 870 Millivolt Commander" (December 1967) is excellent, except for one error. The maximum dc voltage the unit is able to measure is not 100 but 1000. I am amazed at the accuracy of the instrument . . . 2% any place on the scale, on any dc range, and within 3% any place on the scale, on all ac ranges, from 5 Hz to 50 kHz.

E. J. FLYNN

SERVICE DATA NEEDED

Please help me locate an instruction manual and/or a schematic drawing on a scintillator, Model 117, man-

ufactured by Precision Radiation Instruments, Inc., Los Angeles, Calif. The instrument is approximately 8 to 10 years old. I have tried to contact this firm but it is apparently no longer in business.

RAYMOND A. MOORE
659 Candlestick Way,
San Jose, Calif.

CURE FOR COLOR BLINDNESS

In News Briefs (November 1967) I read of a cure for color blindness using an electronic device called *Sunvister* made by Hayakawa of Japan. I would appreciate it very much if you could tell me where I could write to find out more about it.

R. E. PARSONS
Willard, Ohio

Write to Prof. Koichi Honkawa, Hayakawa Electric Co., 22-22 Nagaike-Cho Abeno-Ku, Osaka, Japan.

DISAGREES WITH BALMER

In the November 1967 issue of R-E you published a letter from a Mr. D. R. Balmer who wrote that he was resigning his subscription over disgust with your editorial policies. I heartily disagree with his severe action: Your magazine has far too much technical data and practical information for me to follow his example. However, I don't like excessive use of conversational form—it greatly obscures the central and salient information an article is meant to convey. Please return to the precepts of technical journalism and follow them rigorously.

M. E. KLOTHE
Midland, Mich.

We ain't going to make all our writers cut out all the conversation, but we do intend to make them follow the precepts. Some writers are better conversationalists and some writers are just good engineers and technicians. Our job is to get the information to span the gap between writer and reader.

BASIC IC PROJECTS

p50

Your "30 Basic IC Projects" (January 1968) is an interesting and helpful article, especially the section on logic circuits. However, I believe Fig. 14 is in error. The circuit is identical to Fig. 15, but the two are supposed to have opposite functions. It seems that connection 5 of the right-hand IC of Fig. 14 should be grounded,

(continued on page 12)

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Cover by Harry Schlack

RADIO-ELECTRONICS is published by Gernsback Publications, Inc.
President: M. Harvey Gernsback
Vice President-Secretary: G. Aliquo

ADVERTISING REPRESENTATIVES

EAST
John J. Lamson,
RADIO-ELECTRONICS, 200 Park Ave. South
New York, N. Y. 10003, 212-777-6400

MIDWEST/N.&S. Car., Ga., Tenn.
Robert Pattis, the Bill Pattis Co., 4761 West Touhy Ave., Lincolnwood, Ill. 60646, 312-679-1100

W. COAST/Texas/Arkansas/Oklahoma
J. E. Publishers Representative Co., 8380 Melrose Ave., Los Angeles, Calif. 90069, 213-653-5841; 420 Market St., San Francisco, Calif. 94111, 415-981-4527

UNITED KINGDOM
Publishing & Distributing Co., Ltd., Mitre House, 177 Regent St., London W.1, England

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Mr. Morgan (who has been installing antennas for twenty years and counts his installations in the hundred of thousands) does most of his work in metropolitan areas where that extra sharp, ghost-chasing directivity is mighty welcome. His opinion of the JFD is typical of professional antenna installers from coast to coast.

And it's only natural because the Color Laser offers:

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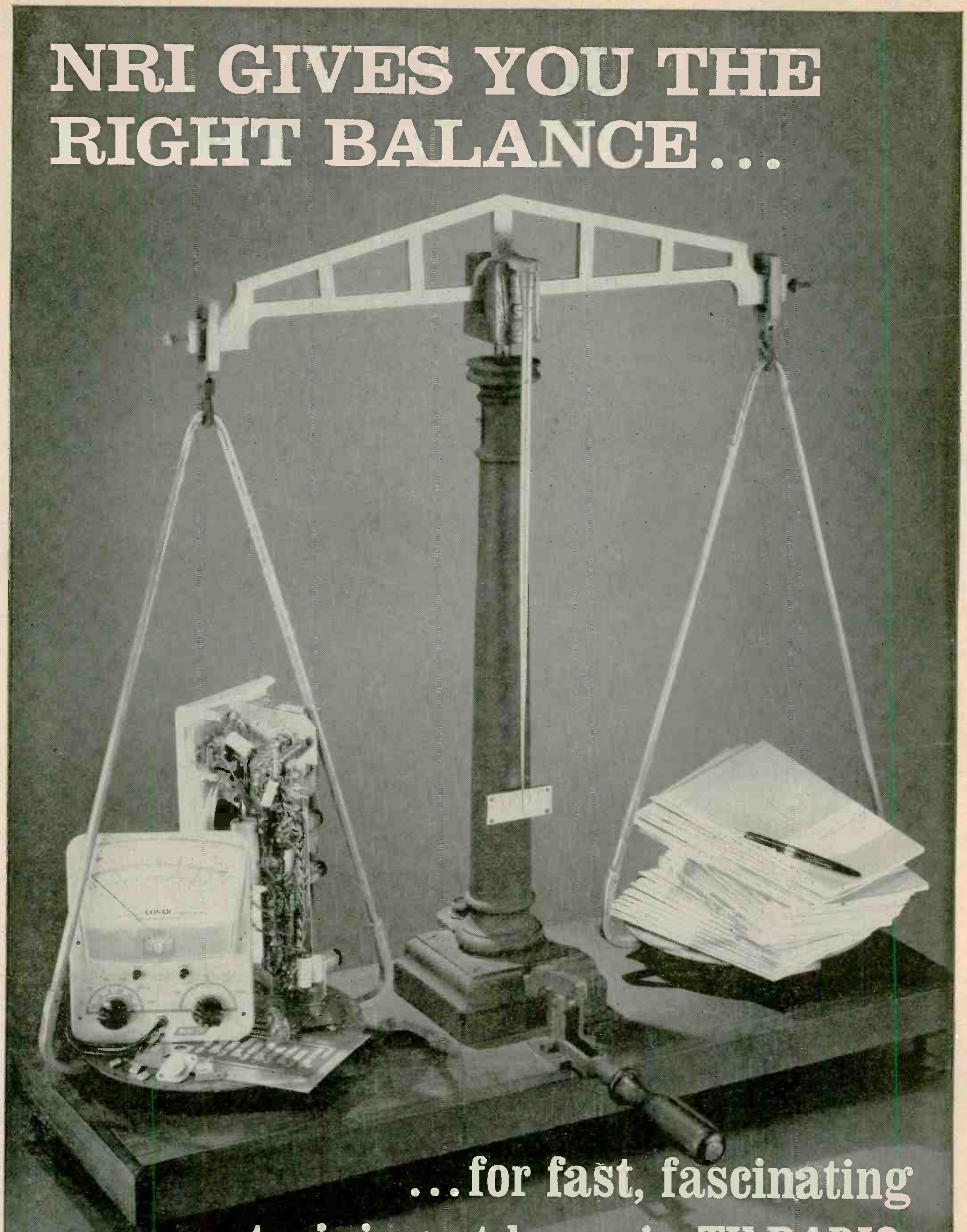
Circle 13 on reader's service card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NRI has trained thousands

L. V. Lynch, Louisville, Ky., was a factory worker with American Tobacco Co., now he's an Electronics Technician with the same firm. He says, "I don't see how the NRI way of teaching could be improved."

G. L. Roberts, Champaign, Ill., is Senior Technician at the U. of Illinois Coordinated Science Laboratory. In two years he received five pay raises. Says Roberts, "I attribute my present position to NRI training."

Ronald L. Ritter of Eatontown, N.J., received a promotion before even finishing the NRI Communications course, after scoring one of the highest grades in Army proficiency tests. He works with the U. S. Army Electronics Lab, Ft. Monmouth, N.J. "Through NRI, I know I can handle a job of responsibility."

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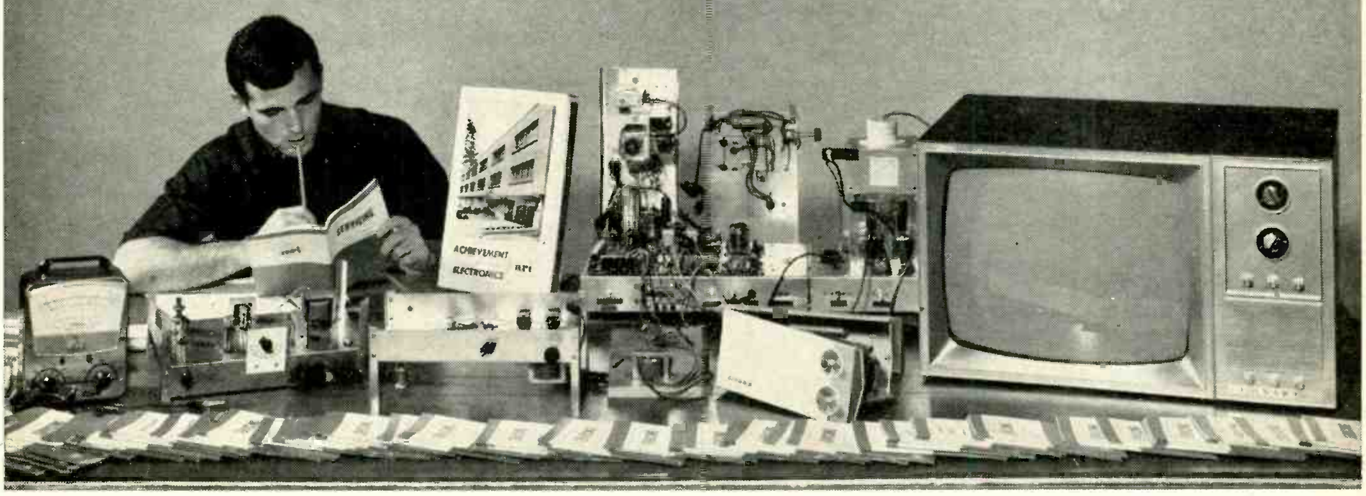

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CORRESPONDENCE
(continued from page 6)

6 should be disconnected and 7 should be the output. This article has whetted my appetite for some articles on computer logic, memory systems, etc. Are any planned?

BROTHER M. HENRY BOLAND, F.S.C.
Saint Paul's
Covington, La.

. . . The article "Basic IC Projects" by Mr. R. M. Marston is one of the finest your magazine has produced. It is timely, educational, useful and extremely well executed. As a technical writer who has contributed many articles to you and to your competitors, naturally I am a little miffed that Mr. Marston managed to scoop me on this project, but more power to him and to RADIO-ELECTRONICS. You are doing a great job with material like this—keep up the good work.

JAMES I. RANDALL
Baltimore, Md.

Lost, one Fig. 14, or who needs an extra Fig. 15. So, scratch the original Fig. 14 and use the one you suggested, as shown in Miss-Q, in this issue. Brother Henry, "He that increaseth knowledge increaseth sorrow, and the man that worketh on this article repenteth." We think you will be pleased with a forthcoming series of articles on computers and that your appetite will be appeased.

see p 80

James, it takes a good guy to give credit to another good guy. So do what you can to keep Brother Henry and the rest of our readers who are hungry for more electronics know-how happy.

FET's AND IC's

How about some articles on audio preamplifier design using FET's and IC's and an explanation of the necessary equalization for tape, phono, and FM. Also, some circuits on tape-recording amplifiers would be appreciated.

PAUL D. KOEHN
Irving, Tex.

PROGRAMED TEXT ON TRANSISTORS

I am looking for a self-instructional programed teaching course, in book form, on transistor theory and utilization. I prefer a book format using the Teaching Machine approach. As an example of what I am looking for, re-
(continued on page 16)

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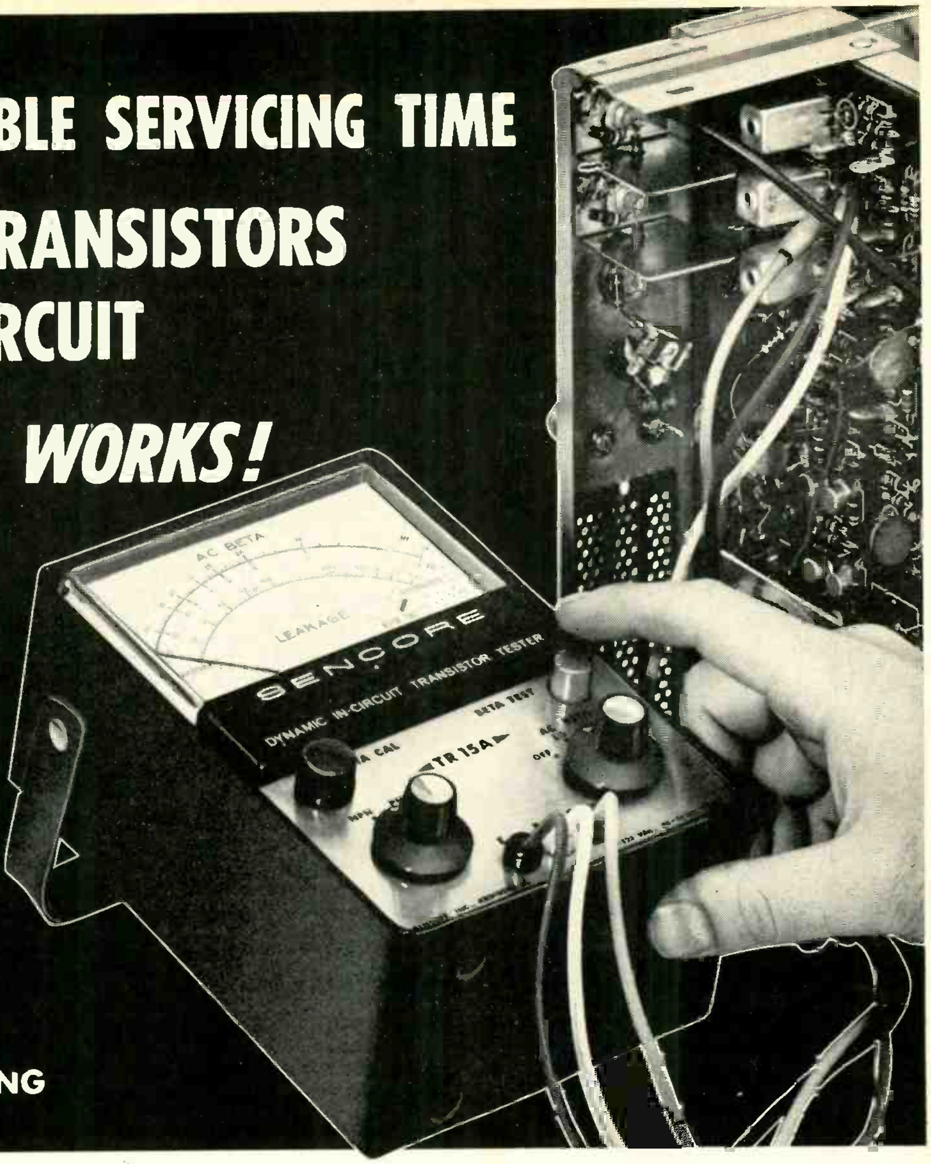
IT REALLY WORKS!



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Circle 15 on reader's service card

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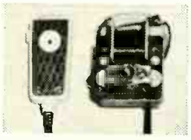

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New Remote Control For Heathkit Color TV

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

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

Deluxe Heathkit "295" Color TV

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

Kit GR-295, (everything except cabinet), 131 lbs. . . . $48 dn., $42 mo. **$479.95**
GRA-295-4, Mediterranean cabinet (shown above), 90 lbs. . . . no money dn., $11 mo. **$112.50**
Other cabinets from $62.95.

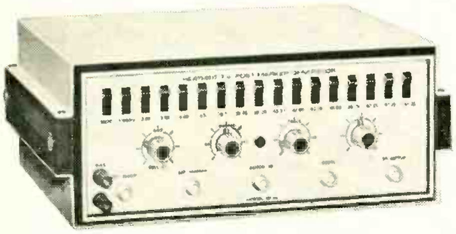
Kit GR-180
$359.95
(less cabinet & cart)
$22 mo.

Deluxe Heathkit "180" Color TV

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

Kit GR-180, (everything except cabinet), 102 lbs. $36 dn., as low as $22 mo. **$359.95**
GRS-180-5, table model cabinet & mobile cart (shown above), 57 lbs. . . .no money dn., $5 mo. **$39.95**
Other cabinets from $24.95.

New! Heathkit Crystal-Controlled Post Marker Generator



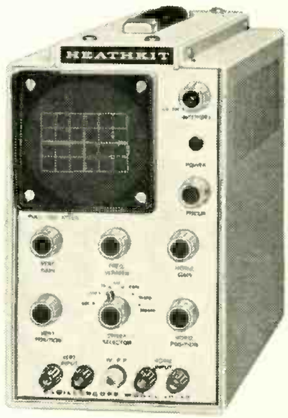
Kit IG-14
$99.95
$10 mo.

Fast, accurate color TV and FM alignment at the touch of a switch! 15 crystal-controlled marker frequencies. Select picture and sound IF's, color bandpass and trap freqs., 6 dB points, FM IF center freq. and 100 kHz points. Use up to six markers simultaneously. Birdie-type markers. Trace and marker amplitude controls permit using regular 'scope. 400 Hz modulator. Variable bias supply. Input and output connectors for use with any sweep generator. Also has external marker input. BNC connectors. Solid-state circuit uses 22 transistors, 4 diodes. Two circuit boards. Handsome new Heathkit instrument styling of beige and black in stackable design. Until now, an instrument of this capability cost hundreds of dollars more. Order your 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**

New! Low Cost Heathkit 5 MHz 3" Scope

Kit IO-17
$79.95



Here is the wideband response, extra sensitivity and utility you need, all at low cost. The Heathkit IO-17 features vertical response of 5 Hz to 5 MHz; 30 mv Peak-to-Peak sensitivity; vertical gain control with pull-out X50 attenuator; front panel 1 volt Peak-to-Peak reference voltage; horizontal sweep from internal generator, 60 Hz line, or external source; wide range automatic sync; plastic graticle with 4 major vertical divisions & 6 major horizontal; front mounted controls; completely nickel-alloy shielded 3" CRT; solid-state high & low voltage power supplies for 115/230 VAC, 50-60 Hz; Zener diode regulators minimize trace bounce from line voltage variations; new professional Heath instrument styling with removable cabinet shells; beige & black color; just 9½" H. x 5½" W. x 14½" L.; circuit board construction, shipping wt. 17 lbs.

CORRESPONDENCE
(continued from page 12)

fer to *Binary Logic* published by McGraw-Hill.

I want to offer this educational help to my employees in a manner that is basic and easy to grasp. Please advise me of any such publication that you may have available, and all particulars concerning it.

C. L. Wolf
Avco Corp.
Cincinnati, Ohio

Try Fundamentals of Transistors, *a programed text by RCA Service Co., published by Prentice-Hall, Englewood Cliffs, N. J.*

IEEE MEMBERSHIP

Where can I obtain an application for membership in the Institute of Electrical and Electronics Engineers?

Gene Cerasuolo
Immokalee, Fla.

Gene, write to IEEE, 345 E. 47 St. New York, N. Y. 10017.

TREASURE FINDER

I built the treasure finder of Charles D. Rakes which you had in the November 1967 issue and it works very well. Although I haven't made any important finds as yet, I am quite pleased with its operation. In building the circuit, I did, however, find it easier to adjust by adding a 0.9-pF to 7.0-pF capacitor trimmer across the crystal to broaden its bandwidth slightly. Also I built mine on a printed circuit board and am using a FT-241 surplus 2-MHz crystal along with 2N2926 transistors.

V. C. Brisbane
Philadelphia, Pa.

R32

I am trying to put together the metal locator described in "Build a Treasure Finder" (November 1967). I have found all the parts in the Akron area except the 1000-kHz crystal. None of the 10 places where I buy parts has this crystal. Please tell me where I can buy a 1000-kHz crystal.

H. O. Franklin
Cuyahoga Falls, Ohio

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We've given the plate wings.

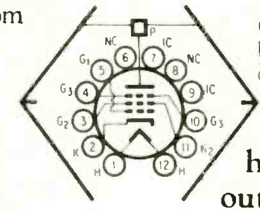
It's been so designed that it acts as a superior heat sink. It holds more heat. Radiates it out from a larger surface. Dissipates it more quickly.

The new tube runs cooler and has longer life.

And it still costs the same as the "A".

It should mean fewer replacement calls.

Try the "C" and see.



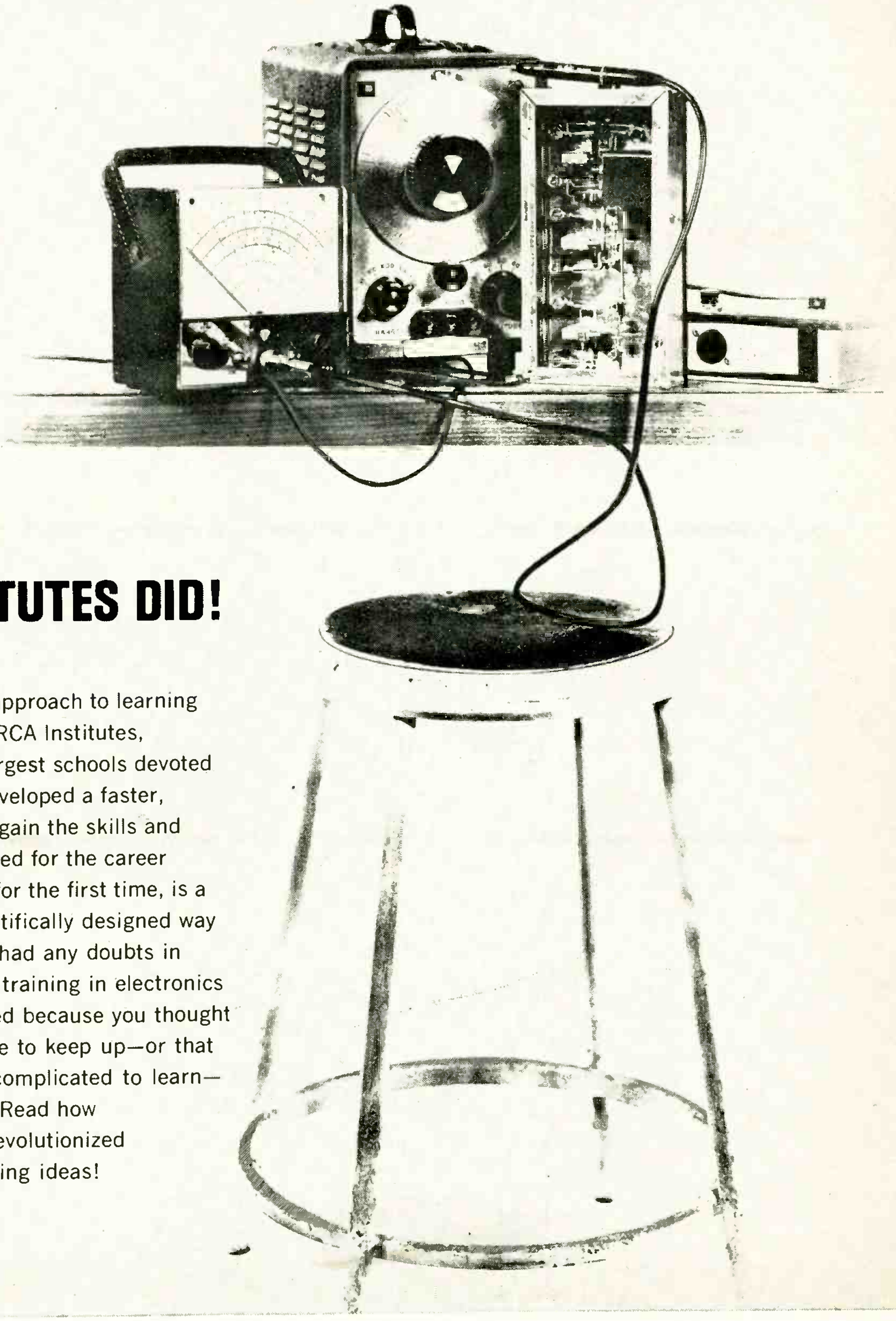
SYLVANIA
GENERAL TELEPHONE & ELECTRONICS

Big plate fins absorb heat and radiate it out of the tube.

Circle 18 on reader's service card

SOMEONE SHOULD DEVELOP AN EASY WAY

TO LEARN ELECTRONICS AT HOME



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summary P 14

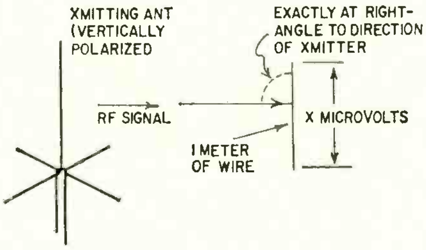
In the Shop . . . With Jack

By JACK DARR

WHAT ARE MICROVOLTS PER METER?

THAT WAS THE QUESTION. THE READER who wrote in was confused. After looking through my reference library, I was too. I found three or four ways of figuring μV/m, including one in a very old book which said it meant "the number of meters an antenna is mounted above the ground." Outside of some very specialized books, there is very little about μV/m in "the literature." So, here's a digest of what I dug up.

The basic expression, microvolts per meter, is used in figuring the field strength of an rf signal. What it means is the number of rf microvolts which will appear across a piece of wire exactly 1.0 meter (39.37") long (Fig. 1). For this definition, the wire is suspended in free space in a radio-frequency field, in a position exactly at right angles to the line toward the transmitter, and with the same polarization.



Now let's see what all this means, in practical work. Also, let's clear up a few popular misconceptions. I ought to know about these; I've been using them for years!

1. The height of the antenna wire above (earth) ground has nothing to do with the definition. (I know—the higher an antenna the more signal it picks up. But that's a different matter.) The expression is an indication of the rf field or voltage at the point where the wire *is*.

2. Frequency also has nothing to do with this definition, except in the case of a resonant wire. Because the wavelength of 300 MHz is 1 meter long, the signal frequency must *not* be 300 MHz or any multiple or sub-multiple of it. If the wire is resonant, the reading has a different meaning

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

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

($\mu V/\lambda$). The quantity μV/m is a standard unit used to indicate the energy that an antenna will intercept in a radiated-energy field at *any* frequency.

3. Polarization of the transmitting and receiving antennas must be in the same plane; if one is vertical, the other should be, too. Usually, this is the configuration for maximum energy pickup. TV signals (in the US and Canada) are horizontally polarized, and so are the receiving antennas. (In Great Britain, they're vertical.) CB signals are almost all vertically polarized, although there's no law that says they have to be. It is easier for mobile units to use vertical whip antennas and for fixed stations to obtain omnidirectional coverage. So far as transmitting range goes, there isn't any appreciable difference between the two.

In the same letter, the reader asked about the very rapid dropoff in the signal energy as you go away from the transmitter. Let's see why this happens.

The transmitted field

Rf signals travel at the speed of light—300,000 meters per second. Let's turn on a transmitter and feed one very sharp pulse of energy to it. (This is one of those "ideal" antennas. I can use it if I want to; it's my antenna!) Fig. 2 shows what happens. 1/300,000 second later, the rf energy radiating from the antenna has gone off in all directions (above the ground surface), and the resulting energy is in the shape of a hemisphere, with a radius of 1 meter, at (a). This is often called a *shell*, or *wavefront*. My ideal

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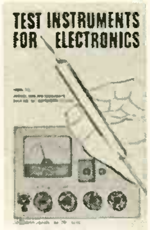

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Circle 21 on reader's service card

In the shop . . . With Jack
(continued from page 22)

transmitter is using 1 kilowatt of energy to produce the rf field in the transmitted shell.

Now, the shell contains an rf field produced by 1 kilowatt. Look at Fig. 2 (b), the same shell *1 second* later. Still having the same total rf field, it's now 300,000 meters in radius. Considerably more *area*, eh? The actual amount of energy or field at b is a heck of a lot less because of the tremendous expansion. If you want the exact figures, you can work it out by figuring the surface area of a sphere with a 2-meter diameter and then another of 600,000 meters diameter, then dividing by two. That's not for me; I'll take your word for it. Just remember this one key fact: No matter how big the shell is, it still has the same *total* rf field it had when it left home! The bigger the shell, the thinner the field gets spread out. So, if we spread a field produced by 1 kW over three miles, we have a fairly good signal; spread the same amount over half of all creation, and it's not quite so powerful!

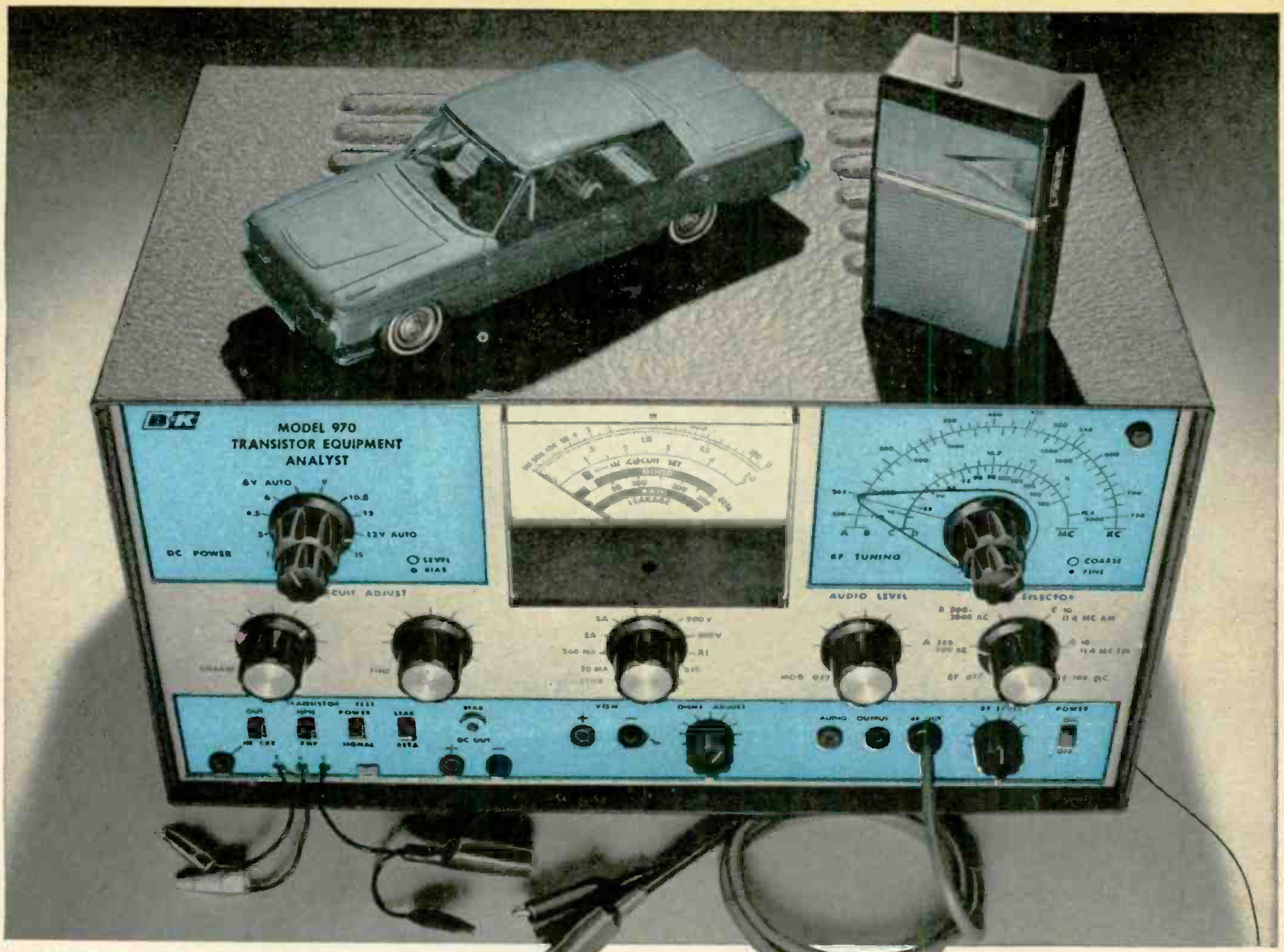
Watts or volts?

One more point: The TV transmitter (like all transmitters) puts out *power*—so many watts of rf. The rf current flowing through the antenna circuit produces a field. And it's this field of energy that's intercepted by the antenna, where it induces a voltage that we can measure in microvolts per meter. The receiving antenna couldn't care less about *power;* all it wants is a little *voltage,* which is amplified by the front end of the tuner.

Finally, my inquisitive friend asked, "Why are low-band TV stations allowed a transmitted signal level of only 100-kW e.r.p., while high-band stations are allowed 316-kW e.r.p.?"

To clear up that abbreviation, e.r.p. means *effective radiated power,* and is commonly used in FM and TV transmitting work. It's the power output of the final amplifier stage, less transmission-line loss, multiplied by the power gain of the antenna. (They get this power gain by reducing radiation in the vertical plane and concentrating it in the horizontal plane.) To get 100 kW of e.r.p., a station could use a 25-kW transmitter and an antenna with a gain of about 4 (depending on the amount of line loss).

The reason for the allowable maximum power difference is simply that frequency affects signal propagation. The higher the transmitting frequency, the less distance the signal travels,



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Circle 23 on reader's service card

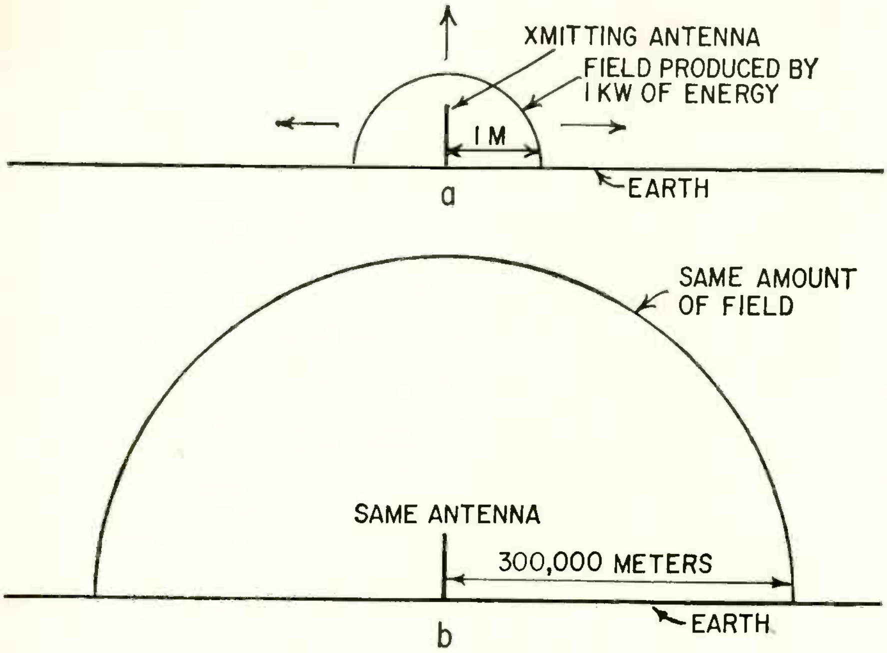
In the shop . . . With Jack

(continued from page 24)

power output being the same. Another way of putting it: Signal attenuation increases with frequency.

So, low-band vhf stations (54–88 MHz) may use no more than 100 kW e.r.p. High-band vhf stations (174-216 MHz) have a harder time pushing their signals out, and are allowed up to 316 kW e.r.p. Uhf stations (470–890 MHz) have an even harder time of it, and can use up to 5 megawatts!

But that's not the whole story. The FCC wants all TV stations to have equal service areas when operating at maximum coverage. But vhf and uhf field strength depends, not only on e.r.p., but also on transmitting antenna height AAT (*above average terrain*). The higher the antenna, the less power needed to produce the same coverage.



The maximum power of 316 kW for a high-band vhf station can be used only if the antenna is not over 1000 feet AAT. Increase the antenna height and you must crank down the power. A high-vhf station with antenna height of 5000 feet AAT, for instance, can have a maximum e.r.p. of roughly 1.5 kW.

Matter of fact, the above rules are also modified by geographical location. In the high-population Northeast US (roughly New England to Illinois and Virginia) the FCC limits on power are more severe than in the rest of the country. This was done because more stations must "live with each other" in populous areas than in sparsely settled regions like, say, Wyoming.

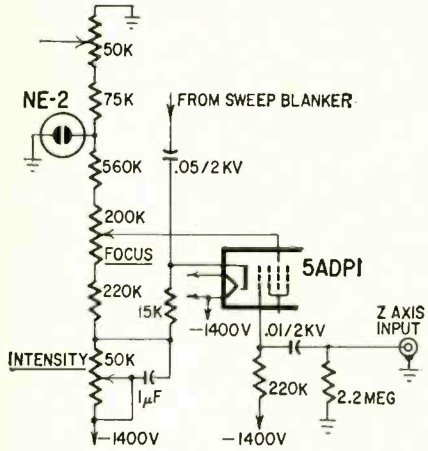
Brightness trouble in oscilloscope

I've got a faithful old DuMont 304 scope, and it's always done very well. Now, though, it's got brightness-control troubles. When I turn the control full-

on, the trace gets very wide, as if blooming. Back down halfway, and it looks pretty good. However, it won't put the spot out as it should.

Any ideas?—R. H., Houston, Tex.

Some. Check all resistors in the negative-voltage network. Also check the voltage between the CRT's cathode and grid. Apparently the grid isn't going far enough negative (with respect to the cathode) to extinguish the spot,



when the brightness control is turned all the way down. I seem to remember a similar trouble in this model once before; check the Z-axis (or intensity-modulation) coupling capacitor. It's connected to the CRT grid, but there is a 2.2-meg resistor shunted to ground on the jack side (see drawing). If this capacitor is leaky, it will upset grid-to-cathode bias.

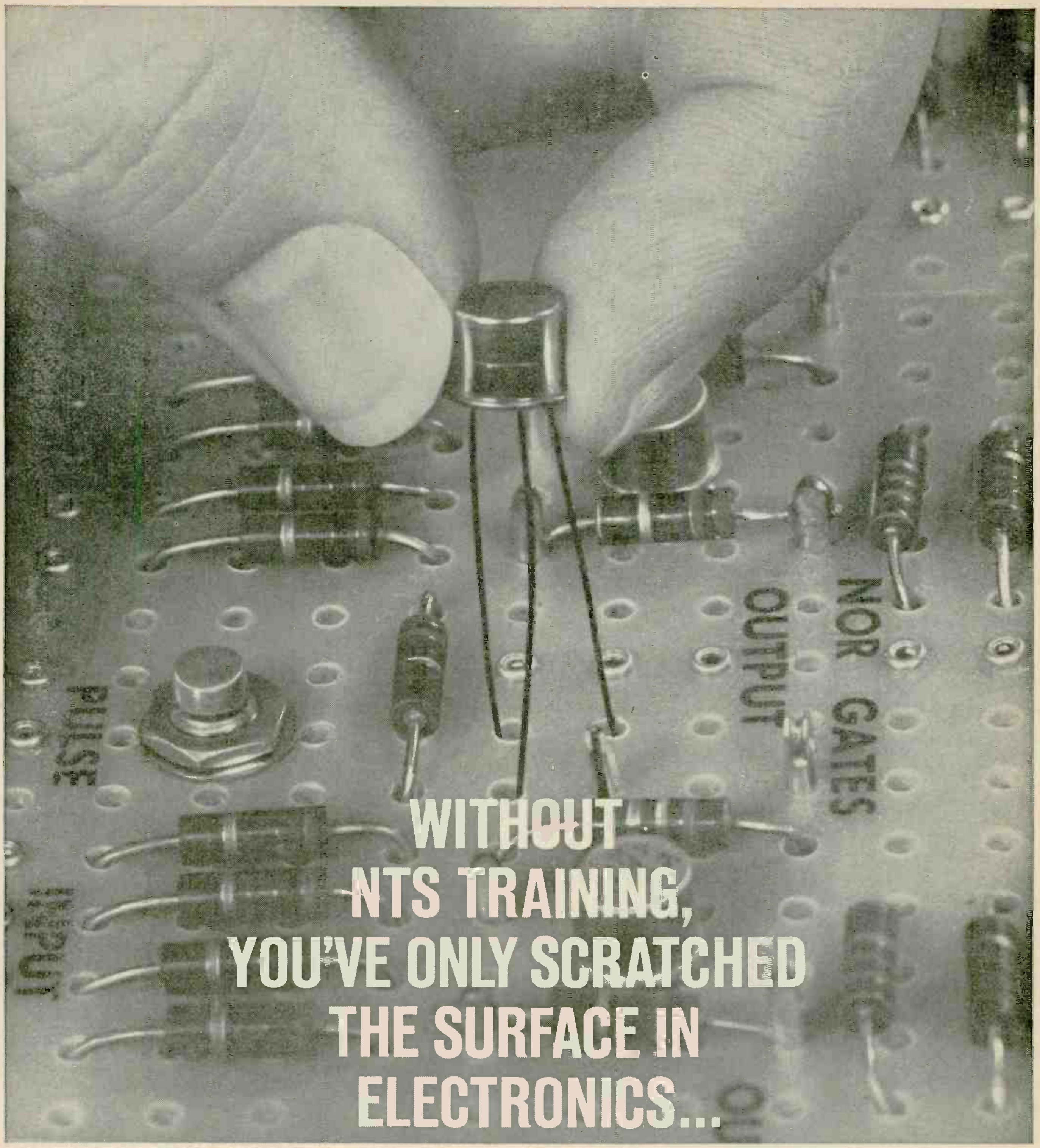
Lightning arresters for coax?

I can't find a good lightning arrester for use on a coaxial cable lead-in system. Any recommendations?—P.K., Los Angeles, Calif.

From much experience in two-way radio antennas, and in TV, I'd say that a very good lightning arrester for any kind of coax would be a simple ground on the outer shield at the point where the line goes into the house. The easiest way is to use a Blitz Bug lightning arrester made by Cush-Craft for coaxial cable.

You can clamp the line in any of the conventional arresters, and then "jump" the normal gap with a wire, so that the outer braid of the coax is actually grounded. You can also slit the outer vinyl jacket, and wrap about 6 to 8 turns of solid copper wire around the braid. Don't try to solder it; you'll melt the inner insulation.

Spray this with Krylon clear plastic, then wrap it tightly with vinyl tape, to keep it weatherpoof. Use a good ground rod. **R-E**



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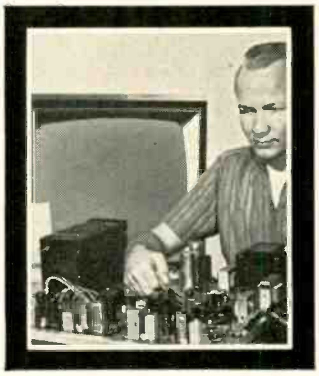

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BUILD AN IC CRYSTAL CALIBRATOR

100 kHz to 30 MHz within 0.0001% for about $15

By JACK ALTHOUSE

WANT TO CHECK THE CALIBRATION of your receiver? your transmitter's vfo? your oscilloscope? your signal generator? Here is a crystal calibrator that makes it possible for you to do all these things—and more.

It's a true secondary frequency standard that can be adjusted to an accuracy of 0.0001% by using the National Bureau of Standards signals from WWV. But, while WWV appears at only a few frequencies, the crystal calibrator gives accurate reference

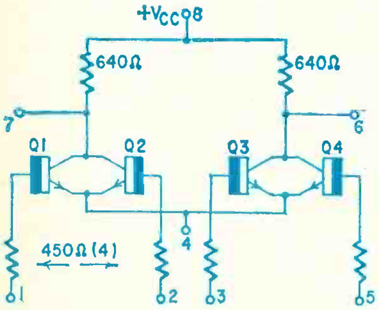

Fig. 1—Inside the μL914 . . . 4 transistors and 6 resistors, all in a TO-5 size case.

points every 100 kHz up to at least 30 MHz.

Maybe you don't have a short-wave receiver to pick up WWV. With nothing but an ordinary broadcast-band resistor radio you can set the crystal calibrator to an accuracy of 0.001%—about 1000 times as accurate as the dial calibration of most test instruments and radio receivers.

This crystal calibrator gives you the accuracy of a standards laboratory. Its output has very sharp rise and fall, on the order of 0.01 μsec. Thus it can be used to check damping, overshoot and ringing in oscilloscope preamplifiers and to check frequency response and bandwidth of high-frequency amplifiers.

All this is accomplished with one reasonably priced crystal, an 80¢ integrated circuit, and a half dozen other inexpensive components. Total cost, including the case and two penlight cells, is about $15.

The circuit

Most components are contained in the integrated circuit chip itself (Fig. 1). The collectors of Q1 and Q2 are tied together and share a common load resistor; Q3 and Q4 share another load resistor. Each transistor has a separate series base resistor.

The four transistors and the six resistors are on a single silicon chip potted in an epoxy case. The eight connections numbered in Fig. 1 are brought out through eight gold-plated leads at the bottom of the epoxy case.

Multivibrator. One way to use the IC is shown in Fig. 2. If pins 2 and 3 are left open, both Q2 and Q3 are cut out of the circuit and take no part in its operation. That leaves just Q1 and Q4. If you connect external resistors R1 and R2, external capacitors C1 and C2, and a 3-volt power supply, the circuit becomes a multivibrator. It will oscillate at a frequency determined by the time constants R1–C1 and R2–C2.

The circuit works like this: When Q4 conducts, its collector voltage drops from +3 volts to ground (zero). This negative pulse passes through C1 to the base of Q1, thus turning it off.

Transistor Q1 will stay off until C1 charges (through R1) far enough to bring the base of Q1 positive; then Q1 conducts and produces a negative going pulse at Q1's collector. The negative pulse from Q1's collector passes through C2 and turns off Q4. Then C2 charges through R2 and the cycle repeats. The result is a continuous square wave.

Crystal control. Now consider Fig. 3. This is the same circuit as Fig. 2 except that C2 has been replaced by a crystal. The crystal, unlike the capacitor it replaces, will pass current at only one frequency. It is a resonant element in itself; thus the value of R2 no longer affects the frequency.

The remaining time constant (R1–C1) has only to be adjusted so that oscillations tend to take place at approximately the crystal frequency. Then, presto!—the crystal takes hold and you have an oscillator stably controlled at the crystal frequency. This circuit is the basis of the IC crystal calibrator.

Binary circuit. But what of transistors Q2 and Q3? They are sitting there on the IC chip, cut out and do-

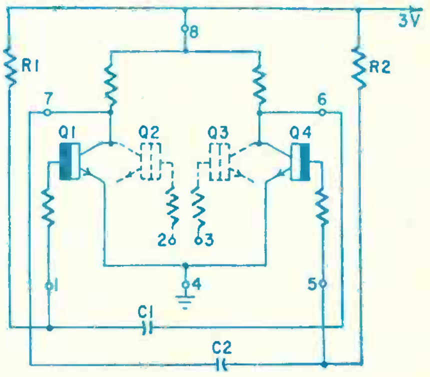

Fig. 2—Transistors Q1 and Q4 are hooked up to form a multivibrator circuit.

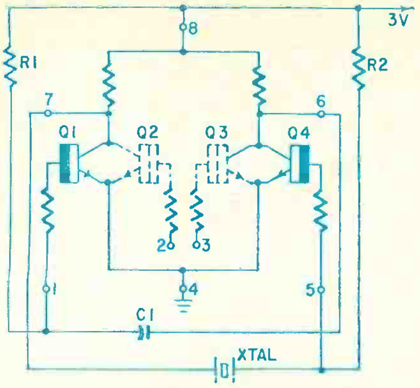

Fig. 3—By substituting a crystal for capacitor C2, the frequency is fixed.

ing nothing. It seems a shame not to use them.

A useful circuit is shown in Fig. 4. Here terminals 1 and 5 are open, leaving Q1 and Q4 cut off. The output lead of Q2 is connected to the base of Q3, and the output lead of Q3 is connected to the base of Q2. This is a direct-coupled binary circuit.

If, for example, Q3 is off it will draw no current through its collector resistor. Thus the base of Q2 is connected to +3 volts through the Q3 collector resistor and the Q2 base resistor. Q2 will turn fully on. The resulting low voltage at Q2 base puts Q3 base at a low potential, and Q3 will stay off. The circuit will remain in this state indefinitely or until a trigger pulse comes along to turn Q2 off. Then the circuit will reverse its state with Q2 off and Q3 on.

Now, if Q1 and Q4 were running in the oscillator circuit of Fig. 3, there would be a series of trigger pulses on the collectors of Q2 and Q3 because they are tied directly to the collectors of Q1 and Q4 on the IC chip.

Calibrator circuit. The circuit of Fig. 5 is the crystal oscillator circuit of Fig. 3 and the binary circuit of Fig. 4 combined. Q1 and Q4 form a crystal oscillator. Q2 and Q3 form the binary that holds the oscillator in place between trigger pulses to give a good "flat-top" to the output waveform.

A few other components have been added to the circuit. Most important is C2. In series with the crystal, it allows you to vary the frequency of oscillation slightly so as to zero-beat with WWV or any other available frequency standard.

C3 is a dc blocking capacitor for the output circuit. A resistor (R3) has been added to the B+ line along with S1, the on–off switch and a 3-volt battery.

Construction

You'll find that the IC crystal calibrator fits into a 5¼"x3"x2⅛" box with case. The output connector is mounted on one end of the box and the battery holder on the other.

Mount the on–off switch on the front panel at the battery end of the box. A rotary switch is used in the unit shown in the photographs. However, a toggle switch can be used if desired. Be sure to leave enough space between the switch and the battery holder so that the batteries can be removed from the holder when replacement is necessary. (The penlight cells will power the unit for more than 100 hours of continuous operation.)

Oscillator components are mounted on a piece of perforated board 2½" wide and 2¾" long. Prewire it as a separate subassembly and then mount it in the box.

Drill four holes near the corners of the perforated board to accept 4-40 mounting screws. Use these holes as a template to make matching holes in the front panel of the box. This is more easily done before the parts are mounted on the board.

Next bend the leads of the IC—one at a time—as shown in Fig. 6. Hold each lead with a pair of long-nose pliers so that the bend occurs about 1/16" from the IC case. Lead 8 of the IC is marked by a flat or a brown line on the side of the case.

Mount the components on the board as shown in Fig. 7. Be sure to provide leads long enough to reach the switch, batteries and output terminals. Two wires come off the board on each end; two are for the output connector and two for battery power. Case ground is made to a solder lug placed under one of the perforated-board mounting screws.

Check and adjust

When the board subassembly is complete, check its wiring, then mount it in the box. Connect the lead wires to the output connector, switch and battery holder. When inserting the batteries be sure to observe the proper polarity. Batteries are in series, with negative ground.

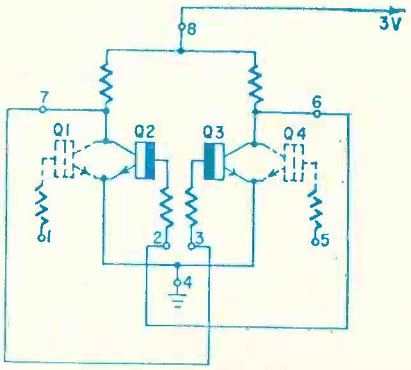

Fig. 4—Transistors Q2 and Q3 as a binary counter produce square-wave pulses.

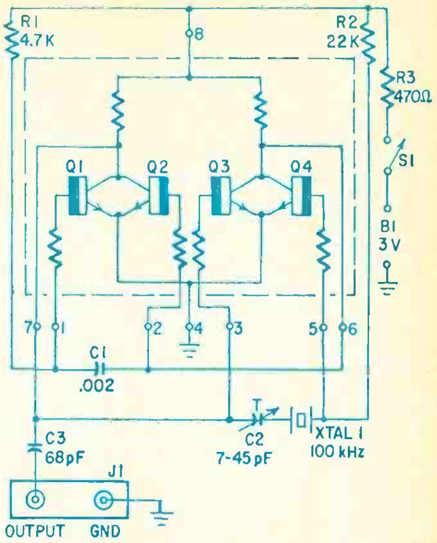

Fig. 5—Combining the functions (Figs. 3 and 4) produces triggered square waves.

Parts List

- B1—Two penlight cells, 1½ volts each, AA size, NEDA 15
- C1—0.002-μF, 10% disc ceramic capacitor (Centralab CF-202 or similar)
- C2—7–45-pF trimmer capacitor (Centralab 825-GN or similar)
- C3—68-pF disc ceramic capacitor (Centralab DD-680 or similar)
- J1—Dual binding post (Millen 37222 or similar)
- R1—4700-ohm, ¼-watt resistor
- R2—22,000-ohm, ¼-watt resistor
- R3—470-ohm, ¼-watt resistor
- S1—S.p.s.t. toggle switch
- XTAL 1—100-kHz crystal (Petersen Z-6A, James Knight H-17T or similar)
- IC1—Fairchild μL914 integrated circuit
- MISC—battery holder (Keystone 140 or similar); perforated board (Vector 85G24EP with T-28 terminals, or similar); aluminum box 5¼" x 3" x 2⅛" (LMB TF-780 or similar).

The μL914 IC retails for $0.80 at Fairchild distributors. It is available in a TO-5 case, a flat pack, and an epoxy package. Only the epoxy costs $0.80. Most distributors do not accept mail orders for less than $10. Semiconductor Specialists (P.O. Box 8725, O'Hare International Airport, Chicago, Ill. 60666) accepts mail orders of $3.00 or more.

The first step is to make sure that the calibrator is oscillating properly. To do this, connect a short length of hookup wire to the output terminal. Couple it loosely to the antenna terminal of a short-wave receiver by twisting the wire around the antenna lead. Tune in WWV (see Table I for data) and listen as you rotate C2. You should hear an audible beat note that changes pitch as C2 is varied.

If the wiring is correct and the specified components (or their electrical equivalents) have been used, the calibrator should pass this test without a hitch. If a raw note or "hash" is heard when the calibrator is turned on, the time constant of R1–C1 is too small. Either R1 or C1 must then be

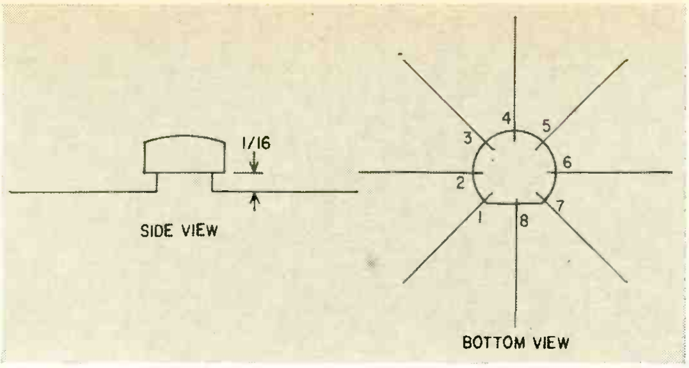

Fig. 6 — Suggested method for bending the leads of the μL914 for mounting.

made larger. The exact values, however, should not be critical. If R1–C1 is too large you'll hear signals every 50 kHz instead of every 100 kHz during the adjustments described below.

Adjustment to WWV

For this adjustment you'll need a plastic screwdriver or alignment tool to vary C2. Adjustments made with a metal-blade screwdriver will shift when the blade is taken off the capacitor.

Tune to WWV and wait for its audio tone to go off (see Table I). Then rotate C2 until the beat note goes to zero. This will bring the calibrator within 50 Hz or so of true zero beat.

When the WWV audio tone returns you will be able to hear a "flutter" on it. This flutter is a change in amplitude. It takes place at a rate which is the difference between the IC calibrator harmonic and the WWV carrier frequency.

Carefully tune C2 to lower the flutter frequency toward zero. This adjustment is best made when WWV is coming in loud and clear with a minimum of fading. You should be able to adjust the calibrator to within about 10 Hz of WWV. If you use the 10-MHz WWV transmission, the procedure gives an accuracy of 10 Hz out of 10 MHz, or 0.0001%!

This accuracy is more than adequate for many measurements. But if you have an application that requires even higher precision, place a vernier capacitor across C2 so that you can adjust the calibrator to within 1 Hz or less of WWV. An E. F. Johnson type 5M11 air trimmer (1.5 to 5 pF) is suitable for this.

Adjusting to BC stations

If your receiver won't pick up WWV, use signals from standard broadcast stations to adjust the calibrator. A transistor radio will do as a receiver.

Tune the radio you are using to a broadcast station that operates on an even multiple of 100 kHz (600 kHz, 700 kHz, 800 kHz, etc.). If you are using a transistor radio, place the end of the case that contains its loopstick antenna near the IC. If you use a table radio, connect a piece of hookup wire to the calibrator output terminal and run it parallel to the plane of the receiver's antenna loop.

Tune C2 as described in the previous section until the beat note goes to zero (seems to disappear). Then listen to the background noise or the program; you'll hear it vary in volume at the difference frequency. Adjust the flutter to as low a frequency as you can easily hear.

Accuracy of this adjustment procedure is limited in two ways: (1) Broadcast stations don't hold their frequencies as closely as WWV. (They are limited to ±20 Hz.) (2) Comparison on the BC band is not as accurate, for the same beat frequency, as short-wave comparison: 10 Hz out of 10 Mhz is 0.0001% but 10 Hz out of 1 MHz is only 0.001%. It is possible, however, to zero-beat the calibrator in the broadcast band to about 1 Hz with a little care. If you find it difficult to hear the flutter, use a scope coupled to the receiver's last i.f. stage. You will see "beat" as an expansion and contraction of the rf signal.

TABLE I
WWV/WWVH BROADCASTS

Operating frequencies:
- WWV—2.5, 5, 10, 15, 20, 25 MHz.
- WWVH—5, 10, 15 MHz.

Tone modulation:
- Tone starts on the hour, 5 minutes past the hour, 10 minutes past the hour, etc.
- Tone lasts for 2 minutes (WWV) or for 3 minutes (WWVH).
- A 600-Hz tone is transmitted on the hour, 10 minutes past the hour, etc.
- A 440-Hz tone is transmitted starting 5 minutes past the hour, 15 minutes past the hour, etc.

Other modulation:
- Time of day is given in voice, Morse code and 100-pps binary code.

Transmitter locations:
- WWV—Fort Collins, Colo.
- WWVH—Maui, Hawaii

Using the crystal calibrator

Receiver calibration. The dials on most commercial receivers have only moderate accuracy. This is due to variations in the electrical values and linearity of the components used in construction. Using the IC crystal calibrator you can check this calibration to a high degree of accuracy.

With the calibrator loosely coupled to the receiver antenna terminal, tune the receiver's main dial and observe the 100-kHz markers. They should appear near the indicated spots on the dial. You'll also hear other carriers. To make sure that you are listening to the calibrator when you hear a signal, just flip the on–off switch. If the signal goes away, it was the calibrator. If not, it was something else.

It's wise to check the overall calibration of the receiver next. This can be done by listening to WWV or a short-wave broadcast station of known frequency to make sure that the receiver is not off by a full 100 kHz so that, for example, what appears to be 9500 kHz is not, in fact, 9600 kHz.

Now, using the logging scale, you

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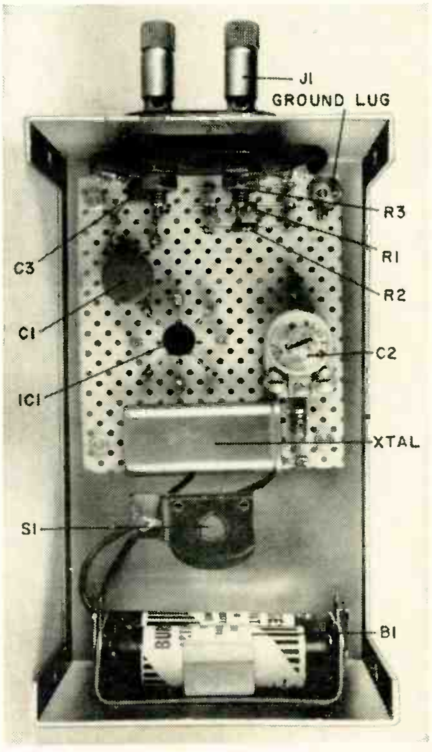

Fig. 7—Mount components on perforated board first; then mount board in box.

HOW TO DEAL WITH RF INTERFERENCE

Don't let electrical and rf noise get you down

By TOM JASKI

DURING THE 60-ODD YEARS THAT electromagnetic radiation has been used by man for communication and control, RFI (radio-frequency interference) has grown considerably. Although Marconi probably transmitted in near silence, it's a safe bet that within a few years someone was complaining of noise on the radio!

Rf interference problems have multiplied at an accelerated rate during the past 15 years. Today we live in a sea of rf produced by millions of transmitters, receivers, industrial and medical equipment, dirty motors, fluorescent lights and corroded metal contacts.

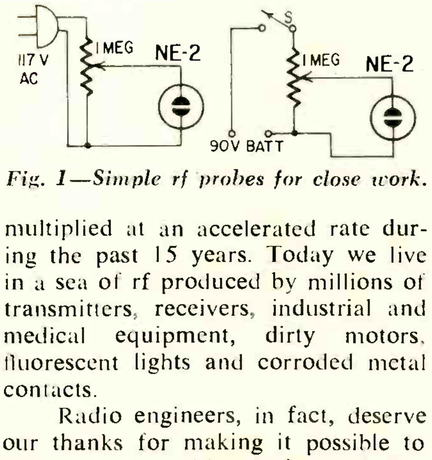

Fig. 1—Simple rf probes for close work.

Radio engineers, in fact, deserve our thanks for making it possible to communicate amidst all the confusion on the air. For with the proliferation of rf energy-producing devices have come highly sophisticated transmission systems such as FM, SSB and multiplex. The question now is not "How can we eliminate interference" but "How can we live with it?"

Noise and junk

Hams call it *QRM*, radarmen speak of *grass*, video operators complain of *glitch* and *birdies*, and one CB'er I know simply calls it *junk*. Whatever term you use, RFI consists of undesirable signals picked up by a receiver. To a radar operator at an airport, it could be the harmonic of a kid's radio-controlled airplane transmitter. To a CB buff, it might be a diathermy machine in a doctor's office down the street. Sometimes ship-to-shore stations get clobbered by harmonics from broadcast stations.

Recently the Federal Aviation Agency prohibited the operation of FM broadcast receivers aboard commercial airliners. The local oscillator of an 88–108 MHz receiver can wreck air-to-ground communications, endangering the lives of all aboard.

RFI causes more damage than marred pictures for a TV viewer or buzz saws to an SWL. There is even evidence to suggest that the human brain can directly pick up and demodulate rf signals—according to scientists at the General Electric Advanced Research Laboratory. It is believed by some that 3- to 4-MHz radiation (if of sufficient intensity) can adversely affect the reproductive cells; that 5-MHz radiation can double the size of a tumor; that uhf energy can affect the eyes and possibly even the nerves of the body; and that microwaves can shorten the life span of human beings (and perhaps other animals). Some authorities claim that rf disrupts the homing mechanism of pigeons and the migrating habits of certain birds.

Communication sources

TV transmitters, ham rigs and CB transceivers have at least one thing in common: All are designed to transmit some kind of information through the airwaves. Diathermy machines, arc welders, fluorescent lamps, neon advertising signs and radar ovens,

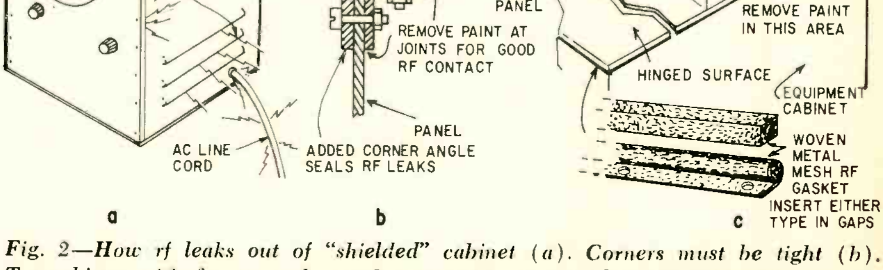

Fig. 2—How rf leaks out of "shielded" cabinet (a). Corners must be tight (b). Treat hinge with finger stock weather stripping to complete shielding pattern (c).

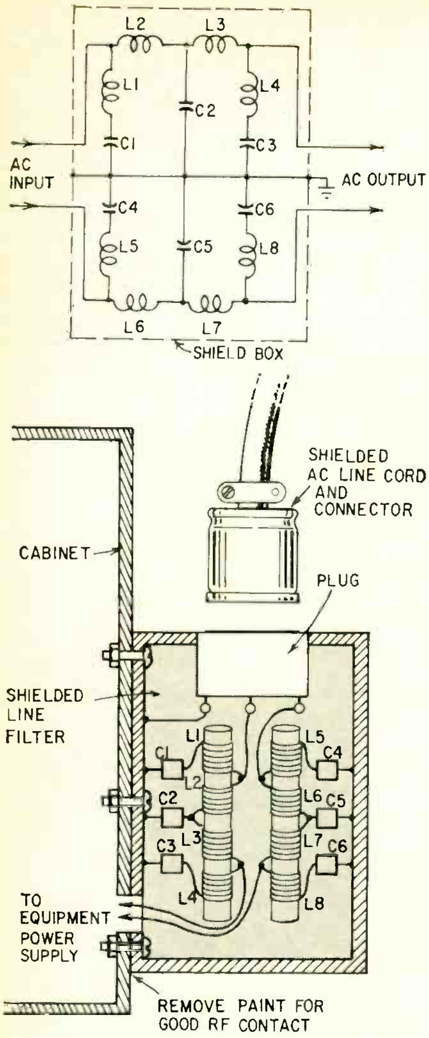

Fig. 3.—Typical power line filter (top) as installed on a dielectric rf heater.

on the other hand, don't transmit intelligence. *But, unfortunately, they do radiate rf energy.*

In most cases, transmitters of intelligence are licensed in the US by the FCC (and in Canada by the DOT) to specified frequencies, with limits on power and spurious radiation. When such devices produce interference, it's usually because they are mistuned, poorly shielded or possibly not well grounded. How can you reduce such interference?

Government rules help by limiting permissible radiation from nearly all such transmitters. Manufacturers build their equipment to meet these specifications, and they usually furnish information to keep the gear clean. Technicians can usually locate the trouble and correct it in an intelligence transmitter.

Obviously the subject of interference from transmitters is quite large and could be covered by several articles. (It has been!) But exact procedures to follow in transmitter troubleshooting are specialized and belong to each field—TV, amateur, CB, broadcast, etc.

It is often much easier to reduce RFI from nonintelligence transmitters —which is what this article is about.

Just plain noise

Diathermy machines and arc welders can be awfully nasty to receivers, for the radiated energy is often spread across a broad band of frequencies. And no one is communicating! Still, adding machines and SCR dimmers are here to stay, and cussing them won't make them go away. Anywhere human beings are, you'll find electric motors—and often brush noise. Factories that use induction heaters aren't going to turn them off so you can listen to the BBC.

Locating RFI

There are several steps you can take to minimize rf noise from sources not used for communication. First, of course, you have to locate the source. A noise-tracing receiver is used by professional RFI finders; it is a sharply tunable, well-shielded receiver which covers a broad frequency range. It has a direction-finding antenna for pinpointing the source, headphones so the operator can monitor the interference, and a meter calibrated in microvolts per meter to measure noise level.

Of course, it's also possible in many cases to use a simple portable radio or TV receiver and use the signal-to-noise ratio you hear as your guide to the source. Naturally, the receiver should use a bidirectional dipole or loop antenna. Nulls are sharper than lobes for direction-finding work.

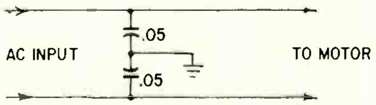

Fig. 4—Simple line filter for small motor.

Much noise from motors and electric appliances is transmitted via power lines, and you'll probably find interference tracing leading you into a building near the ac wiring. When you approach the noise-producing equipment, the receiver will probably saturate. An inexpensive and easy-to-use RFI indicator for close work is shown in Fig. 1. You adjust the potentiometer until the neon ignites, then back off the control slightly. When you put the bulb near an rf source, it fires.

Noiseproofing the source

An RFI axiom states that blocking noise at the source is ten times better than attempting to minimize it at the receiver. As you'll see in Fig. 2, some industrial heating, welding and processing equipment that uses an rf oscillator lacks proper shielding.

Holes and poor metal-to-metal joints in cabinets can leak rf, which is then coupled into adjacent power, intercom or other wiring. It even gets into metal building members.

Metal cabinet joints should be made as shown in Fig. 2(b). Doors and hinges can usually be made rf-proof only by using wiping contacts (finger stock) and mesh-type rf gasket material as in Fig. 2(c).

Direct metal shielding keeps rf out of free space, but there is still the power line. The simplest remedy is an ac filter for rf; a typical filter used in a dielectric heater is shown in Fig. 3. The best installation uses a shielded box around the filter and shielded line to the ac outlet.

Motors should also be filtered to prevent brush noise from contaminating the ac line. Small motors (up to about 1/8 horsepower) can be quieted withe the circuit of Fig. 4. Larger motors create more noise and will require more extensive filtering, as illustrated in Fig. 5. The series inductors must be capable of carrying rated current of the filtered device.

Fluorescent hash

In today's highly civilized world, probably the most widely used noise producer is the common fluorescent lamp. Such interference is spread across many frequencies, but not uniformly (Fig. 6).

Fluorescent lamps produce their interference mainly on cutoff. While the gas in the tube is still ionized, the lowering voltage (in the ac cycle) may be sufficient to allow the tube to arc over several times and produce RFI. Two suitable fluorescent line filters are shown in Fig. 7; the capacitor-only filter will do for most lamps, but the inductor model (Fig. 7-bottom) is necessary for really noisy units.

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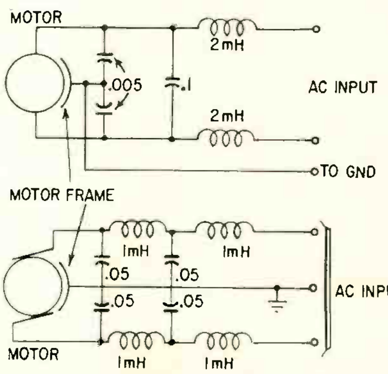
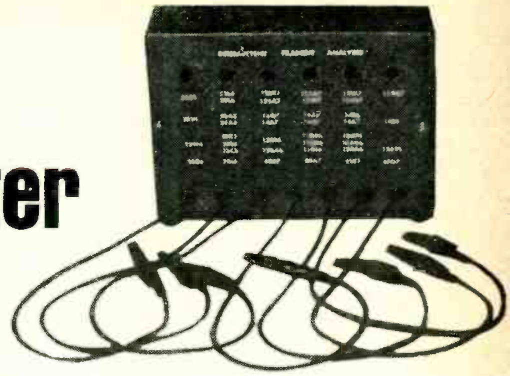


Fig. 5—Single (top) and double section (bottom) filters for electric motors.

Build:

Intermittent Filament Analyzer



"Winking" series-strings can be made to behave

By DON ANGLIN

ONE OF THE MOST TIME-CONSUMING jobs in repairing ac–dc radios or transformerless TV sets is locating a tube with an intermittent heater, especially if it is a thermal intermittent which opens for only a few seconds at a time and closes before you have a chance to make a test. Fortunately, there is a very simple way to spot this type of trouble and you can do it without the use of a meter or tube checker and without the need to hover over the set while it is "cooking."

You can let the set play while you attend to some other matters . . . as soon as you hear the set act up, take a peek at your "Intermittent Heater Analyzer" and chances are you will know instantly which tube is acting up. The gadget is simply a half-dozen neon lamps with current limiting resistors and 7 test leads. You can have more or less neon lamps as you wish . . . number of test leads needed is one more than the number of lamps. Operation is the same for each neon-lamp circuit.

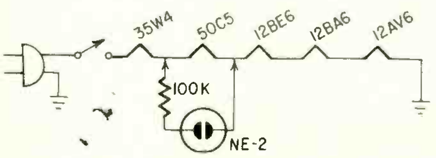


Fig. 1—Neon lamp acts as an open heater monitor. It glows when 50C5 is open.

How It Works

In a series-string radio or TV set the full 117-volt ac line voltage is distributed across the string. When the string is "complete," current flows and causes a voltage drop across each tube in accordance with the resistance of the tube's heater and the amount of current flow. When the string is open, no current will flow and no voltage will drop across any of the tubes, causing the full 117 volts to appear across the open or break in the circuit.

For example, examine Fig. 1 and assume that the heater in the 50C5 is opening and closing intermittently when the switch is closed. Under normal operation the voltage drop across this tube is nominally 50 volts. However, when the heater opens, the potential across the break is the full line voltage. If a neon lamp were placed across the 50C5 heater, the lamp would light when the heater is open, and would be dark when the heater is working. The neon lamp requires a minimum of about 60 volts to stay lit and therefore blacks out when the break in the heater mends itself.

All you have to do then is bridge a suspected tube with a neon lamp, but if you checked one tube at a time it would still be time consuming.

To cut down on the time required to monitor each tube separately, simply keep tabs on as many as 6 at a time, as shown in Fig. 2. When working on a TV set or where the number of tubes exceeds the number of neon lamps in the analyzer, simply divide the heater string into a number of sections and let each lamp monitor a section, as shown in Fig. 3. Once you have isolated the trouble to a particular section, place the analyzer leads across each tube in the section and await the results with confidence.

Not all intermittent troubles in a heater string are tube troubles—be on the alert for cold solder connections and breaks in a printed circuit board. Also keep in mind not to section off a group of tubes where the voltage drop across the section (under normal conditions) exceeds the firing point of the neon lamp.

Construction

Any kind of a small cabinet can be used to house the neon lamps and their limiting resistors. If you use neon lamps with resistors built in you can save some assembly time. Neon lamps can be NE-2's and the resistors can be about 100,000-ohm, ½-watt jobs. Follow the circuit shown in Fig. 2. There is nothing critical about the construction. It's a good idea to pass the test leads through grommets in the cabinet to prevent abrasion of the insulation, and to use small insulated alligator clips to prevent shorts in a crowded chassis. The lamps can also be pressure-fitted into appropriate sized grommets or mounted behind a set of holes as shown in the photo.

If you wish, you can dress up the front of the cabinet with markings showing typical tube lineups or heater pin connections. **R-E**

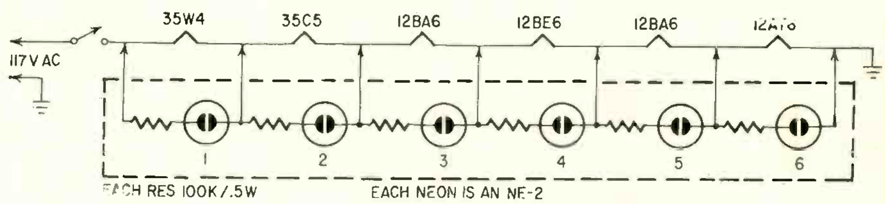


Fig. 2—With separate lamps for each tube in the string, you can spot trouble quick.

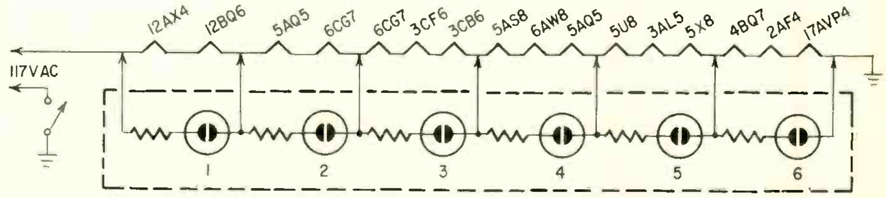
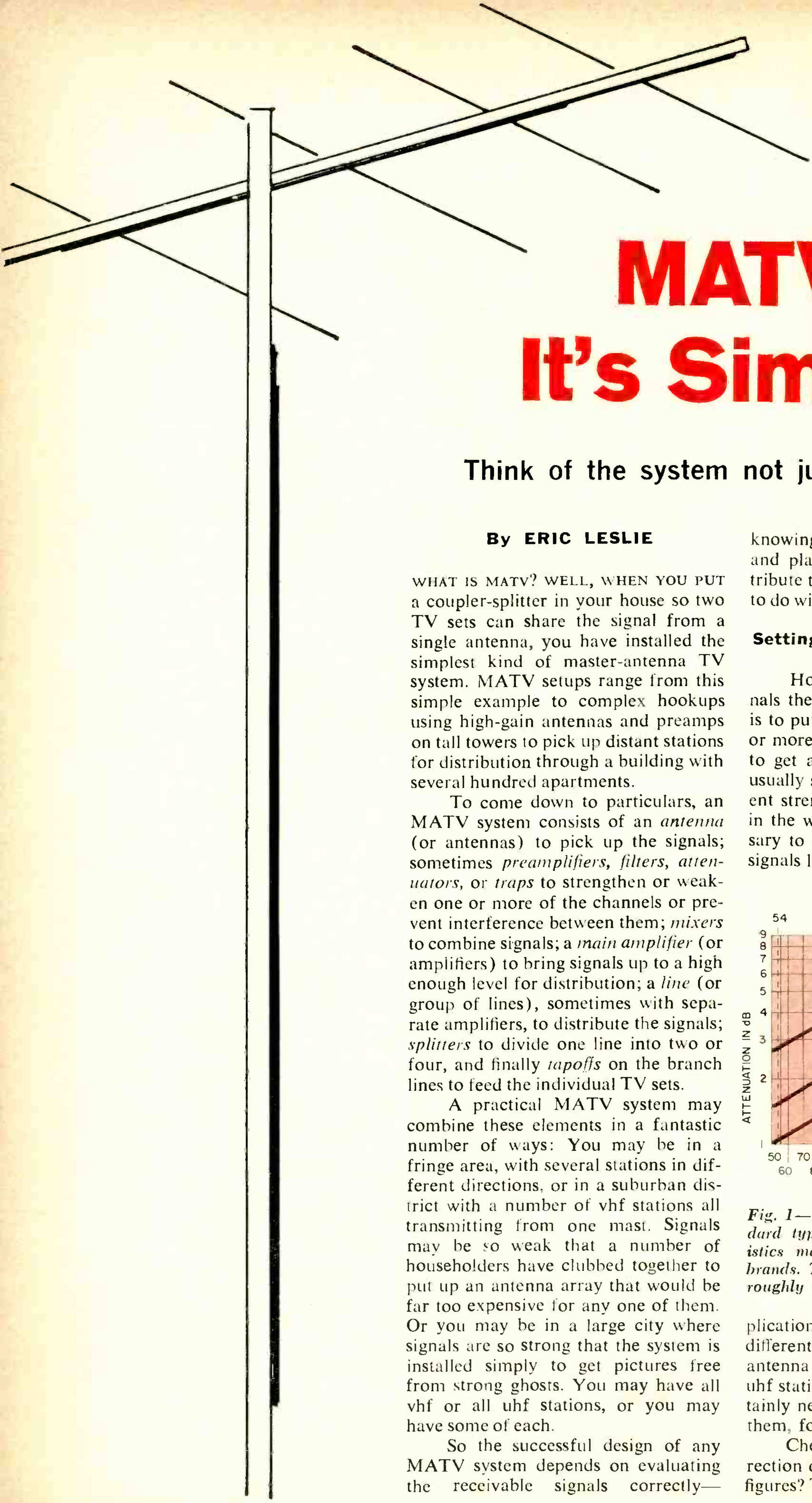


Fig. 3—When the number of tubes exceeds the number of neon lamps, divide the string into sections and localize the fault. Then monitor each lamp in the defective section.



MATV It's Simple

Think of the system not just the antenna

By ERIC LESLIE

WHAT IS MATV? WELL, WHEN YOU PUT a coupler-splitter in your house so two TV sets can share the signal from a single antenna, you have installed the simplest kind of master-antenna TV system. MATV setups range from this simple example to complex hookups using high-gain antennas and preamps on tall towers to pick up distant stations for distribution through a building with several hundred apartments.

To come down to particulars, an MATV system consists of an *antenna* (or antennas) to pick up the signals; sometimes *preamplifiers, filters, attenuators,* or *traps* to strengthen or weaken one or more of the channels or prevent interference between them; *mixers* to combine signals; a *main amplifier* (or amplifiers) to bring signals up to a high enough level for distribution; a *line* (or group of lines), sometimes with separate amplifiers, to distribute the signals; *splitters* to divide one line into two or four, and finally *tapoffs* on the branch lines to feed the individual TV sets.

A practical MATV system may combine these elements in a fantastic number of ways: You may be in a fringe area, with several stations in different directions, or in a suburban district with a number of vhf stations all transmitting from one mast. Signals may be so weak that a number of householders have clubbed together to put up an antenna array that would be far too expensive for any one of them. Or you may be in a large city where signals are so strong that the system is installed simply to get pictures free from strong ghosts. You may have all vhf or all uhf stations, or you may have some of each.

So the successful design of any MATV system depends on evaluating the receivable signals correctly—knowing what you have to work with; and planning your installation to distribute them efficiently—knowing what to do with your working material.

Setting up a system

How to find out what kind of signals there are in your area? First step is to put up a test antenna (or use one or more already up). Now things start to get a little complicated. There are usually several station signals of different strengths. You are most interested in the weakest one. (It may be necessary to do something about too-strong signals later, but that's a different complication.) If the signals come from different directions, you may need an antenna for each one. And if there is a uhf station or two, you will almost certainly need an antenna for each one of them, for best results.

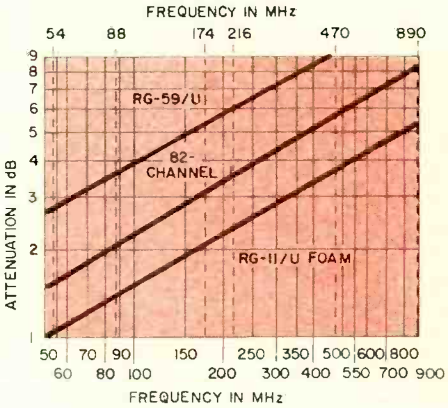


Fig. 1—Approximate impedance of standard types of coaxial cable. Characteristics may vary slightly with different brands. The curve for RG-59/U foam is roughly the same as that for 82-channel.

Check the signal strength and direction of each station. How to get the figures? There's only one reliable way—

use a field-strength meter. If you are making a single installation, borrow or rent one. But if you plan to make more installations in the future, you can't afford to be without such a meter. Of course, one of those small, battery-operated portable TV receivers can give you a fair idea of signal intensity. It can also tell you whether or not you've got ghosts—which the field meter can't see.

What you're after is rf signal; if there's enough on the roof, or somewhere reasonably close above it, then an MATV system is practical. If the signal is too weak, a system isn't feasible.

While there are other ways to conduct a signal search and make a system estimate, this is the easiest. Get up on the roof, and take along that field-strength meter and a portable TV set. Judging from the pictures others in the area get, decide whether to try an antenna with medium or high gain. You may even need a mast-mounted preamp and a short tower if you're way out in the deep-fringe area.

Using the field meter, find out how many microvolts of rf you get on each channel you hope to use. Then hook up the midget TV and go over the channels again. The field meter can't see ghosts; the receiver can. Swing and reposition the antenna, use the booster if necessary, but keep trying until you get the best possible picture on each channel. Keep a record of how many microvolts on each channel, which way the antenna's pointing, which antenna, which preamp, etc.

Don't forget to recheck the setup at least once or twice. Check it during the day and again at night. Check it today and then tomorrow. You may find atmospheric variations and have to pick another spot for the antenna to get a day-in, day-out stable signal.

Remember, once you establish that the rf is up there, even if a stacked Yagi and a high-gain preamp is needed to dig it out of the noise, only then can you make the rest of the system. It's fairly easy to add line amplifiers to overcome line, splitter, and tapoff losses. The hard part is setting up the head end.

Go to the bottom

The distribution network in an MATV installation is calculated from the far end—the last receiver on the longest line. There are losses all the way back to the amplifiers, and you simply add them up in decibels. (If you can't work with dB's, read the article on decibels in the February 1968 issue of RADIO-ELECTRONICS.)

The greatest signal loss in a new MATV system is usually in the distribution lines. It's between 8 and 9 dB per 100 feet at 900 MHz in most of the 82-channel coax now used. (This stuff goes by various brand names. It has less loss than RG-59/U but is cheaper than RG-11/U foam.) The loss drops with frequency, and if the highest channel you ever expect to have is, say, channel 43, you can figure losses at only 7 dB per 100 feet (see Fig. 1).

A rough example of a simple apartment system was calculated in the article previously mentioned. Let's try a more complex one here. This is a garden apartment development with four buildings. Two of them have 16 apartments each; the other two have 8 each. The two buildings in front are 70 feet apart; the other two are 200 feet behind them. The superintendent's office is in one of the front buildings. The antennas and head-end equipment will be installed there (unless tests show much less interference—automotive or otherwise—at the rear).

Stations in range are three: two vhf and one uhf. The vhf stations are in different directions, so two antennas will be needed for them, plus a third for the uhf station. Signal varies from 20 dBmV (10,000 μV) on one vhf signal and 10 dBmV (3,000 μV) on the other to -6 dBmV (500 μV) for the uhf station. (0 dBmV is, of course, 1 millivolt, or 1000 μV.

Since there is only one uhf station and no immediate prospect of another, we can use a single-channel amplifier for the uhf signal. A single broad-band amplifier can be used for the two vhf stations. The highest frequency ever likely to be used is channel 43, for which the losses in the 82-channel

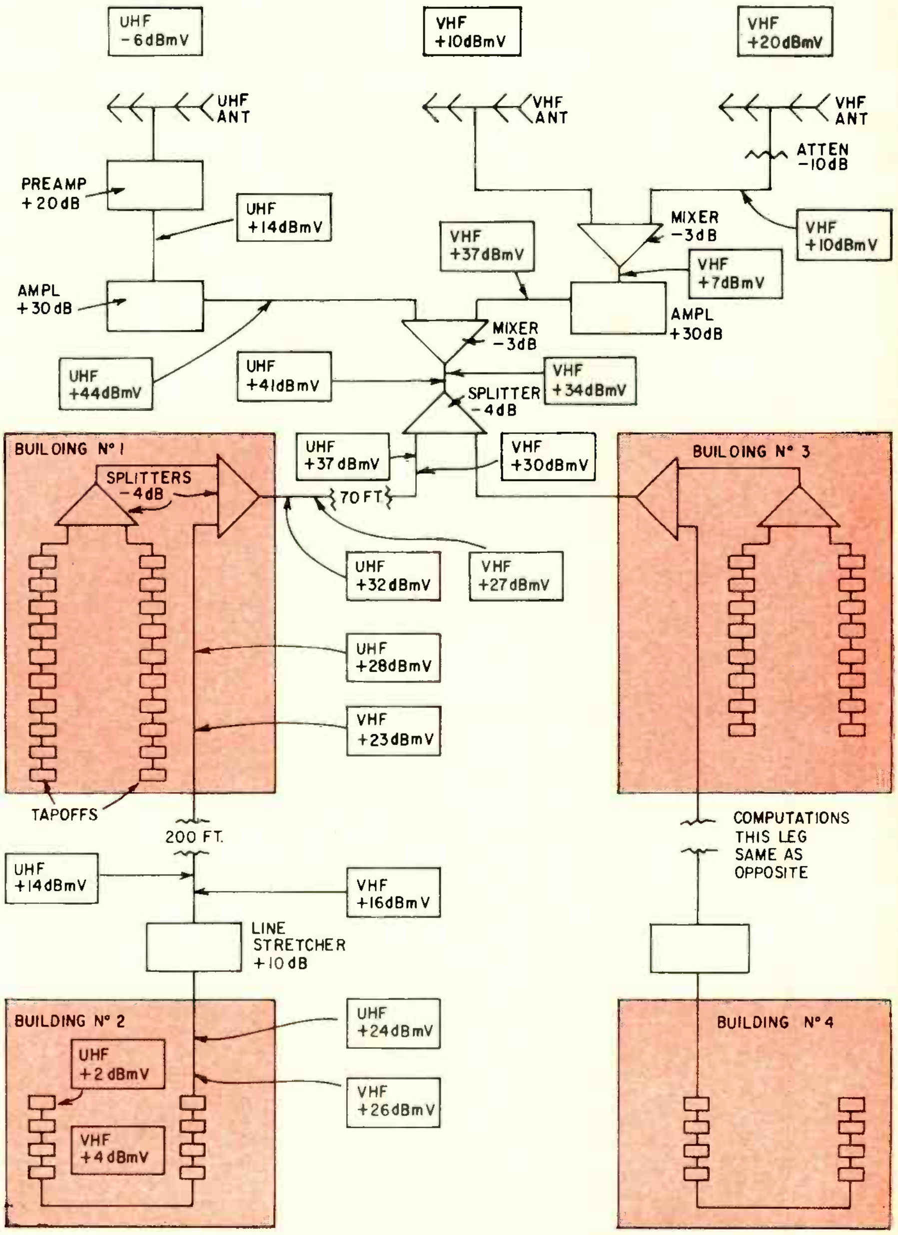
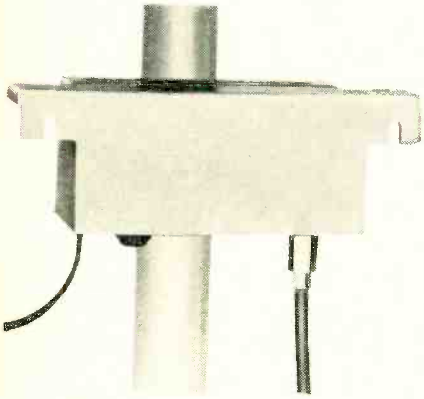


Fig. 2—The four-building garden apartment installation. The same general arrangement could be used in a small motel or vertically for an apartment building.

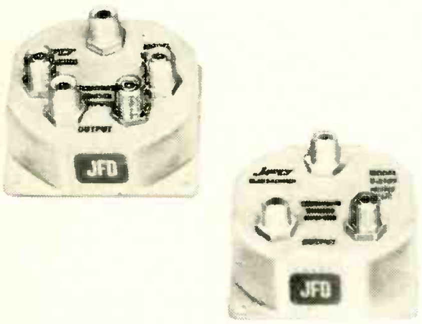
Example of a one-channel, or strip, uhf amplifier, the Blonder-Tongue MCS-U.



Blonder-Tongue photo

Mast-mounted amplifiers like this may be one-channel or broadband, uhf or vhf.

Line-extending amplifiers, like the JFD Line Stretcher above, can maintain moderate signal levels over long distribution lines. This unit's gain increases with frequency, to compensate for the rising loss characteristics of coax cable.



Active splitters. The two-way unit, at right, has a gain of 2 to 6 dB (increasing with frequency to compensate for the frequency-dependent cable losses). Gain of four-way type, left, is 1 to 3 dB.

Combination tapoff. One-output types, for 75 or 300 ohms, are more common.

cable are a little less than 7 dB per each 100 feet.

Standard practice for many years was to convert uhf signals to vhf channels. Amplifiers and coax to efficiently handle uhf over any long cable runs were not easily available. This is no longer true. Also, all new receivers sold have all-channel tuners, and there are more stations on the air, making conversion systems not so practical for the future.

Plans and calculations

On first looking over the situation, it appears that two schemes could be followed. Starting with Building No. 1, we could run a line to No. 2, then to No. 3 and on to No. 4. Or we could run a parallel hookup, with one line from building No. 1 to No. 2 and another to No. 3 and No. 4. Drawing a few layouts and calculating makes the parallel method seem preferable.

So we start—at the last outlet in Building No. 2—with our terminal tapoff loss. We can use a 13-dB tapoff here. Then we have the through (or insertion) loss of the 8 tapoffs at, say, 0.5 dB each. The distribution cable in the building will lose about 5 dB and the line to No. 1 some 14 dB. Here we lose another 4 dB in the splitter and 5 dB in the line to the head-end equipment. We have another splitter and the mixer here, about 7 dB. Tabulated, our losses run:

Terminal loss	13 dB
8 tapoffs @ 0.5 dB	4
340 ft cable @ 7 dB/100 ft	24
2 splitters @ 4 dB	8
1 mixer	3
	52 dB

This would call for quite a bit of power from the head-end amplifiers, and might mean very heavy signals to the receivers nearest the head end, with weak ones near the end of the line. Fortunately, the line-extending amplifier, or *line stretcher,* makes it possible to avoid that. A small transistor amplifier inserted near the end of the line brings the signal up 10 or 15 dB, depending on whether it is designed for both vhf and uhf or for vhf only.

With a line extender giving 10 dB gain, we can start at the head end with a little more than 40 dB, or only about one-quarter the voltage that would have been required for a 52-dB level.

So we tabulate our gains: For the uhf channel, where losses will be highest, we have:

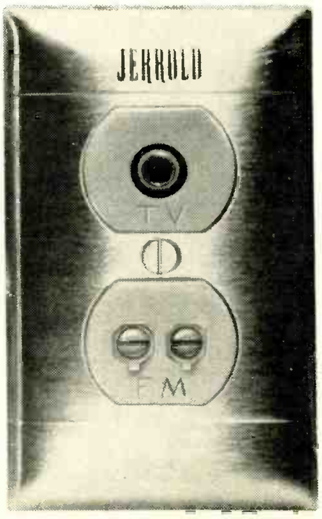
Antenna signal	−6 dB
Antenna preamp	+20
Main amplifier	+30
Line stretcher	+10
	+54 dB

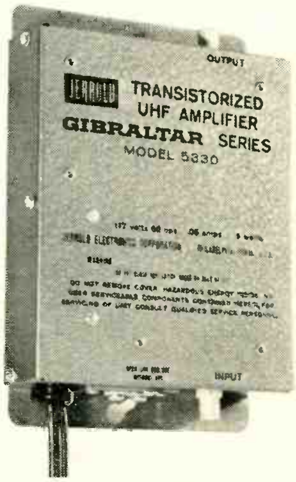
which will give us an extra 2 dB of signal at our last set on the line.

The logical place for the line stretchers would seem to be in Building Nos. 2 and 4, where a boost will be in just the right place to give enough signal to the last set. The whole plan will then look like Fig. 2.

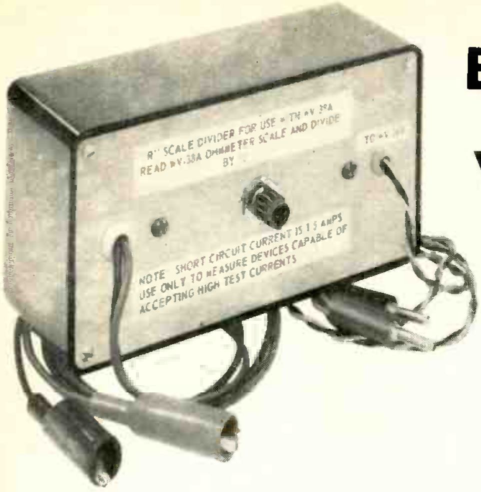
The vhf side

Now, how about that vhf signal? Input level is higher and line losses lower. Will we have overloading? Distortion? Crosstalk? As a start, we put a 10-dB attenuator in the lead from the antenna with 20 dBmV signal, bringing the level to the same as the other. Output will now be +37 dBmV from the main amplifier, boosted by another 10 dB at Building Nos. 2 and 4. The main difference in loss will be in the cable, where we will have about 3.5 dB loss per 100 feet, instead of 7. This will mean a higher, but tolerable signal,
(*continued on page 91*)





Five-transistor broadband uhf amplifier.



BUILD: VOM RESISTANCE-SCALE DIVIDER

How to get a 0.1-ohm reading on a 1-ohm spot

By J. F. STERNER*

IF YOU HAVE TRIED TO MEASURE HALF an ohm (or less) on your vom, you probably gave up fast. On the typical 20,000-ohms-per-volt vom, the 1-ohm division occupies about ¼ inch of the scale. Reading tenths of an ohm on such a scale is chiefly guesswork.

This R-scale divider expands the R × 1 scale by a factor of 10; a 1-ohm reading occurs at the 10-ohm mark. The other readings follow suit—the original 1-ohm mark becomes 0.1 ohm, and the 30-ohm mark becomes 3 ohms.

The divider is very useful for checking mechanical ground connections on chassis of hi-fi sets and ham gear, for relay contacts, for connections in coaxial cables, and even for ground connections in automobiles. You can use this accessory with an RCA WV-38A or a Simpson 260 (Series 3 or later) vom, or any other vom with a 50-μA range and an R × 1 scale similar to the above.

There's another advantage in this divider: It's more accurate than the usual vom's low-range ohmmeter scale. Since most vom's use a single D or C cell on the R × 1 range, accuracy depends greatly on the internal impedance of the battery. The R-scale divider uses *four* D cells in parallel, which means one-fourth the usual internal impedance. Thus overall accuracy is about four times that of the usual vom.

Construction

You couldn't ask for a simpler piece of gear to wire (Fig. 1). The divider is built in a plastic utility box (Fig. 2), with the four D cells nesting in the bottom. Although you can use small wire to connect the divider to the vom, you must use *heavy test leads* to connect to the unknown resistance. Use at least No. 14 wire and make the leads no longer than 20 inches. Carry the same wire back to the batteries and solder directly to the cells. Be sure to make good solder joints at the batteries and at the terminal strip where R1 is connected. Short-circuit current is 1.5 amperes, so circuit resistance must be as low as possible.

For best results, use good alligator clips. The clips should have strong springs and clean jaws, to make good contact with the unknown resistance.

Operation

Plug the positive (red) divider-to-meter lead into the 50-μA input of the vom; insert the negative (black) lead in the vom common input jack. Set up the vom on the 50-μA dc range. Then short the test leads of the divider and adjust the ZERO SET pot (on the divider) for full-scale (zero ohms) reading on the vom. External resistance values measured will then equal one-tenth the values printed on the R × 1 scale.

Special considerations

The R-scale divider should be used only to test circuits capable of accepting high test currents. As mentioned before, short-circuit current is 1.5 amperes. The current flowing through a 1-ohm external circuit is 750 mA at 0.75 volt; that through a 3-ohm circuit is 375 mA at 1.125 volts.

Such high current is desirable for testing supposedly low-resistance connections on contacts. Even a low resistance will show a prominent reaction to a high current. **R-E**

* Electronic Components and Devices Div., RCA, Harrison, N. J.

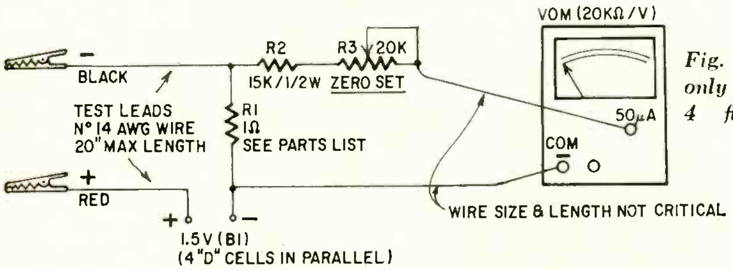


Fig. 1—Divider has only 3 resistors and 4 flashlight cells.

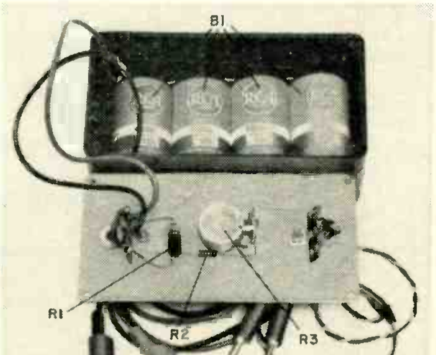
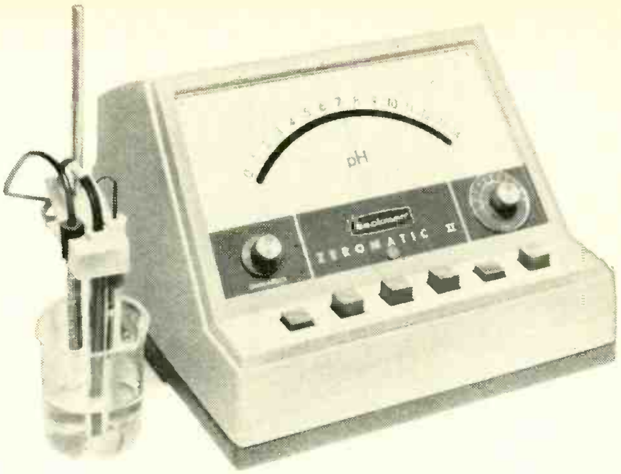


Fig. 2—Use short heavy leads to connect the batteries and the alligator clips.

Parts List

B1—1.5-volt D cells. (4 reqd.)
R1—1-ohm, 1%, 5-watt resistor. (You can make your own, by winding a sufficient amount of fine copper wire around a high-value 2-watt resistor.)
R2—15,000-ohm, ½-watt resistor
R3—20,000-ohm, linear-taper potentiometer
MISC—1⅞" x 3¾" x 6¼" plastic utility box with cover; 2 3-lug terminal strips; 2 alligator clips; 2 plugs to mate with vom input jacks; grommets, wire, etc.



pH METER REPAIRS ARE A CINCH

It's a supersensitive VTVM with superclean probes

By JOHN W. DIETRICH

THE *p*H METER IS PROBABLY THE MOST common electronic instrument in any well-equipped chem lab (industrial, research, educational or whatever). While, unlike TV sets, not every family is likely to have one or two, it seems safe to say that every firm that does serious chemical laboratory or manufacturing work will have at least one.

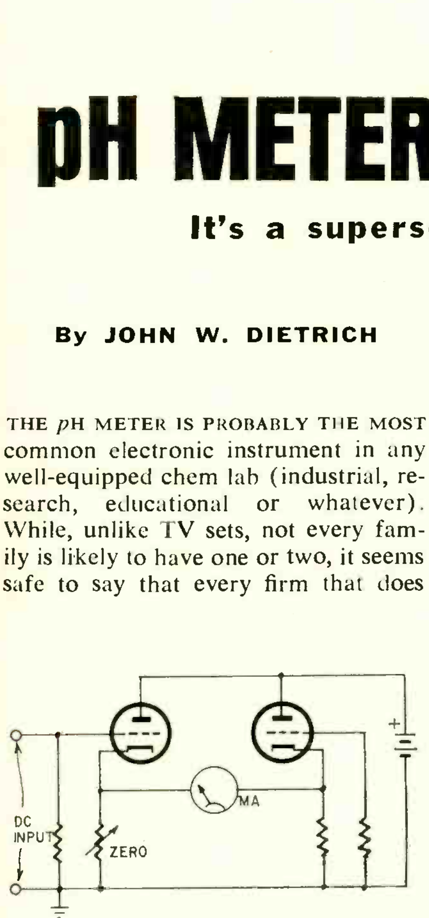


Fig. 1—Simple dc differential amplifier is basis of shop vtvm as well as high-sensitivity circuit in the pH meter.

So what *is* a *p*H meter? For that matter, what is *p*H?

The *p*H unit is a measure of relative acidity or alkalinity of a solution. It is somewhat analogous to the decibel in acoustics and electricity. Like the dB, it is logarithmic. (For a more detailed explanation of *p*H, see Measuring *p*H.)

A *p*H indication of 7 is established as *neutral* (that is, the solution is neither acid nor alkaline or basic). A *p*H of zero to 7 indicates an acid solution; a *p*H of 7 to 14, an alkaline (basic) solution.

The precise measurement and control of *p*H has become extremely important in many aspects of chemical work, perhaps especially so in biological, medical and agricultural fields.

The meter part of the *p*H meter is little more than a sophisticated and very precise vtvm, using circuitry similar to that of your shop vtvm. The unique instrumentation of the *p*H meter is in the probes, which generate a very tiny emf that depends on the relative acidity or basicity of the solution they are immersed in.

Because the probes are extremely delicate devices, there is little you can do for them by way of servicing or repair. On the other hand, they are usually built to last. Unless they are dropped or otherwise seriously mishandled, they will give little trouble.

Because the *p*H meter deals with *micromicroampere* currents, the vtvm circuitry associated with it must have extremely high input resistance or it will simply short-circuit the measured voltage source. The typical vtvm has about 11 megohms input resistance. The better general-purpose lab meters have as much as 110 megohms. You will recall that an 11-megohm source of voltage when bridged by an 11-

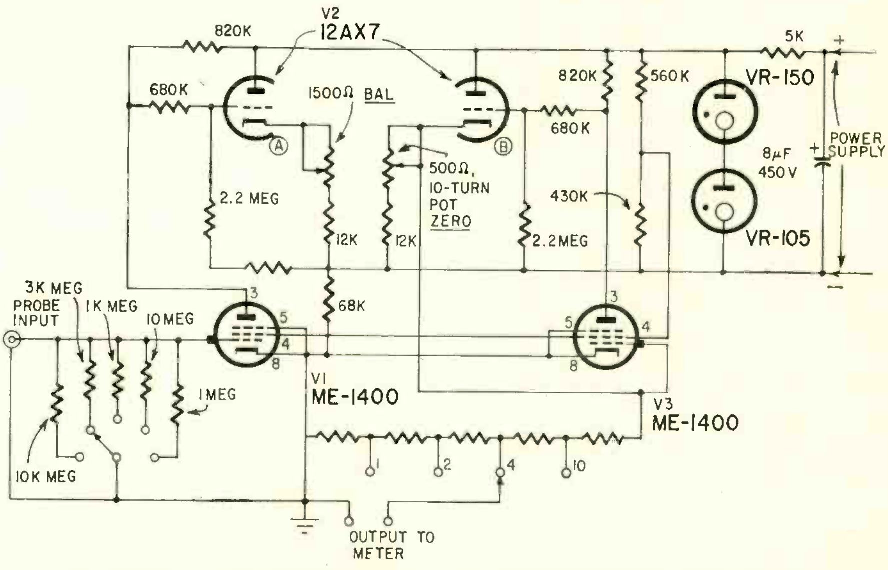
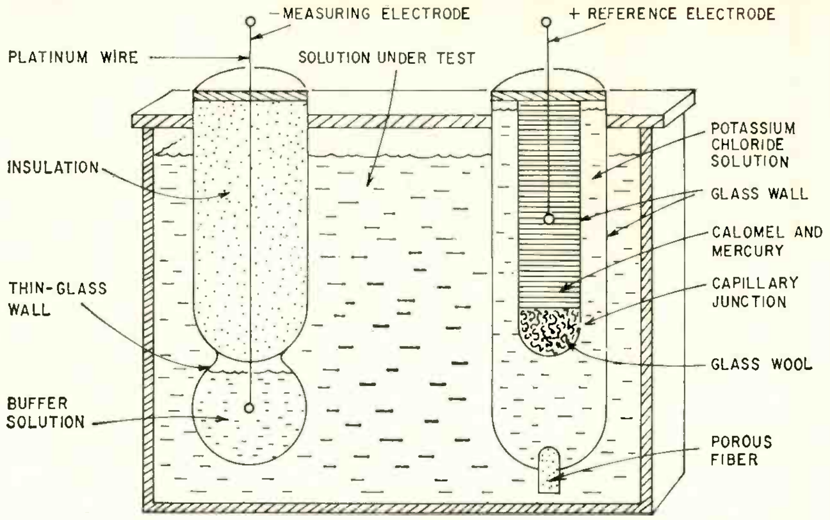


Fig. 2—Circuit of a typical pH meter. Note balanced arrangement and location of balancing and zeroing adjustments. Meter movement (standard) is not shown.

megohm meter "looks like" only half the voltage that would be there without the meter. Thus, to measure voltages from glass probes whose resistance is around 500 megohms or higher, the meter input resistance should be around 1000 megohms or better.

Usually a balanced meter circuit is used to compensate for slight drift in the meter components. This is typical of ordinary vtvm design, as well as of *p*H meters that use dc amplifiers The milliammeter is usually connected between the cathodes of two balanced triodes, typically 12AU7's or 12AX7's, as shown in Fig. 1.



The acidity or alkalinity of a solution is gauged usually by the concentration of hydronium ions (formula H_3O^+) in the solution. The pH unit indicates that concentration, and is defined by this equation:

$$pH = \log \frac{1}{h},$$

where h is the hydronium-ion concentration, and "log" is the common logarithm of the fraction (1/h)—log to base 10.

Pure water is neutral at 77°F and has pH of 7. A pH of zero is defined as an acid of unit strength; a pH of 14 is defined as a base of unit strength. A change of one pH unit corresponds to a change of 10 in the ratio of concentration.

The drawing shows the basic scheme for measuring pH with the so-called glass electrode. The glass membrane surrounding the measuring electrode is extremely thin—around 0.1 mm, and has an electrical resistance of somewhere around 1000 megohms. It is part of the electrical circuit, and thus the current that can be drawn from the cell is very tiny. Hence the need for an electronic measuring instrument with unusually high input resistance, as described in the body of the article.

No fingerprints

The *p*H *meter* is highly sensitive to leakage in input-circuit components, due for example to minute amounts of dirt or to fingerprints. The insulation must be perfect. even in considerable humidity. The modern *p*H meter is sensitive to currents as small as 10^{-17} ampere! (This amounts to only 64 electrons per second flowing in the probes!)

The electrometer tube makes this high sensitivity possible by its special design. A grid current of 1 pA (1 picoampere, or 1 micromicroampere) produces a 1-volt drop across 10^{12} ohms. Therefore the electrometer grid current must be much lower if bias is to be reasonable and under control. Design of the electrometer tube and its operation stresses absolute minimum grid current. The tube is highly evacuated to minimize ion effects on grid current. A number of the more common electrometer tubes are listed in the table, along with base diagrams and some typical operating voltages.

Glass resistors

Grid resistors for electrometer tubes are often switched to provide several input resistances. Typical values are 100, 1000, 3000 and 10,000 megohms. The resistors are glass-encased for stability and low leakage. Handle them by their wire leads, touching the glass as little as possible, for any leakage path shunts the resistance. Be sure to wipe dirt and fingerprints from the glass with a clean cloth and alcohol when work is completely finished.

Electrometer plate voltages are usually in the 5- to 15-volt range. The low voltage keeps electron velocities in the tube low and prevents gas ionization and secondary emission. The filament is operated at low voltage to minimize heating of grid wires and photoelectric effects. Electrostatic and light shielding must be good, or the few microamperes of plate current will not be true copy of the grid voltage applied by the probes. A gain of 2 or 3 is common, with electrometer plate-load resistances of 500,000 ohms typical. The electrometer grid circuit has a large time constant—the product of the high resistance and the grid-to-cathode capacitance of the tube.

Fig. 2 shows a typical electrometer circuit. The Mullard type ME-1400 tube is used in a balanced input circuit. Operating-voltage variations and aging are neutralized in this way. The ZERO control is adjusted for a *p*H reading of 7 at the start of measurements. The probes are placed in "pure" water for this adjustment in the lab. The service tech may simply short the input jack, omitting the probes.

A change in plate current of V1 when a dc voltage is applied to its grid changes the voltage between points A and B. The attenuator network at the output is the calibration resistance for this unit. (No values are shown because they vary with each instrument.) Although Fig. 2 shows a dc amplifier, some *p*H meters may use ac amplifiers with a chopper at the input. The principle is the same in both cases.

One *p*H meter uses a 12AX7 as the electrometer tube. The input resistors are limited to 2000 megohms because a true electrometer tube is not used. This limits the input sensitivity to a degree, but is entirely practical. If high input sensitivity is not important, any good vtvm may be used as a *p*H meter of sorts.

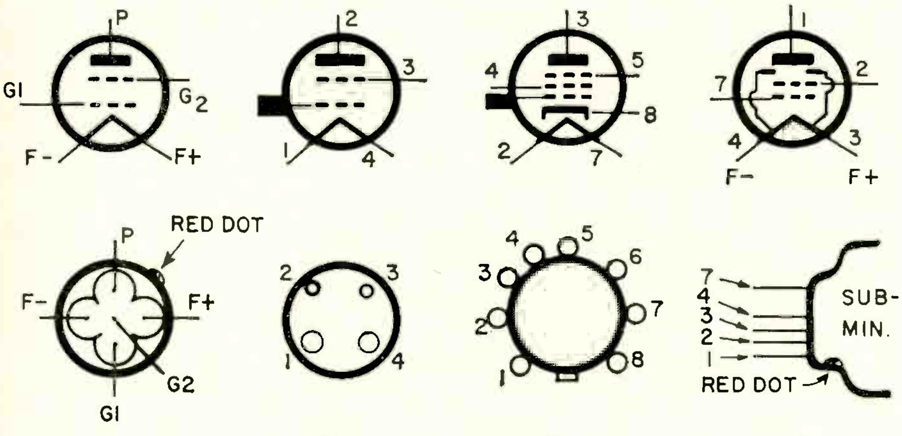
Now, solid state

Until recently, no transistor could approach the extremely high input resistance of the electrometer tube. An IGFET (insulated-gate field-effect transistor) now does the job, however. The type 2N3796 can be used in a very compact and portable *p*H meter.

The *p*H meter can be serviced as easily as your vtvm, if you remember the critical points of the electrometer circuit. They are: high input sensitivity, very low operating voltages and excellent insulation. If you receive the probes with an instrument for repair, isolate the trouble to either probes or electronic circuit. Frequently the probes are at fault. A good ground or a clean shiny contact surface mean

ELECTROMETER TUBES

Type	Mfr.	E_f (volts)	I_f (mA)	E_p (volts)	I_p (μA)	E_{g1} (volts)	E_{g2} (volts)	Base	Remarks
VX-41A/5800	Victoreen	1.25	10	5	7	−3	4	1	
32, 931, 932, 2532	Beckman	1.5	60	15	200	−2	6	2	
1229	Gamma	2	60	15	200	−2	6	2	See Beckman 32
ME-1400	Mullard	4.5	32	15	200	−3	12	3	
CK-5886	Raytheon	1.25	10	12	6	−2	4.5V	4	As pentode
CK-5886		1.25	10	10.5	200	−3	—		As triode



1 2 3 4

little to those who use the instruments, so green, corroded contacts are common. Bad cable grounds are even more common. Either can produce more voltage by electrolytic action than the probes can develop. Burnish the contacts to a shine, and clean the insulation with alcohol.

Isolate the trouble by removing the probes and shorting the *p*H meter input. If the ZERO control is effective and the meter can be zeroed, chances are the meter is okay. If not, the trouble is in the instrument and not in the probes. Double-check by switching the meter to the ±700-mV range and apply a millivolt calibration source, a known voltage to make the meter read between half and full scale. The meter should indicate the applied voltage accurately.

Meter trouble

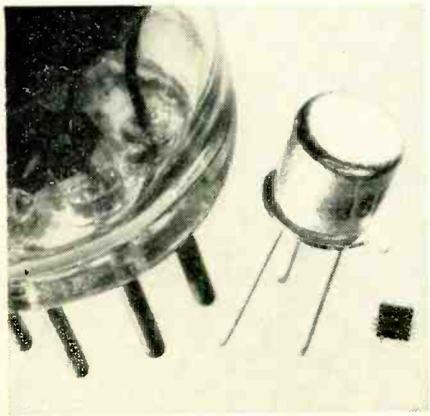
If the instrument is not ac-powered, check or change the batteries. Test tubes by substitution with new tubes. Be *sure* to wipe the electrometer tube's glass envelope clean with alcohol. Then dry it free of dirt and fingerprints. Troubleshoot by starting with the milliammeter and working toward the *p*H meter input. Look for balanced voltages if the tubes are in pairs. Remember the instrument is merely a current amplifier. Use your vtvm and check for low plate and screen voltages on the electrometer tube(s). Watch for extremely small (very-high-resistance) leakage paths in the electrometer grid circuit.

Make sure the input jack has bright shiny contacts and the insulation is good. Many corrosive materials are splashed around in the lab. and corroded contacts are probably the prime cause of trouble. **R-E**

NEWS BRIEFS

(continued from page 2)

manium.) In 1948 Shockley patented the junction type. (A single bar is used, composed of three layers of alternately positive or negative semiconductor material.) Today the point-contact type is nearly obsolete, while virtually all transistors are junction types. (An exception is the insulated-gate, field-effect transistor.)



In 1956, Bardeen, Brattain and Shockley won a Nobel prize for their discovery of the transistor effect. Today the three physicists are college professors.

Meanwhile, the transistor has grown from a laboratory curiosity to what is probably the most important and widely used electronic device.

In most areas of electronics, transistors have almost completely replaced vacuum tubes. The trend toward miniaturization has continued with several transistors being encapsulated—along with other components—in a tiny IC. Photo shows base of a vacuum tube (left), a transistor (center), and an IC (right).

In its 21st year, the transistor has really come of age.

E. N. PICKERILL DEAD AT 82

The man who held wireless license No. 1 issued by the U.S. Government, died of a heart attack in January at his home in Mineola, N.Y.

Elmo Pickerill learned radio from Marconi and de Forest, and flying from the Wright brothers. He met Dr. de Forest in 1904 and became interested in the then-new art of wireless telegraphy. Later he built and operated the first wireless station atop New York's Waldorf-Astoria hotel. He was a ship's radio operator for many years and served in the Signal Corps during World War I.

Wanting to prove that radio could link aircraft with the ground, he persuaded Orville and Wilbur Wright to teach him to fly one of their planes. Flying solo on August 4, 1910, he transmitted the first wireless message from an airplane. Later he became a barnstorming pilot and chief pilot for RCA, where he worked from 1920 to 1950. As early as 1925, he foresaw the importance of radio to aviation, predicting that successful airlines would depend on radio for their operation.

Pickerill was the recipient of many awards in both radio and aviation. At his death, he was a past president and present director of the Veteran Wireless Operators Association, past president and present secretary of the de Forest Pioneers, and a member and former officer of several aviation societies. **R-E**

HOW TO USE A DE-Q'er

How to peak up a receiver

By LEONARD E. GEISLER

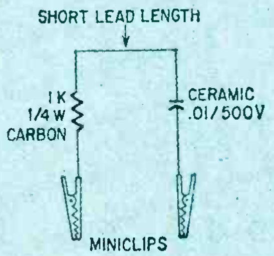


Fig. 1—The DE-Q-ER is used to sharpen the resonant point of the i.f. transformer windings during the alignment procedure.

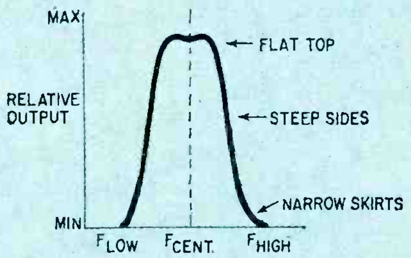


Fig. 2—Ideal i.f. amplifier response—steep symmetrical sides are indicative of good adjacent-channel selectivity.

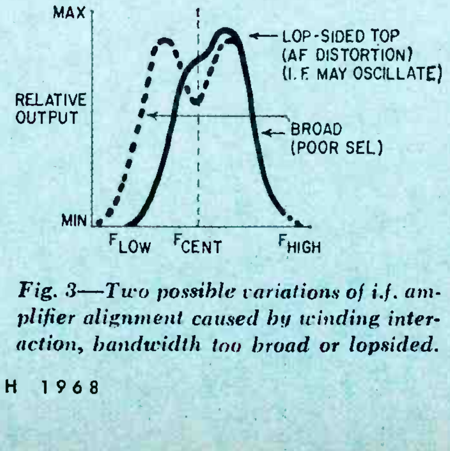


Fig. 3—Two possible variations of i.f. amplifier alignment caused by winding interaction, bandwidth too broad or lopsided.

Problem

Some communications and other type radio receivers seem impossible to align properly despite careful observance of ordinary alignment procedures.

Cause

Interaction and close coupling of coils in i.f. transformers tend to mask the actual resonant point of each winding, and it is sometimes difficult to pinpoint a peak reading within a narrow adjustment range. Loss of gain and poor selectivity are typical characteristics of a lop-sided or too wide an i.f. bandwidth. Distortion and loss of clarity set in when the bandwidth is too narrow. Not all receivers are designed to have the same bandwidth. But in order to get the receiver to do what it is supposed to, it is necessary to have it properly aligned.

Solution

Follow the alignment instructions if available, and use the DE-Q-ER shown in Fig. 1. Shunt the primary winding of the i.f. transformer to be adjusted with the DE-Q-ER and peak the secondary winding to the intermediate frequency. Switch the DE-Q-ER position to the secondary and peak the primary. Repeat these adjustments for the other i.f. transformers. In the case of broadbanded i.f. strips, having stagger-tuned, high-gain i.f. tranformers, as in some FM receivers and TV sets, the DE-Q-ER will help keep the set from breaking into oscillation during the alignment procedure.

Result

The i.f. passband should now have a relatively symmetrical response curve as shown in Fig. 2. Actual waveform depends upon transformer design. If you are using a visual alignment technique (scope and sweep generator) you can retouch the adjustments to optimize the response curve.

Discussion

Mutually coupled circuits—such as those found in i.f. transformers—react strongly when tuned close to resonance. The DE-Q-ER broadbands the winding it shunts and tends to make the coil look more like a resistive rather than an inductive device. Under these conditions, signal transfer is due to stray capacitance between primary and secondary windings, and interaction between coils is reduced considerably. The unshunted winding can be more accurately peaked at the desired frequency.

Several ac/dc table model radios, a transistorized all-wave receiver and some "antique" car radios which formerly whistled and chirped have been quieted with the aid of the DE-Q-ER. This method of alignment is not new, and there is a feeling shared by some, that, "If it's good enough for grandpa, it's good enough." **R-E**

How To Build A Crossover Network

Use a nomograph and skip the math

By MAX H. APPLEBAUM

AN OLD ADAGE STATES: "A CHAIN IS only as strong as its weakest link." Similarly, the frequency bandpass of an audio system is only as wide as its narrowest component.

Your amplifier and speakers may separately have flat responses beyond 20 kHz, but if the wrong frequencies, in the wrong proportions, are fed to either woofer or tweeter, decreased bandwidth and/or distortion may be the result. If the speakers are driven to full power ratings at frequencies outside their normal range, their voice coils may overheat. If too much low-frequency energy is fed to the high-frequency speaker, and some high-frequency energy fed to the low-frequency speaker, the overall efficiency of the unit will be reduced substantially.

Obviously, a properly designed and built crossover network is not only desirable, it is *necessary*.

Circuit function

Crossover networks are built in many different configurations. The simplest type is a single capacitor shunting the woofer in a series-connected woofer-and-tweeter pair (Fig. 1). A more complex type consists of two separate pi-section filters, one high-pass, the other low-pass (Fig. 2).

When crossover networks are used, each speaker is supplied with a certain range of frequencies, in varying degrees of amplitude. Typical crossover plots are shown in Fig. 3; the curves represent relative attenuation versus the ratio of the actual frequency to the cutoff frequency, for various rates of attenuation. Curves are drawn for both the woofer and tweeter outputs at each rate of attenuation which results from crossover networks normally used.

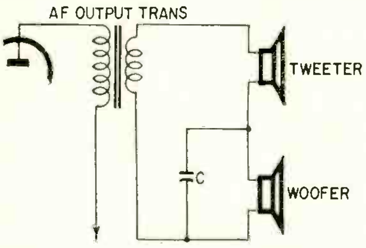


Fig. 1—Simple crossover circuit uses a single capacitor; to keep the highs out of the woofer. Slope is approximately 6 dB/octave . . . just a bit too gentle for best high-fidelity work.

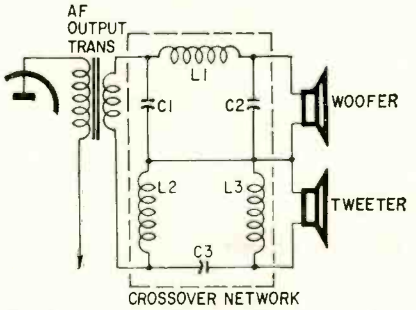


Fig. 2—Double-pi network usually has a cutoff rate of about 18 dB/octave. This may be too steep for some applications because of excessive phase shift above and below the crossover frequency.

Crossover frequency (f_c) is defined as that frequency at which the power delivered to both speakers is equal. This usually occurs with a 3-dB attenuation in power at each speaker, assuming an ideal network having no loss. The rate of attenuation is given in dB per octave, where an octave is defined as that range in which the frequency is either doubled or halved.

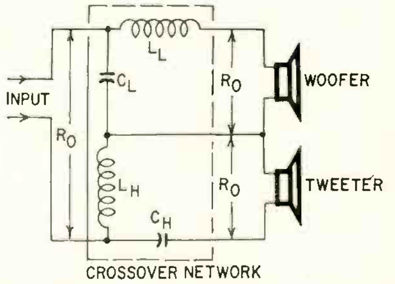


Fig. 4—The 12 dB/octave crossover network shown here is a happy medium between circuits that do too little, and those that do too much. Phase shift two octaves above and below the crossover frequency is about midway between the 180° for 18 dB/octave and 90° for 6 dB/octave networks.

The simple capacitor circuit of Fig. 1 provides attenuation with a gradual slope or rate of attenuation of 6 dB per octave. On the other hand, the complex network of Fig. 2 provides a sharp slope of 18 dB per octave. Each has a certain disadvantage. The single capacitor may not remove enough of the high frequencies from the woofer, while the sharp slope of the complex network may cause too much phase shift.

One of the most popular networks

(*Text continued on page 81*)

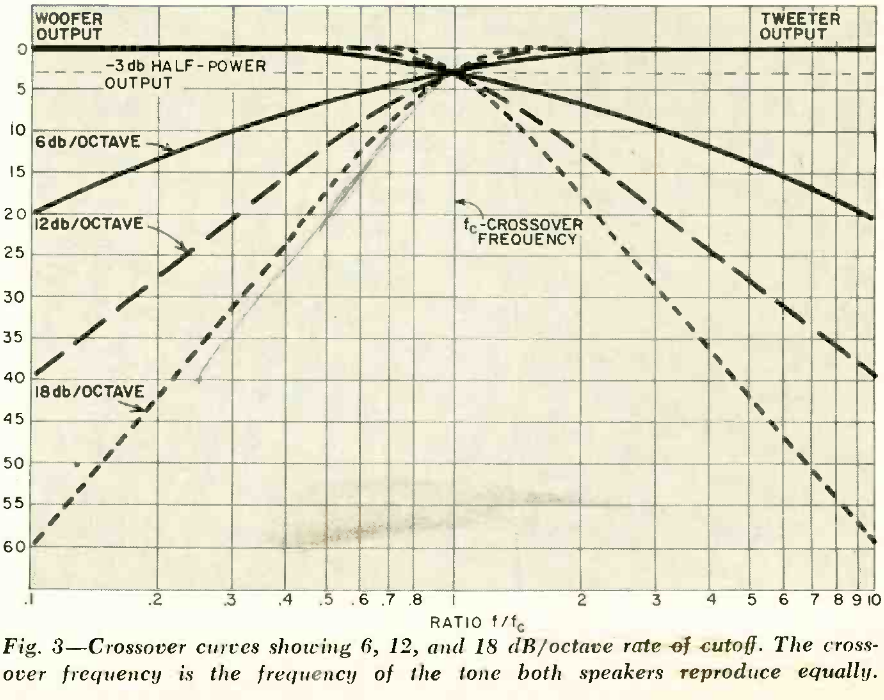
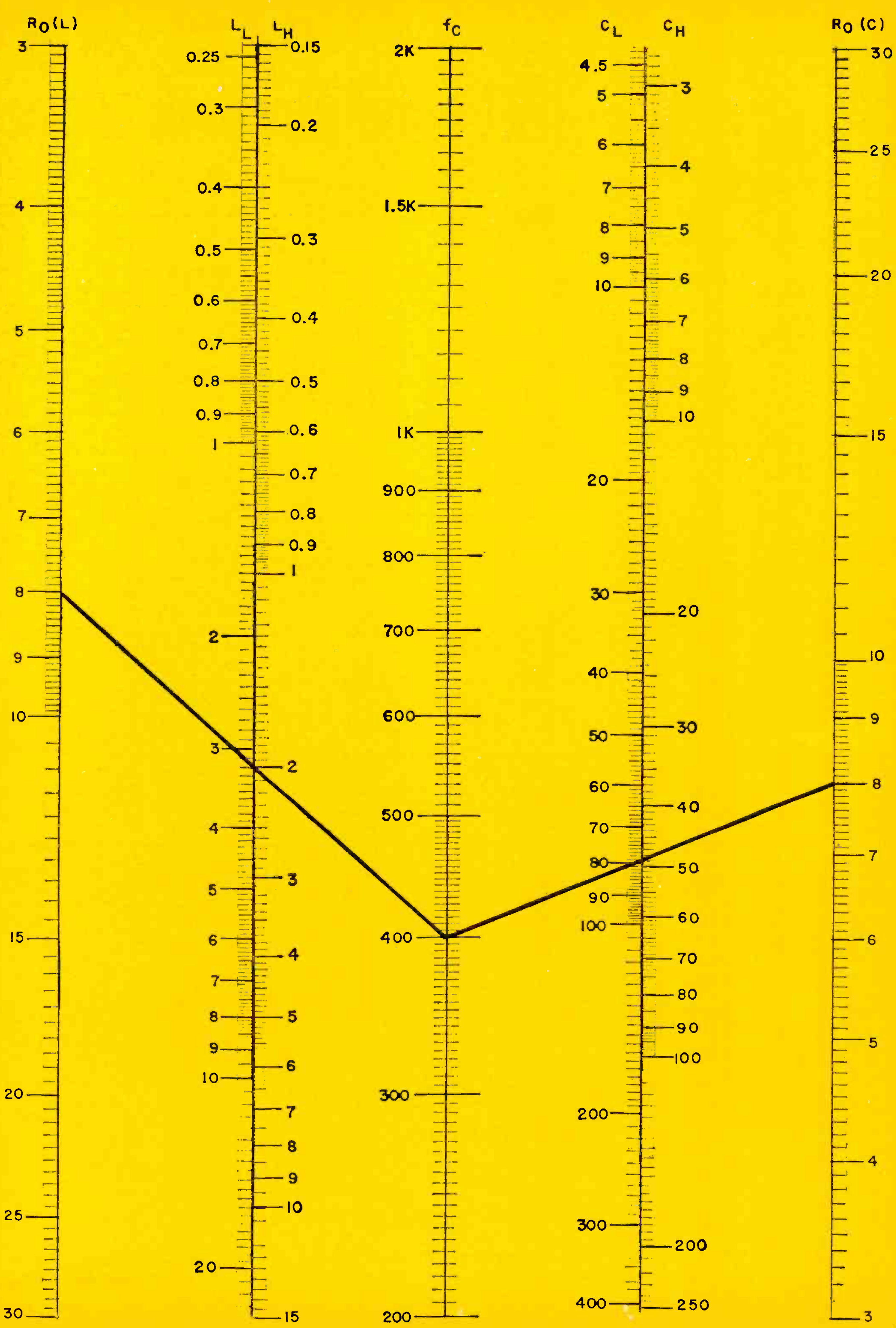
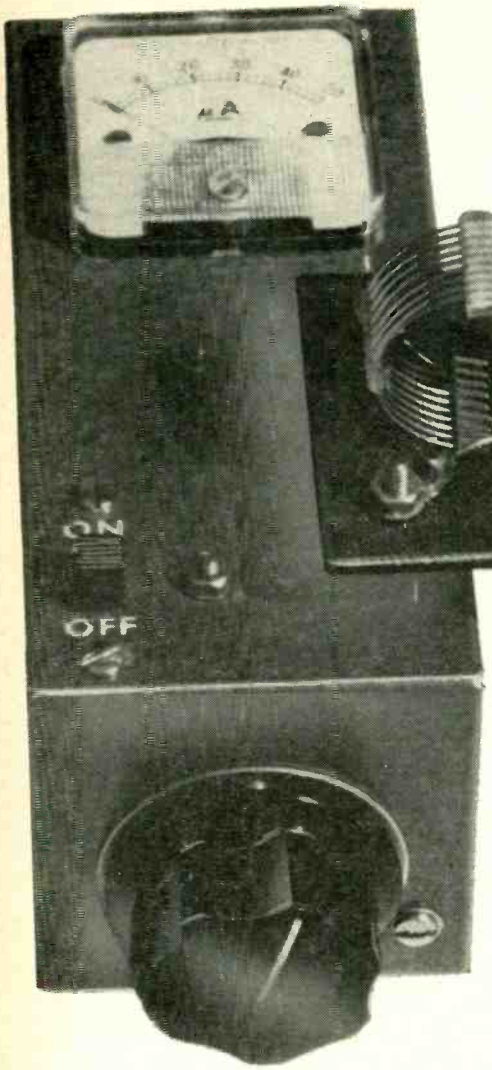


Fig. 3—Crossover curves showing 6, 12, and 18 dB/octave rate ~~of~~ ~~cutoff~~. The crossover frequency is the frequency of the tone both speakers reproduce equally.


RO (L)
3 4 5 6 7 8 9 10 15 20 25 30
LL
0.25 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 2 3 4 5 6 7 8 9 10 20
LH
0.15 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1 2 3 4 5 6 7 8 9 10 15
fC
2K 1.5K 1K 900 800 700 600 500 400 300 200
CL
4.5 5 6 7 8 9 10 20 30 40 50 60 70 80 90 100 200 300 400
CH
3 4 5 6 7 8 9 10 20 30 40 50 60 70 80 90 100 200 250
RO (C)
30 25 20 15 10 9 8 7 6 5 4 3



BUILD:

FET Field Strength Meter

Sensitive enough to check all transmitters . . . tunes 10 to 250 MHz

By LYMAN E. GREENLEE

USEFUL FOR TRANSMITTER TUNEUP, troubleshooting a rig or just making sure you're radiating full power, this field-strength meter FSM employs only one field effect transistor (FET) and a minimum of parts. It can be used in several radio services, as it covers the range of 10–250 MHz. Also, it's small, portable and battery-operated, simple to assemble and easy to use.

The device is sensitive—a 100-mW transmitter will throw the meter off scale at distances up to 10 feet with no antenna.

As shown in Fig. 1, the FET-FSM consists of a tuned circuit plugged into a high-impedance voltmeter. A set of six coils covers the range from 10 to 250 MHz.

Incoming rf from the tuned circuit is rectified by diode D1, and residual rf is filtered by pi-section filter RFC1–C3–C4. The resulting dc is applied to the gate of Q1, which is used as a variable resistor in the meter bridge circuit. Potentiometer R5 is the meter zero adjustment, while D2 limits meter current to about 1½ times full-scale value, or 75 to 100 μA. This avoids meter burnout by overloading. To prevent Q1 gate from floating, a 10-megohm resistor (R1) is used.

This circuit is ideal for modifying an existing field-strength meter; components are small and will probably fit inside present cabinets.

Design tips

Mount the tuned circuit components on a 2″ x 2″ piece of Bakelite. Each coil (L1) is connected to a pair of banana plugs that fit jacks J1 and J2 on the meter case. Be sure to use nylon jacks—as specified in the parts list—for proper frequency coverage.

Resistor R4's value is chosen to place the zero set position in the middle of R5. If the zero point falls at one end of R5, increase or decrease the value of R4 to move the zero point toward the middle of R5's range. It's best to complete assembly and then select the value of R4.

Set R2 at 1200 ohms before installation. After the circuit is working, make final adjustment of R2 by inserting a 0–100-μA meter in series with the 0–50-μA meter. Then adjust R2 for full-scale deflection of the 100-μA meter. Adjustment is not critical, however; the 0–50-μA meter

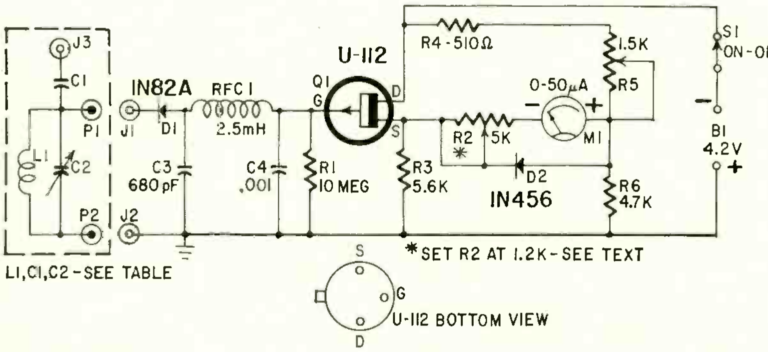


Fig. 1—Q1—an FET—makes the voltmeter high impedance. Rf induced into hi-Z tuned circuit L1-C2 produces a voltage which is indicated on meter in bridge.

Parts List

- B1—Battery, 4.2 volts, mercury (Burgess H133, Eveready E133, Mallory TR133, or similar).
- C1, C2—See table
- C3—680-pF silver mica capacitor
- C4—0.001-μF, 100-volt Mylar capacitor
- D1—1N82A diode
- D2—1N456 diode
- J1, J2, J3—Banana jacks, nylon (E. F. Johnson 108-902 or similar)
- M1—Meter, 0-50 μA (1⅝″ square)
- P1 through P12—Banana plugs (H. H. Smith 102 or similar)
- Q1—P-channel junction field-effect transistor, Siliconix U-112. Available for $4.75 postpaid from Elcom Electronics Inc., 170 Central Ave., Farmingdale, N. Y. 11735.
- R1—10-megohm, ½-watt resistor
- R2—5000-ohm miniature potentiometer (Mallory MTC-1 or similar)
- R3—5600-ohm, ½-watt resistor
- R4—510-ohm, ½-watt resistor
- R5—1500-ohm potentiometer
- R6—4700-ohm, ½-watt resistor
- S1—S.p.s.t. slide switch
- MISC—Aluminum box, 2¼″ x 2¼″ x 5″; socket for Q1; 1 piece linen Bakelite 1/16″ x 1⅝″ x 2¼″; 6 pieces linen Bakelite 1/16″ x 2″ x 2″; 6 pieces aluminum as shown in Fig. 4; terminal strip; CB walkie-talkie whip.

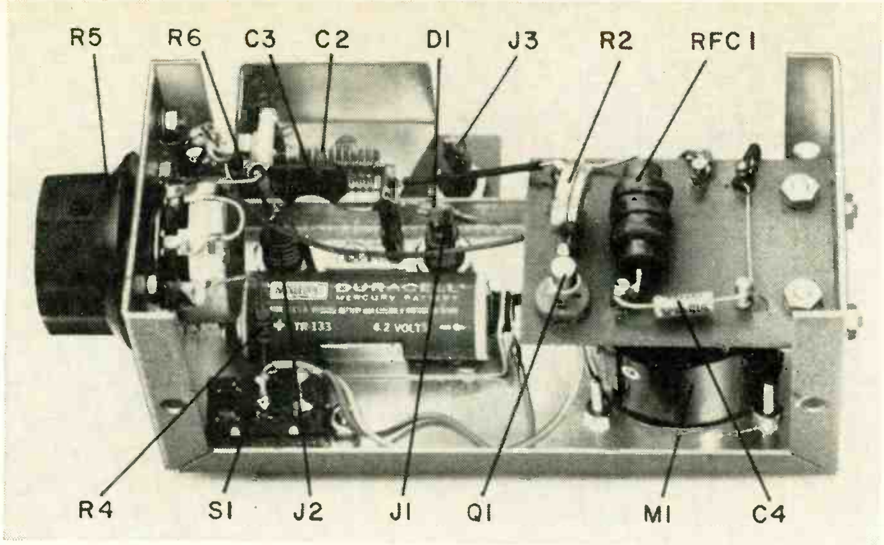


Fig. 2—Home-brew Bakelite circuit board and point-to-point wiring.

will stand 100% overload without damage.

Decreasing the value of R1 will give better stability but less sensitivity; increasing the value of R1 to, say, 20 megohms, will increase sensitivity at the expense of stability. If you plan to use the meter to measure strong signals, reduce R1 to 5 megohms. For weak-signal use only, increase R1 to as much as 20 megohms.

Construction

Lay out and cut the mounting holes in the front of the aluminum box. Be sure you allow space for the battery under R5 (Fig. 2). Note that the wiring tie mounts between the two nylon banana jacks so that C3 can be kept as close as possible to D1, and all the leads can be made very short.

Cut and drill the circuit board as shown in Fig. 3. You can use Vector, Useco or similar terminals to support components. The miniature potentiometer (R2) is mounted by simply inserting the three prongs into the board. It will be held firmly in place when connections are soldered underneath the board. You can use a socket for the FET, or you can solder it directly into the circuit. However, if you use the socket, it will be easy to replace or substitute the FET.

Make up the aluminum bracket shown in Fig. 3 and attach it to the circuit board with two 4-40 machine screws and nuts. Install all components on the board and do all wiring *before* mounting it in the case. Install wires to the meter before you mount the board. Now bolt the board to the case with two more 4-40 machine screws and finish the wiring of the rest of the components; finally, make connection to the board. You will have only four wires going to the board: D1 to RFC1, meter plus, meter minus, common ground, and a wire to S1 from the Q1 drain.

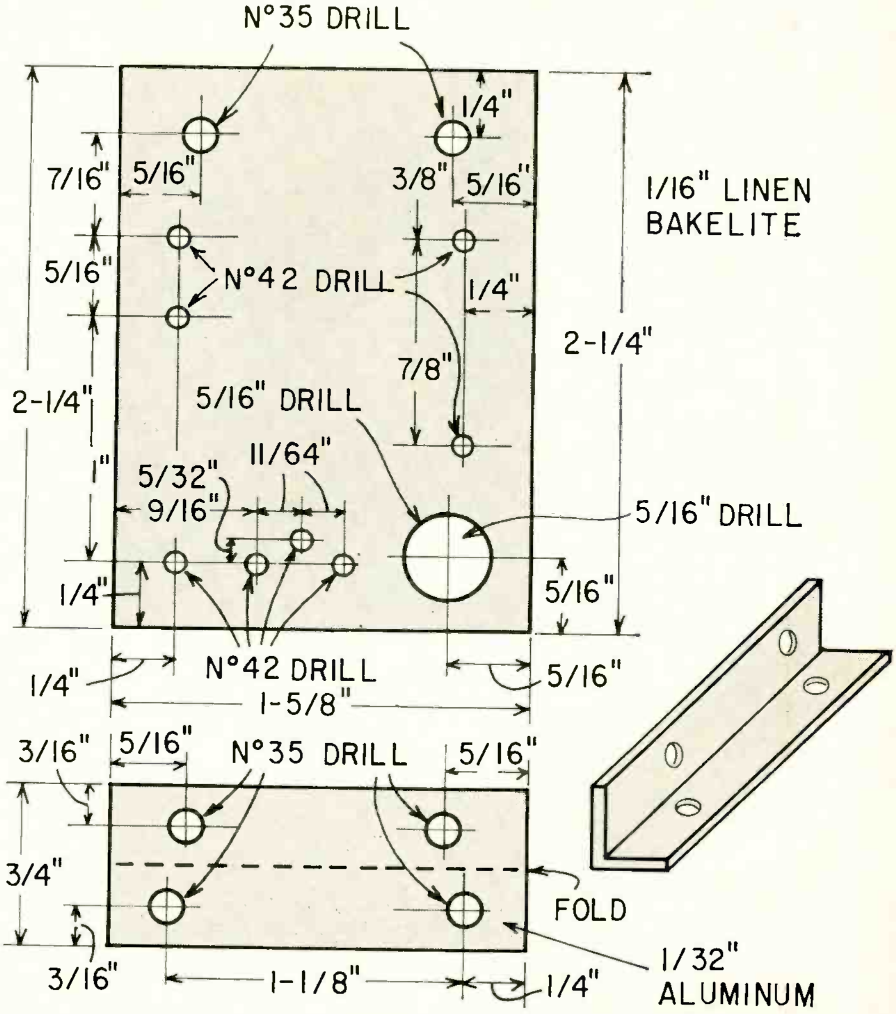
Refer to the table for tuned-circuit details. Each tuning unit is mounted on a 2" x 2" piece of Bakelite drilled as shown in Fig. 4. Be sure the two holes for the banana plugs permit a proper fit for banana jacks J1 and J2 previously mounted on the front of the box. Cut the 2" x 2" pieces of Bakelite to size and stack-drill all of them at once.

Now make the 6 aluminum angle brackets (Fig. 4) to hold and protect the tuning capacitors. Stack-drill these to save time and obtain uniformity of all pieces.

Coil No. 1, for 10–23 MHz, is wound on a Miller slug-tuned form with 30 turns of No. 26 enamel wire, close-spaced (Fig. 5). This coil is also tuned with a 4–30-pF trimmer connected directly across L1. Mount this trimmer directly across the two banana plugs so that it is accessible from the top for tuning adjustments. The coil form is mounted in the ¼" hole used for mounting the variable in the other five tuning units. The double tuning (capacitor and slug) is necessary to cover the range from 10–23 MHz.

Coil No. 2 consists of nine turns cut from a B & W Miniductor No. 3015. Solder the coil directly to the

Fig. 3—Circuit board and hole dimensions. Board mounting bracket is made of aluminum, folded and drilled as shown to mount on end of cabinet.



banana plugs. The tuning capacitor is a Hammarlund MAC-30, and the coupling capacitor to the antenna is 10 pF. Construction of coils Nos. 2 to 6 is essentially the same except for C1. This coupling capacitor is 10 pF for the first three coils. None is used for coil No. 6, and a "gimmick" is used for coils Nos. 4 and 5. The "gimmick" consists of a short piece of insulated hookup wire soldered to the antenna jack and wrapped around the "hot" side of the coil banana plug as shown in Fig. 5.

In most cases, the antenna will not be needed. It plugs into J3, and nearly any 27-MHz walkie-talkie antenna may be used. Get one with a banana plug (or bolt it to a banana plug) to mate with J3 on the tuning assembly.

The field-strength meter may be used as an untuned indicator by plugging the antenna directly into J1. It will be desirable to connect an untuned rf choke between J1 and J2 if the meter is to be used untuned for measuring strong signals from a nearby transmitter. Size of this choke will be governed by the frequency.

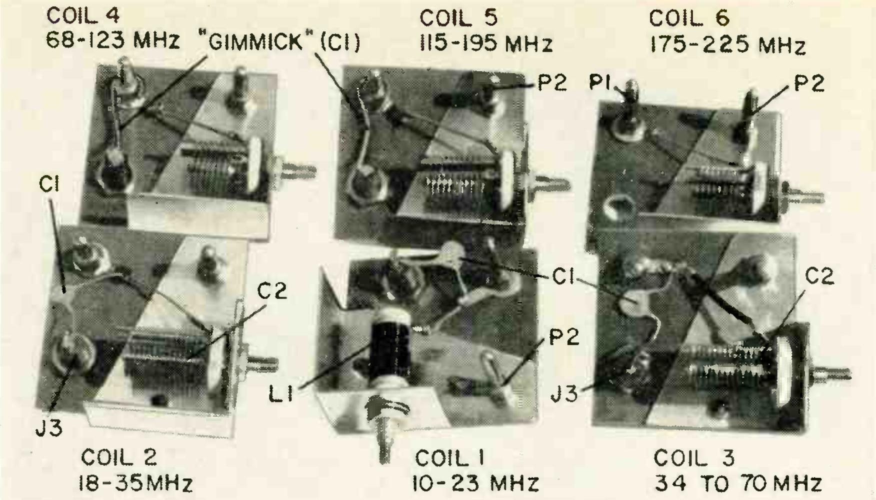
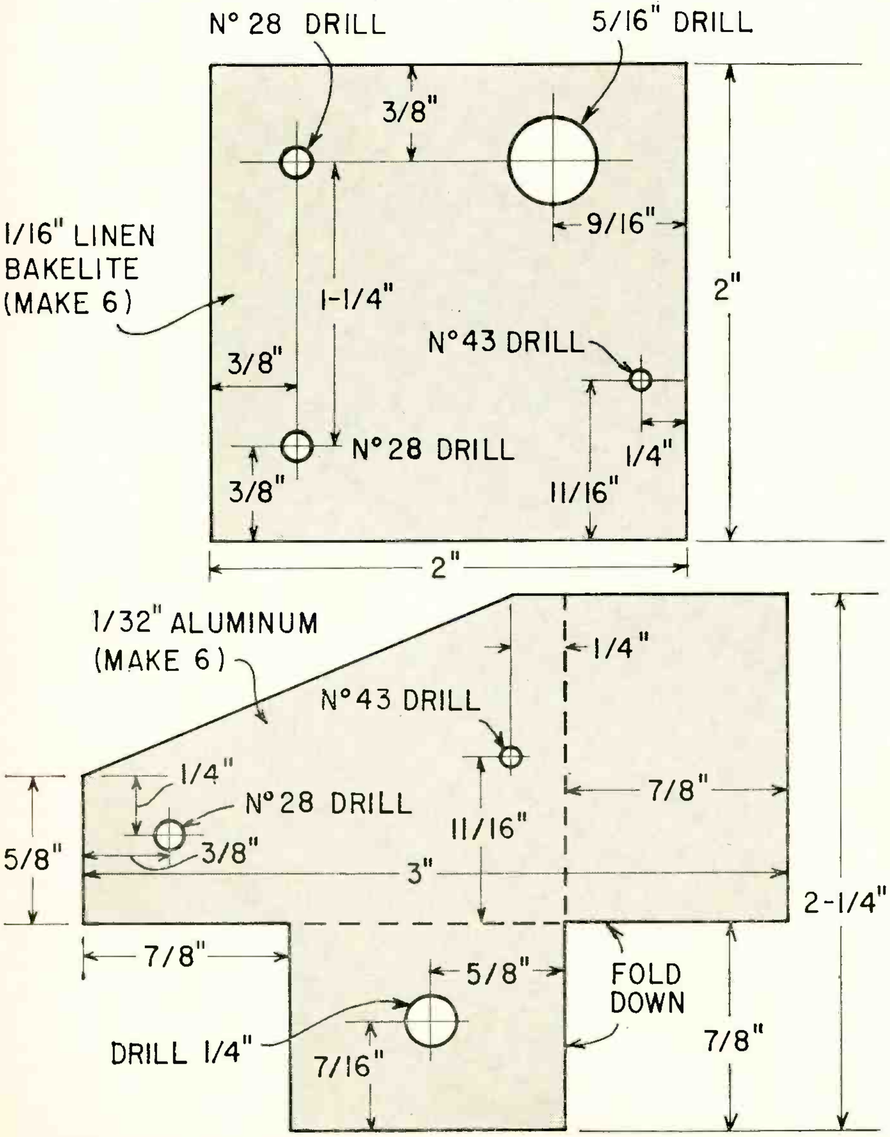


Fig. 5—Six tuning assemblies cover the range of 10 to 250 MHz. Each is adjustable by means of a trimmer, so you can peak the transmitter reading.

Fig. 4—Make six of these pieces of Bakelite to mount the tuning assemblies. Square pieces are Bakelite; others are aluminum stock.



Tuning stub for vhf

Insert two vertical wires into J1 and J2. Space them about ½" apart. You can use No. 12 or 14 bare copper wire to make these. They should be about 12" long. To tune, run a shorting bar up and down the two parallel wires. This arrangement serves as a tuner and antenna at the same time. You will be tuning a ¼-wave stub, and the highest usable frequency will be determined by how close you can get to D1 with the shorting bar. This type of tuning is excellent for 450–500-MHz frequencies. A regular coil and capacitor tuner is good only up to 250 MHz or slightly beyond, because of the high minimum capacitance of the components. **R-E**

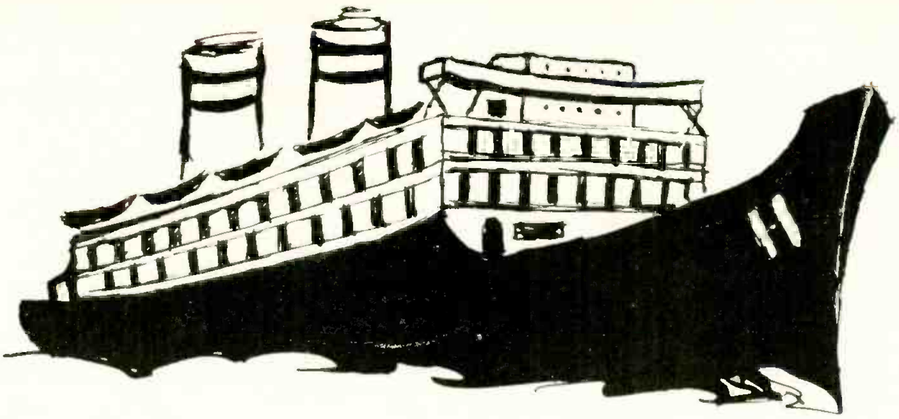
COIL DATA FOR 10 to 250 MHz:

COIL NO:	L1, TURNS	DIA.	CAPACITANCE, C2, pF: MIN.	MAX.	C1
1	30	⅜" **	4	30	10 pF
2	9	1" ‡	3	32	10 pF
3	5	¾" ф	3	32	10 pF
4	5	⅜"	2.2	21.5	"G"
5	3	⅜"	1.9	15.8	"G"
6	1	¼"	1.9	15.8	NO

NOTES:

** Use J. W. Miller No. 4400–2 coil form. (30 TURNS No. 26 enamel wire.)
‡ Cut B & W Miniductor No. 3015 to size.
ф Cut B & W Miniductor No. 3011 to size.
"G" Refers to "gimmick" capacitor, i.e. a loop of wire around one banana plug at "hot" end of L1, soldered to antenna jack, J3. **NO gimmick capacitor used on coil No. 6.**

Coil No. 1 is slug-tuned with a 4–30-pF trimmer in parallel. Indicated frequency range is achieved by tuning with both slug and trimmer.
Other coils are tuned with air capacitors such as Hammarlund MAC series or E. F. Johnson M series variables.
Use No. 18 bare copper wire for winding coils 4, 5 and 6. Make the space between turns approximately wire diameter, and squeeze coil for final frequency adjustment. Diameter shown in above table is outside diameter of the winding form. A pencil or ballpoint pen of the correct diameter makes a good form to use when winding these coils.



Digital Computers At Sea

By CLEMENT S. PEPPER

ABOUT THREE-FOURTHS OF THE EARTH'S surface is covered by water to an average depth of about 15,000 feet—a total of 575 million cubic miles. That's a whale of a lot of water, but only recently has it become of more than casual interest to more scientists. As the scientists discover more benefits from the oceans for defense, food, oil and minerals, their interest deepens.

Scientific curiosity becomes intense as men seek to identify and catalog previously unknown characteristics of the sea. Important measurements now regularly include temperature at and below the surface, sound velocity under various conditions, salt content, pressure, ambient-light intensity, magnetic field, gravity and sea-floor properties. In general, these measurements are made with great accuracy.

Nearly all oceanographic instruments in common use until recently were analog devices. They consisted of an output-recording device—a chart recorder, for example—fed from a sensing transducer through a linear amplifying system. They generally record from one source and cannot cope with the enormous task of gathering the needed information.

Any environment as complex as the sea requires multichannel, multi-use instruments capable of storing enormous quantities of data. By multiplexing, a single digital recorder can collect and store data from many sources. What's more, information recorded in analog form is subject to distortion and must be converted to digital equivalents before any kind of computer can process it. The technique is slow and tedious, often becoming another source of error.

In spite of their obvious advantages, digital systems are only now coming into common use. The reasons for the delay are simple. Digital systems are complex, expensive and little under-

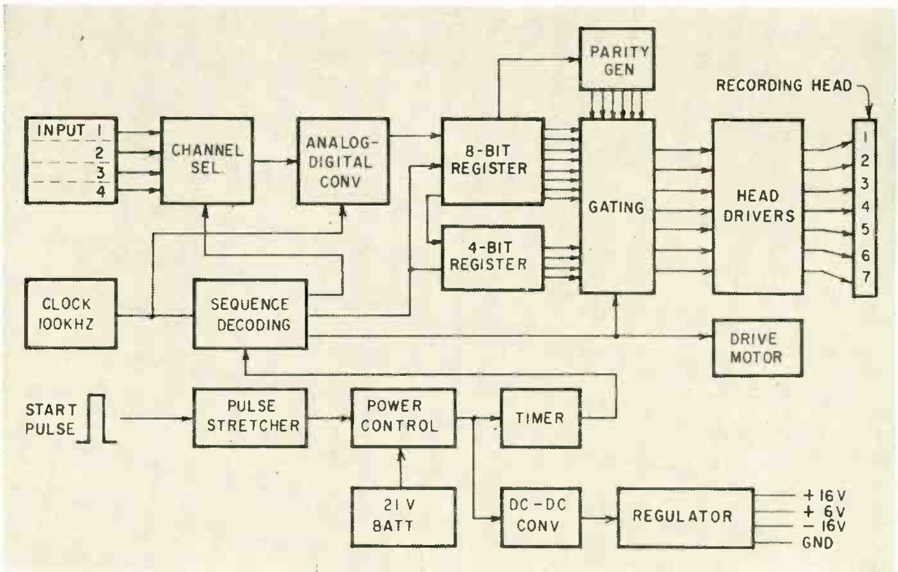
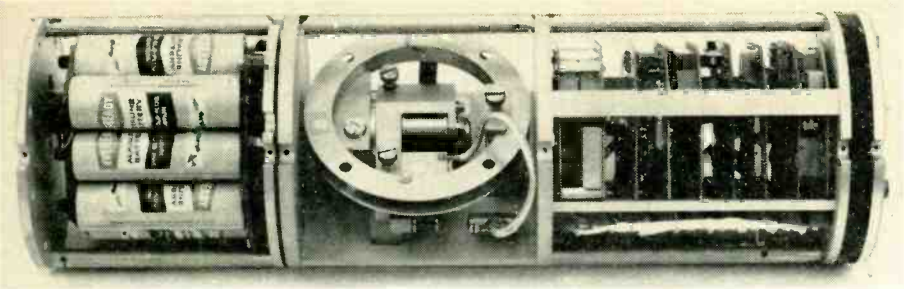


Fig. 1—Block diagram of digital recorder. By converting data from analog to digital form prior to recording, much time can be saved and computations are more accurate.

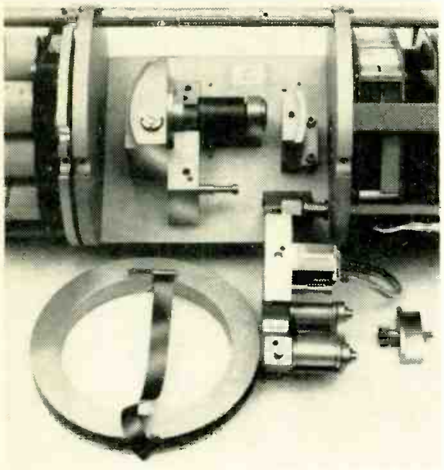


Photos courtesy of University of California, San Diego Scripps Institution For Oceanography

Digital recorder measures 22" long by 6⅜" in diameter. Battery pack is good for more than 15,000 data entries. Recording head and tape-loop assembly are in center section.

stood. Technicians capable of maintaining them are hard to find. Off-the-shelf digital recording systems have been designed for use under ideal laboratory conditions.

By contrast, in deep-sea applications, special packaging, very low power drain and nonstandard operating sequences frequently are required. Additionally, most equipment available until



Endless tape removed from recorder. The 7-channel head is on the arm next to tape.

recently had to include an analog-to-digital converter. Finally, the scientist wants to observe collected data at sea in its reduced form, and shipboard computers, until recently, have been rare. As more computers go to sea, the use of digital equipment undoubtedly will increase.

Digital-system versatility

Sampling techniques permit a single digital recorder to store data from dozens of sources. A good example is the general-purpose buoy developed by Convair Div., General Dynamics Corp., under sponsorship of the Office of Naval Research (ONR). The buoy has been designed for unattended recording, remaining active for periods of more than a year. It is large—40 feet in diameter by 7.5 feet thick—and its data system can handle 100 separate inputs. Information picked up by the buoy's sensors is sampled periodically and stored in one of two memory units. The first is a short-term memory; it transmits data when commanded from shore, normally at 6-hour intervals. The second memory is long-term and is capable of storing information for a full year at a time.

A different recording technique is used in DIVEAR (*D*iving *I*nstrumentation *V*ehicles for *E*nvironmental and *A*coustic *R*esearch. This system is operated by the Ordnance Research Laboratory of Pennsylvania State University. Three unmanned, instrumented buoys are dropped from a ship at specified distances. As they sink through the water, sonic signals are transmitted to the buoys from the mother ship. Receivers in each buoy detect these signals, which have been modified by passing through the water. The information is recorded in each buoy on a digital tape system. At a preset depth, ballast weights are dropped from each buoy, which then permits the buoys to return to the surface. The buoys are recovered and the data evaluated.

Data transmission and processing

Large-scale, long-term ocean surveys have produced a demand for buoy-installed, digital telemetering systems. ODESSA, produced by Geodyne Corp. for the Environmental Science Services Administration (formerly the US Coast and Geodetic Survey), is typical of this new generation of undersea devices.

The system consists of two main elements, the *instrument mooring assembly*—of which there may be several—and a *shipboard assembly*. Sensing and digit-forming packages are assembled on a cable attached to a buoy containing the telemetering packages. The shipboard unit contains command, receiving and processing equipment and controls and monitors the mooring assemblies.

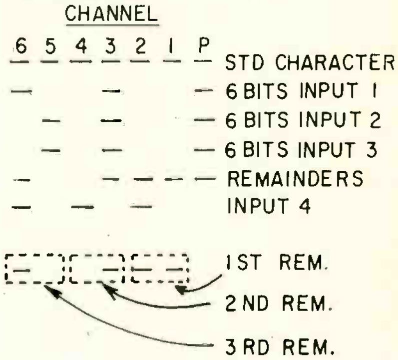
In a completed system, each buoy can be separately interrogated and the stored data read out for automatic processing. Such systems can operate at sea for a year or more. Typical

Bit-By-Bit Recording

As explained in the article, only 36 feet of tape are used to store 30 days of data gathering at 3-minute intervals. During this time, 14,400 frames are recorded (30 days x 24 hours x 60 minutes ÷ 3). One frame consists of 6 lines, for a total of 86,400 lines. There being 200 lines per inch, 432 inches are required, or a total of 36 feet.

Of the 6 lines in each frame: one line is for a standard character which serves as a reference; the next 3 lines accommodate 8-bit words (actually 6 bits and 2 remainders); the 5th line picks up the two remainders from each of the 2nd, 3rd and 4th lines; and the 6th line accepts a 6-bit word. Accuracy to within 0.5% can be obtained with an 8-bit word.

Each bit in each line falls into 1 of 6 channels and is monitored for accuracy by a system of odd parity, the markings of which are contained in another channel. Odd parity merely means that the total number of "marks" on a line must be odd. Note the blank space for parity on Input 4 . . . in the diagram . . . the number of marks being odd, there is no need to add a mark for parity. In the other channels a parity mark is added to make the total odd. An even parity system could be used if the computer were programed to accept it.



INPUT	BINARY	DECIMAL
1	00100111	39
2	00101010	42
3	00101001	41
4	01010101	85

The first six marks and spaces (left to right) in the binary designation (8-bit word) of the number 39 is shown in Input 1 as marks in Channels 3 and 6—the two remainders appear in Channels 1 and 2 on the Remainders line. The remainders for Inputs 2 and 3 appear in Channels 3 to 6 respectively. Input 4 has no provision for carrying the remainders and therefore presents a less accurate readout. Note the channels on the tape actually are printed in horizontal rows rather than vertically as shown here. Illustration shows 1 complete frame.

oceanic parameters measured are: ocean-current speeds from .05 to 7 knots, current direction to ± 5° magnetic, temperatures over the range of 0° to + 40°C ± 0.2°, salt content from 0 to 40 parts per thousand, and depth from 1 to 100 meters within 1%.

A deep-sea recorder

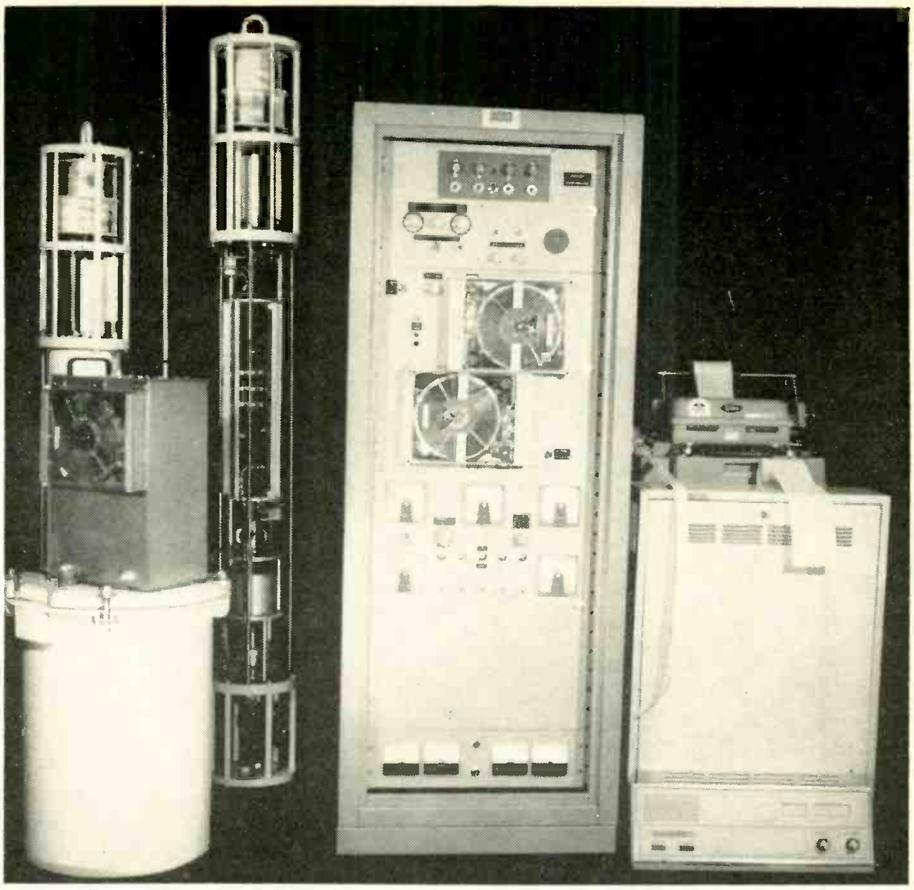
The data recorder shown in the photographs was manufactured by Data Science Corp. of San Diego and constructed specifically for long-term recording on the ocean floor. It is relatively simple and straightforward as such recorders go. As the block diagram of Fig. 1 illustrates, the recorder samples and records four inputs sequentially upon command from a programer included in the instrument package. The recorder is an incremental type; that is, the tape is advanced only when information is being recorded. Data are stored digit-by-digit at a recording density of 200 bits per inch; standard ½-inch, seven-channel tape is used, as shown in Fig. 2. Six channels provide information storage, and a seventh is used for parity. Parity is used to detect errors. In the event of an error the computer automatically stops processing until the error is accounted for.

The recorder is usually operated for 30 days on the sea floor with samplings made at 3-minute intervals. All this requires only 36 feet of tape. (See "Bit-By-Bit Recording" for a detailed explanation of the markings on the recording tape.) To conserve power, the entire system shuts down between measurements, a function made possible by magnetic-core memory elements. Batteries are alkaline types having several times the capacity of ordinary zinc-carbon cells, especially at the reduced temperatures found on the sea floor.

A tape produced by a recorder like this cannot be read by the processing computer unless the recorded information meets rigid specifications. Improper loading points, missing end-of-file characters, gaps in the record and other faults make it impossible to process the tape. Thus, tapes carelessly handled or improperly recorded at sea may be entirely useless. Data taken from the tape is transferred to punched cards which can then be programed with additional instructions for computations.

Computers at sea

Data taken at sea should be evaluated before returning to port. Why? If the desired data is not obtained, an incompleted or missed experiment can be repeated without having to make another sea voyage necessary. An on-site evaluation, however, is possible only when there's a computer aboard.



Components of ODESSA system include, left to right, buoy instrument with a tape recorder on the lid, a more complex buoy of modular construction, control console capable of handling 12 buoys, and the print-out unit that produces final copy.

One of the earliest sea-going computers is installed on the *Atlantis II*, a research ship operated by the Wood's Hole Oceanographic Institution, Wood's Hole, Mass. The computer is a multipurpose type, model PDP-5, manufactured by Digital Equipment Corp. The *Evergreen*, a US Coast Guard oceanographic vessel, has an identical model.

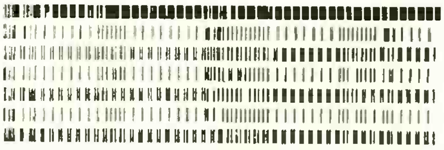


Fig. 2—Photo of bit pattern recorded on ½" tape. Only 36' are needed for 30 days.

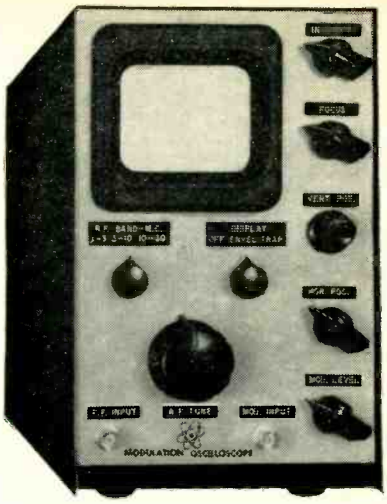
The Scripps Institution of Oceanography, La Jolla, Calif., has planned the installation of an IBM 1800 on the *Thomas Washington*. This extremely versatile computer will make possible on-board data processing and recording. Scripps will provide an engineer and a programer to assist the scientific party in using the computer. The same type of computer also may be used on the *Argo* and the *Horizon*, sister ships in the Scripps fleet.

The *USS Marysville* (EPCER 857), which is used by the US Navy Electronics Laboratory, San Diego, recently left for an extended scientific cruise in the western Pacific, with a Univac 1218 computer on board. Other instruments include: a thermistor chain for continuous temperature measurement from the surface to a depth of 800 feet, four sea-current recording meters, an echo sounder and a bathythermograph. The computer will be used to plot horizontal and vertical temperature gradients. Computations will be made for studies of thermal structure and acoustical scattering caused by small sea creatures. The immediate availability of the computer is a real asset to the expedition.

Some ships now under construction will have built-in computer installations. A new Navy survey ship, the *USNS Silas Bent*, is described as having the world's most advanced shipboard computer system. The *Bent* is a medium-sized ship, displacing 2,590 tons. She is 285 feet long and has a 48-foot beam; her cruising speed is 15 knots. The craft will carry a crew of 44 and provide ac-

(continued on page 82)

BUILD A MODULATION SCOPE MONITOR



Get 100% transmitter modulation without guesswork

By ROBERT J. REED

HIGH-QUALITY MODULATION OF A RADIO-telephone transmitter is a prerequisite. While there are several ways to predict the degree and quality of modulation, it is difficult to find an instrument that provides more information than a cathode-ray oscilloscope. Such troubles as undermodulation, overmodulation, rf and audio distortion and a host of other evils can be detected readily.

Here is an oscilloscope, especially designed for modulation analysis, that is a worthwhile addition to anyone who works with AM transmitters. It covers the range of 1.5 to 30 MHz and displays either a wave envelope or a trapezoidal pattern. It also has a built-in 400-Hz tone generator, synchronized to the horizontal sweep circuits for drift-free display of wave-envelope patterns.

How it works

Signal from the transmitter is fed to the rf input jack J1, switched to T1, T2, or T3, stepped up by transformer action, tuned to resonance by C1, and fed to the vertical sweep plates of the cathode-ray tube.

Horizontal-sweep voltage for the different waveform displays is selected by display switch S2. When S2 is in position 3, a trapezoidal pattern can be displayed on the CRT. In this position, the switch removes B+ from V1, V2, and V3, and simultaneously connects J2 to R1. Modulated B+ voltage from the transmitter is applied to J2 by a shielded cable. The desired audio-voltage level for the scope is established by the panel-mounted pot R1 and fed to the horizontal plates of the CRT.

When S2 is in position 2, an envelope pattern can be obtained. Plate voltage is applied to tubes V1, V2, and V3. Jack J2 picks a 400 Hz tone from R2, the output load-resistor of cathode follower V1-a. This signal is used to modulate the transmitter.

Tube V1-b is the tone oscillator, a fixed-frequency Colpitts type. Due to the high-level feedback developed across R3, the output sine wave from V1-a has less than 3% distortion.

Sweep oscillator V2 generates a sawtooth waveform which is amplified by V3 and applied to the horizontal sweep plates of V4. This circuit employs a thyraton relaxation oscillator. Its frequency is determined by the time constant of C7, R10, and R11. In operation, the sweep-oscillator frequency is adjusted to approximately 200 Hz so that every other cycle of the tone oscillator triggers the sweep tube and synchronizes it to one-half the tone-oscillator frequency. This provides a stable display

VOLTAGE, RESISTANCE AND WAVE FORM CHART

TUBE		VOLTAGE	RESISTANCE
12AU7	Pin 1	+50	470K*
	2	−1.1	10K
	3	+6	10K
	6	+300	0*
	7	−0.5	39K
	8	+18	10K
6C4	Pin 1, 5	+160	220K*
	2	—	—
	6	0	350K
	7	+9.5	15K
2D21	Pin 1	−0.7	100K
	2, 7	0	0
	5	—	—
	6	+15–20	85K*

*Measured to B+

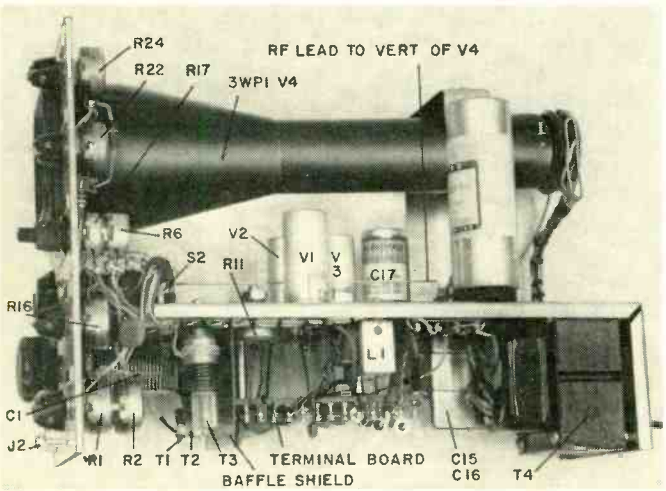


Fig. 1—The rf section, nearest the front panel, is neatly shielded from the rest of the components on the chassis.

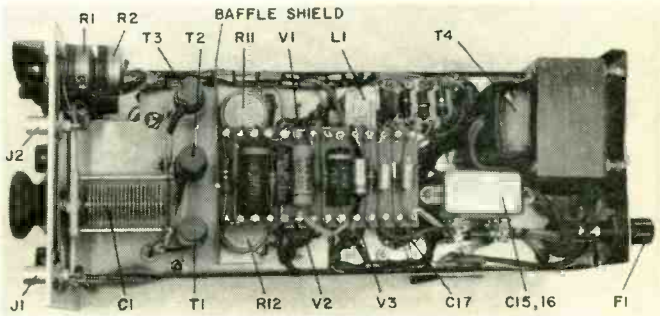


Fig. 2—Sweep-circuit components are mounted on the centrally located terminal board.

of two wave envelopes on the CRT screen.

The synchronizing voltage is applied from the tone-oscillator tank circuit through a network comprised of R6, C6, and R8. R6 is the SYNC-PHASE control that compensates for wave-envelope phase shift introduced by the transmitter's speech-amplifier circuitry. By adjustment of this control, the CRT sweep is triggered at the same time the wave envelope begins to move from its zero axis, thus displaying the two wave envelopes evenly on the screen. The control is for viewing convenience only and can be omitted by connecting C6 to the junction of R7 and L1.

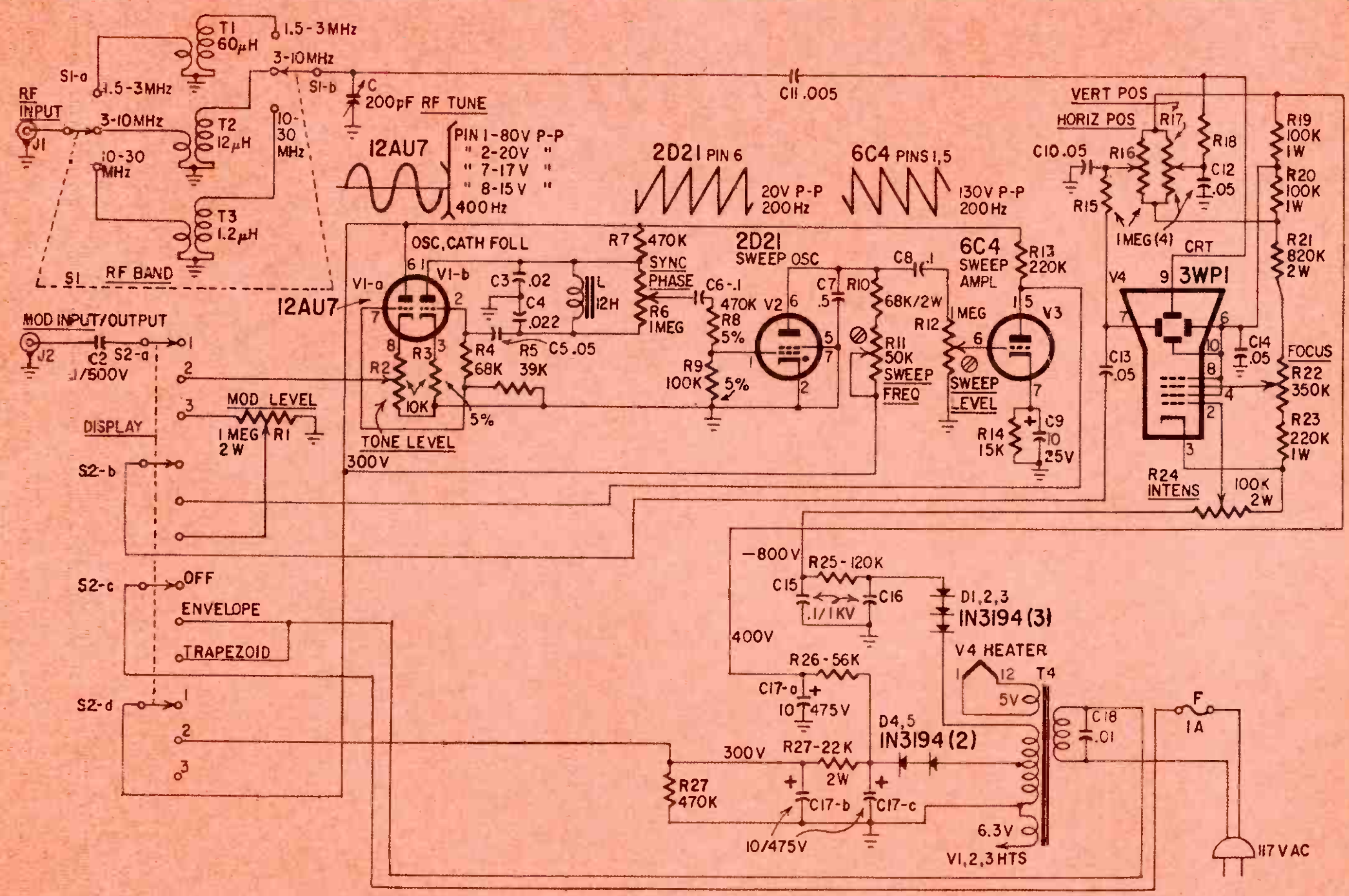
High voltage for the CRT cathode is taken from the negative 800-volt dc point in the power supply. The CRT plates are returned to B+ 400 volts dc, giving a total of 1,200 volts across the tube. Filament voltage for the CRT is taken from the 5-volt winding of T4, which actually supplies 5.6 volts when lightly loaded. This figure lies within the filament rating of V4 and gives good beam brilliance. B+ voltage for V1, V2, and V3 is taken from the rectified center-tap voltage of T4 and filtered by R27, C17-b, and C17-c. Diodes D1, D2, and D3 must be able to withstand a total of at least 2,000 piV and 10 mA forward current. Diodes D4 and D5 may be one or more rectifiers totaling at least 1,200 piV and 400 mA forward current.

Construction

The scope is built on a 4½ x 11½ x 3-inch open-sided chassis, attached to a 5¾ x 8¾-inch front panel. A baffle shield is installed 3 inches behind the front of the chassis to isolate the rf section from the rest of the circuit.

Power transformer T4 is installed on the underside of the chassis near the rear edge.

All sweep- and tone-oscillator circuitry are mounted near the center of



Waveforms are shown on schematic as an aid to troubleshooting. No input signal is necessary to obtain these waveforms.

PARTS LIST

C1—0-200 pF, Hammarlund HFA-200-A or equivalent
C2—0.1 µF, paper
C3—.02 µF, paper
C4—.022 µF, paper
C5, C10, C12, C13, C14—.05 µF, ceramic
C6, C8—0.1 µF, ceramic
C7—0.5 µF, ceramic
C9—10 µF, 25 volts, electrolytic
C11—.005 µF, ceramic
C15, C16—.1 µF, 1,000 volts, paper
C17—10 + 10 + 10 µF, 475 volts, electrolytic
C18—.01 µF, ceramic
F—1-amp slo-blo fuse
L1—10-henry choke, Stancor C-2318 or equivalent
J1, J2—coaxial jack, any type
R1, R6, R12, R16, R17—1-megohm pot (R1–2 watts)
R2—10,000 ohms, pot
R3—10,000 ohms, 5%
R4—68,000 ohms
R5—39,000 ohms
R7—470,000 ohms
R8—470,000 ohms, 5%
R9—100,000 ohms, 5%
R10—68,000 ohms, 2 watts
R11—50,000 ohms, 1 watt, pot
R13—220,000 ohms
R14—15,000 ohms
R15, R18—1 megohm
R19, R20—100,000 ohms
R21—820,000 ohms, 2 watts
R22—350,000 ohms, pot
R23—220,000 ohms, 1 watt
R24—220,000 ohms, 1 watt
R25—120,000 ohms
R26—100,000 ohms, 2 watts, pot
R27—22,000 ohms, 2 watts
R28—470,000 ohms
S1—3-pole 3-position wafer switch
S2—4-pole 3-position switch
T1—1.5–3-MHz coil, 60 µH, 145 turns No. 28 enameled on ½-inch diameter form. Primary—11 turns No. 22 hookup wire
T2—3–10-MHz coil—12 µH, 50 turns No. 22 enameled wound to cover 1¾ inches on ½-inch diameter form. Primary—6 turns No. 22 hookup wire
T3—10–30-MHz coil—1.2 µH, 13 turns No. 16 enameled wound to cover 1 inch on ½-inch diameter form. Primary—3 turns No. 22 hookup wire
T4—650 VCT, 6.3- and 5-volt secondaries, Stancor PC-8406 or equivalent
V1—12AU7
V2—2D21
V3—6C4
V4—3WP1
D1, D2, D3, D4, D5—1N3194 or equivalent
All resistors—10% ½ watt unless otherwise noted
All capacitors—400 volts unless otherwise noted

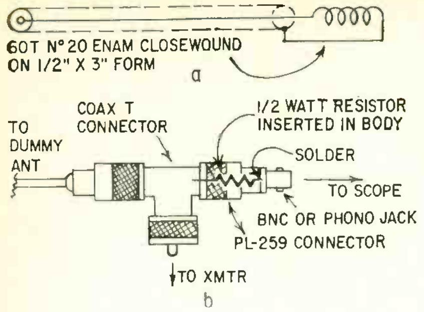


Fig. 3—Rf pickup coil and pickoff probe give two ways of transmitter rf sampling.

the chassis. Remaining components are supported on a terminal board mounted on 1¾-inch standoffs, as seen in Fig. 1. Choke L1 is mounted between the terminal board and the chassis.

Except for the rf portion, circuit layout is not critical, although sensible standard construction practices should be followed.

The secondary windings of T2 and T3—as noted in the parts list—include 5-inch leads. If very short leads are run to switch S1, an extra turn should be added to each coil; primary lead length is not critical. Tuning capacitor C1 may be larger, but the important thing is that the minimum capacitance must be 10 pF or less. Leads in the rf section should be dressed for minimum stray capacitance. The lead running from S1 to the vertical sweep plate of the CRT was run above the chassis on 1-inch insulated standoffs and kept clear of tube shields, and other components.

Keep in mind that the minimum capacitance of C1 and the total stray capacitance of the rf-carrying leads limit the upper-end tuning range. In my scope, this combination measured about 20 pF, a figure not difficult to obtain.

The pickup coil is constructed as shown in Fig. 3-a and attached a 4-foot length of coaxial cable. For low-power transmitters, or where the pickup coil cannot find a strong rf field due to shielding or other causes, the pickoff probe shown in Fig. 3-b should be used. On Citizens-band transmitters, a 1,000-ohm resistor works out very well. For different power levels, the resistor will have to be determined experimentally. A good rule of thumb is:

$$R = 100\,P_o$$

where R equals the resistance in ohms and, P_o equals the transmitter output power in watts. Resistors of less than 820 ohms should not be used, however, due to their loading effect.

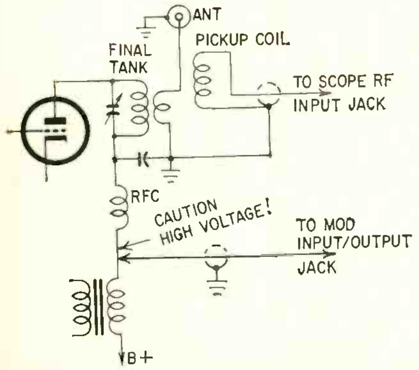


Fig. 4—Direct connection shown provides audio voltage in low-powered transmitters.

Adjustment and operation

When wiring is completed, turn down intensity control R24 and turn on the power. Set display switch S2 to position 2 (envelope display). Check the power-supply voltages. They should be approximately 800 volts negative, 400 volts positive and 300 volts positive.

Increase the intensity until a spot or line appears on the screen, then adjust SWEEP LEVEL control R12 for the desired sweep width.

To set the sweep frequency, temporarily disconnect the lead that runs from S1 to the CRT's vertical plates and jumper or connect it to the high end of R2. Set sweep-frequency control R11 for maximum resistance. Set sync-phasing control R6 to the center of its rotation, then adjust R11 until the tone frequency is synchronized on the screen. Continue to advance R11 until the pattern jumps out of synchronization, then turn the control halfway back toward the point where the pattern first locked in. Turning the sync-phasing control should shift the pattern ±90° and still hold synchronization. Reconnect the lead from the vertical plate to S1.

A standard signal generator can be used to check the rf tuning section if the signal is strong enough to produce at least ⅛- to ¼-inch deflection on the cathode-ray tube.

To display a trapezoidal pattern, the scope is connected as shown in Fig. 4. A shielded lead is connected from the high side of the modulation-transformer secondary to J2 on the scope. (NOTE—A direct connection can be made in transmitters in which the B+ does not exceed 450 volts. In other rigs, a voltage-dividing network will be necessary to avoid breakdown of input blocking capacitor C2.) The rf pickup coil is placed near the antenna or final tank circuit. With an unmodulated carrier applied to the scope, a vertical line will show on the screen; with a modulated carrier, trapezoidal patterns like those shown in Fig. 5 will be displayed.

For the envelope display, a shielded audio cable is connected from J2 to the input of the modulator as shown in Fig. 6, and the 400-Hz tone level is adjusted to give the desired output. A stable pattern of two wave envelopes like those in Fig. 5 will appear on the CRT screen. The audio lead can be disconnected while the transmitter is voice-modulated, but the pattern will "run" across the screen and will be difficult to observe. Actually, the trapezoidal pattern is best utilized under voice-modulated conditions. The envelope pattern technique, however, provides an audio tone for troubleshooting.

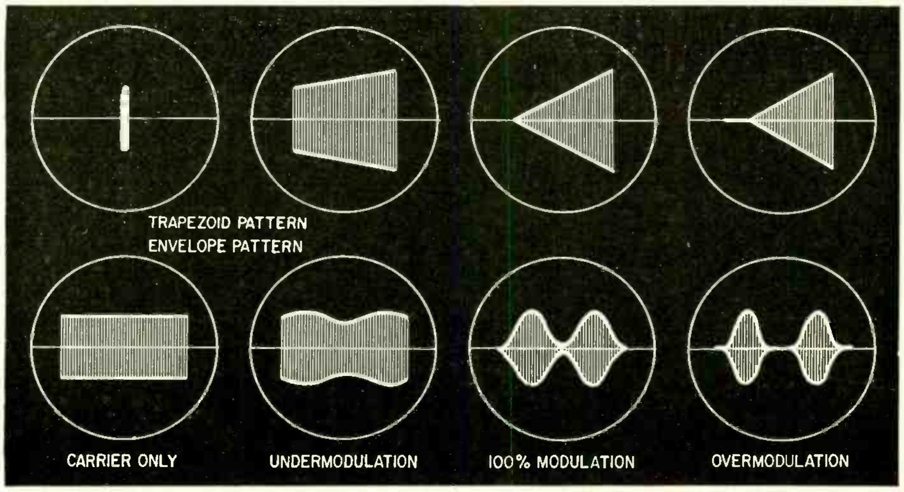


Fig. 5—Trapezoidal and wave-envelope patterns provide varied information in analyzing and monitoring AM rigs. The trapezoids are easier to interpret.

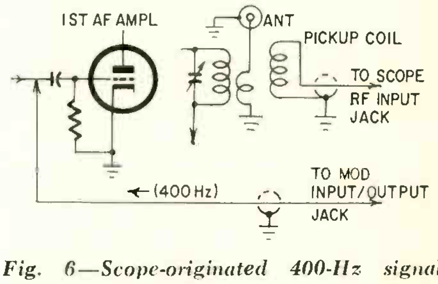


Fig. 6—Scope-originated 400-Hz signal fed to transmitter syncs waveform.

If only one frequency or one band is of interest, S1 and two rf transformers can be eliminated. If higher frequencies are required, an extra rf band could be added—30 to 55 MHz, for example. A coil of 7 turns of No. 16 enameled wire wound to cover 1 inch on a ½-inch form; with a one- or two-turn primary. It's not as difficult as it looks. **R-E**

Bioelectronics and Life

Pacemakers, man amplifiers and eyeball controls

By ALLEN B. SMITH

SCIENCE HAS ALWAYS CONCERNED ITSELF deeply with the mechanism of life. Man's desire to understand how his body and mind function is very old. As science evolved, some men tried to apply new tools to these problems. Explanations based on myth, religion and the supernatural gave way—though not always—to explanations based on direct observation and on conclusions drawn from observation.

Science, like any human endeavor, has its "fashions." At various times in the history of science, particular approaches to the phenomenon of life and consciousness have predominated. There have been primarily chemical theories, primarily mechanical ones, electrical, electronic, statistical ones, and so forth. No responsible scientist would claim that any one of these approaches is *the* correct one, so they are most often found in combinations.

This is very much an electronic age, and a huge number of scientists are preoccupied with coupling electronics to living bodies. Electronics is being used to measure and regulate biological processes, to augment human brain and muscle power, and even to duplicate some hitherto uniquely human functions.

Because any successful attempt to meld electronics and biology calls for familiarity with other scientific areas, present research is producing scientists who are the very opposite of the oft-condemned "specialist"—the man whose knowledge, though perhaps profound, is so narrow that he cannot understand or appreciate work in other fields.

Let's investigate some of the fascinating results of what we might call interdisciplinary cooperation. The devices we'll look at were all born from the combined talents of engineering, physics, chemistry, biology, metallurgy, and perhaps a dozen other fields. Often, two or more fields come together in one man.

Self-powered Pacemaker

A self-powered electronic *Pacemaker* used to regulate the beat of damaged human hearts is a remarkable example. Most pacemakers consist of small battery-powered pulse generators worn in a harness or belt next to the patient's body. Two leads enter the chest cavity through surgical incisions so the electrodes may be attached to heart-muscle fibers. The regular pulse from the generator stimulates the heart and induces a smoothed, stronger heartbeat. Little success has been achieved in placing the entire unit inside the patient's body, because new incisions must be made from time to time to replace the power cells. The *self-powered* microminiature pacemaker is likely to solve this problem and others as well.

This newest internal bioelectronic device was developed by Carl C. Enger of the Department of Surgery, Western Reserve University School of Medicine, and Miroslav Klain, a researcher at the Cleveland Clinic Foundation. Working experimentally with nonhuman hearts, these two scientists have produced a tiny unit which literally is plugged into the heart muscle and stitched to it. Muscular contractions of the heart itself generate sufficient movement to operate a piezoelectric transducer. Voltage from the transducer powers the pacemaker. The circuit is shown in the diagram.

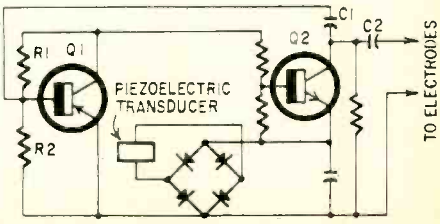
Silicon planar transistors are used because they are small and have low leakage. Capacitors are of deposited tantalum, and the diodes are silicon. Output from the transducer is nominally 2 volts; pacemaker output to the heart is a 2-volt pulse 1.5 msec wide.

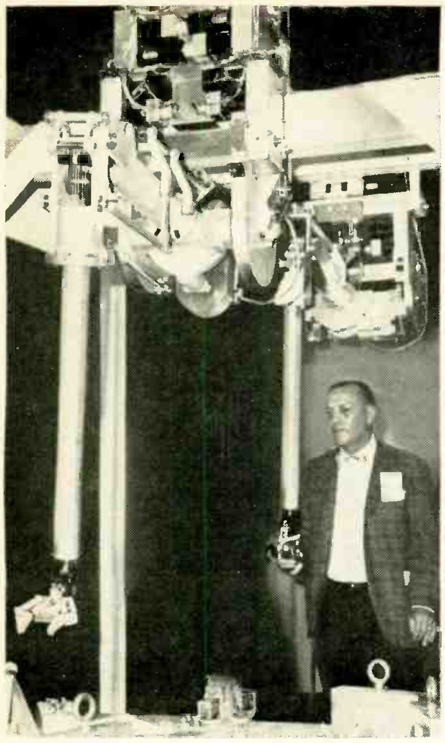
Transistor Q1 controls the voltage at the base of Q2, the output switcher. Rate and duration of the output pulse are determined by the time constant of C1 and R2 and the base-to-emitter impedance of Q1. Capacitor C2 prevents dc from appearing at the output. Direct current in the heart-muscle fibers would cause electrode poisoning due to electrolysis and protein buildup at the point where the electrodes pierce the heart muscle.

The pacemaker measures 2 x 0.6 x .07 inch, with all circuitry contained at one end in an area about ½ inch square. The transducer takes up most of the space. The complete unit weighs less than 3 gm. To protect the device from corrosive body fluids, it is coated with an inert silicone-rubber compound, then plated with a thin layer of gold. Two platinum electrodes about ⅛-inch long protrude from the microcircuit area and conduct the output pulse directly into the heart muscle. Efficiency of the complete package (mechanical-to-electrical conversion) is 99%.

The transducer itself is an interesting bit of solid-state technology. It isn't a normal slice of crystal, but a sandwich

Self-powered Pacemaker features; minimum number of components, small size, high reliability, and very low power needs. Transducer eliminates battery by converting heart-muscle movements into electricity.





Slave manipulator developed by Argonne National Laboratories for handling radioactive materials safely is actually a sophisticated man amplifier. Operator (background) slips his hand into an anthropomorphic hand support. Through servomotors, his movements are coupled to the slave's arm, wrist and hand assembly.

composed of a central brass strip to which are adhered opposing layers of a crystalline material—lead zirconate titanate. Each layer of this piezoelectric material is .010 inch thick, and the brass supporting base is approximately .003 inch thick. To provide electrical contacts, silver electrodes are plated to the outside surfaces of the crystal layers. The complete transducer, called a *piezoelectric bimorph*, is about .025 inch thick and flexible enough to withstand the muscular contractions of the heart without fracturing.

This self-powered cardiac device is not yet used in human patients, but it will undoubtedly find wide acceptance in the immediate future.

Living machines

Bionics is another field in which electronics theory and hardware find extensive use. This science of "living" or natural machines was named just a scant 6 years ago. It encompasses the growing interest in life/machine relationships by medical, social, biological and physical scientists on one hand and engineers on the other. With extremely varied areas of interest, bionicists may attempt to communicate electronically with dolphins, develop a new ground-speed indicator for aircraft, patterned after the eye of a beetle, or design a TV camera that duplicates the optical mechanism of the horseshoe crab!

A particularly interesting branch of bionics is the use of body-generated forces and electrical pulses to operate machines directly. Into this category fall "man amplifiers" that permit a man of normal strength to lift or move objects weighing a thousand pounds or more.

Walking truck

There are three basic types, each with a wide range of possible uses. The first, being developed by General Electric Co., is the "walking truck." In this device, the operator stands in a cab with a harness attached to his limbs and upper body. This exterior skeleton or *exoskeleton* couples his movements to the "legs" and "arms" of the vehicle through a series of servo-controlled hydraulic and elecrtic motors which multiply his applied force many times. Sensitive feedback circuits activate small servomotors within the exoskeleton to give the operator a sense of "feel." This feedback, not only helps him judge the force necessary for each task, but also assists him in maintaining his balance while "walking" the truck on its 12-foot legs.

Cornell Aeronautical Labs has developed a second type. In their approach, the exoskeleton itself is provided with torque-multiplying hydraulic motors. A man wearing this structure has what amounts to an exterior skeleton made of steel. It magnifies every motion and enables him to lift far greater loads than he otherwise would be able to move or carry. While much developmental work yet remains to be done on these two devices, the armed services and industry alike expect to gain substantial benefit from man amplifiers.

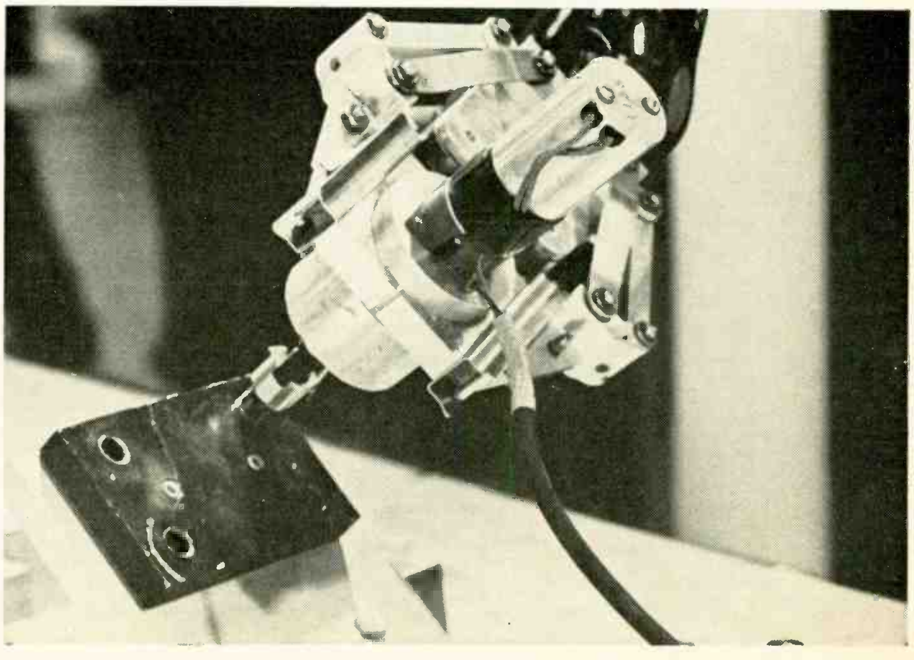
A third basic type seeks to overcome the major shortcoming of force-sensitive servo-controlled machines like those described above. That problem concerns the time lag between the operator's muscular contraction and the activation of the appropriate control system. Though small, this delay gives an unreal response sensation that requires conscious effort and much experience to overcome.

By using surface-contact electrodes similar to those employed in making brainwave traces, the minute electrical signals associated with muscular contraction can be used to control the electromechanical system directly. These bioelectric pulse trains, called *electromyographic* (EMG) signals, originate in the cortex of the brain. They travel through the body's neurological system to initiate muscular activity. Though very low in amplitude (10 to 1,000 μV), this biologically generated electricity is sufficient to control sensitive servo-system amplifiers. Noise can be a disturbing factor, but greater efficiency in pickup devices and greater knowledge of where the sensors should be placed should give greater signal-to-noise figures.

Artificial limbs

In most work done so far, particularly in the field of prosthesis (fitting artificial limbs), digital computers are used to evaluate each new subject's EMG patterns. Information thus obtained is used to determine sensor locations on various points near the patient's useful muscles. EMG signals operate the artificial limb as the patient performs

The slave can be made to work power tools and to perform complex operations in radioactive and other unfriendly environment to man. Both hand and foot controls are used.



his usual mental and motor actions. Even in cases where a limb was amputated years previously, residual EMG patterns often remain.

A description of the operating sequence of one such artificial limb will illustrate how the system works. To lift a cup, for example, EMG signals generated in the brain by the patient's desire to grasp the handle are amplified after being picked off two opposing muscles in the remaining part of his amputated arm. These signals are mixed to provide a difference signal whose amplitude is proportional to muscle tension. This resultant signal controls both the velocity and the force of the "finger" mechanism through a miniature servo system. Closing and opening the fingers takes about ½ second when driven by about a third of the available muscle force.

When the fingers touch the cup's handle, a second servo assumes control of the operating motor and regulates it according to the force applied to the handle. Because of random noise pulses in the differential voltage loop, a bit of backlash is provided to keep the servo motor from reacting to the noise.

Although this example concerns but a single limb motion, work is already well advanced both here and in Europe on artificial limbs and complete man amplifiers using EMG control. NASA, for example, is developing an exoskeletal arm for use by pilots and astronauts under high-G conditions where they would otherwise be unable to move.

Eyeball control

An interesting related system was developed experimentally by Philco Corp. some time ago. An airborne weapon-aiming system was controlled by the pilot's head and eye movements. A coarse-aiming servo loop was controlled by the position of his head, and a fine-aiming loop received its control signal from an optical scanning device that determined the position of his eyes. All he had to do was turn his head toward the target and focus his eyes on the point of aim; the weapon-control system did the rest. Experiments using EMG signals obtained from the eye muscles to control the fine-aim servo met with some success. Development of this and similar concepts continues.

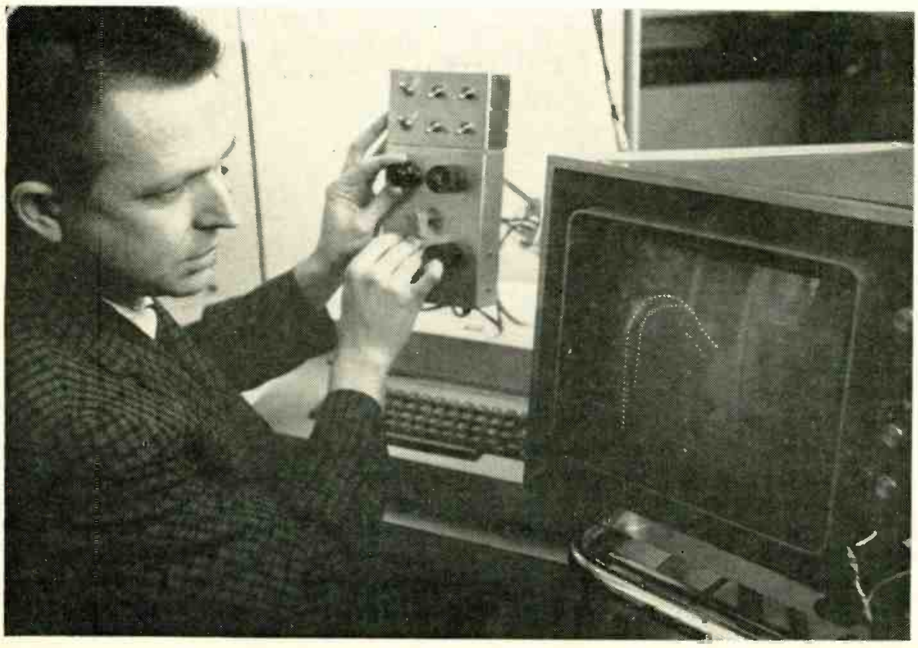
Speech synthesizer

In yet another recent development, Bell Laboratories engineers have constructed a computer-connected speech synthesizer. The new talking machine provides a visual display corresponding to the tongue, lip, jaw and palate of a human speaking a particular word or sound. A control panel permits the programer to alter the structure of the vocal model until a perfect enunciation is attained for each word and transitional sound. The computer then remembers its speech lesson and can be programed to speak understandable phrases.

No single individual can possibly be expert in several dozen areas of scientific investigation. Yet, more and more often, workers in one aspect of pure science are required to borrow from seemingly unrelated fields to understand the results of their work in the broad context of life. Dividing lines between chemistry, physics, electronics, biology are constantly being moved or removed to accommodate several sciences.

One day we may need a new science to describe the work of a man who will select the essence of achievement in all fields through a massive computer-controlled information clearinghouse and apply the accumulated data in solving fundamental questions. These generalists may bring us closer to a real understanding of who we are and where we came from.

An oscilloscope is used to monitor the vocal structure of the computerized voice synthesizer. The synthesizer can be adjusted and programed to speak phrases intelligibly.



Using already established techniques and soon-to-be-perfected concepts of life simulation, man may yet succeed in constructing "living" machines. Two highly theoretical concepts may speed that day. The first is an energy system analogous to solid-state molecular electronics. It is based on ionic movement in liquids rather than on molecular movement in solids. This "liquid-state" electronics theory is being developed by Aeroneutronics Div., Philco Corp. A long way from completion, it already suggests high-density computers capable of healing themselves and growing in capacity.

Secret of life

The second concept is being explored at the Weizmann Institute of Science in Rehovoth, Israel. One most thoroughly frustrating secret of life has been the ability of human muscle fibers to convert chemical energy directly to motion. All engines and mechanisms contrived by man so far, require at least one intermediate step in the conversion. But now, although the results are still highly experimental, scientists at Weizmann have succeeded in constructing fibers from an artificial collagen (the material from which human tendons are made) that contract abruptly when sprayed with a salt solution. And they relax when rinsed with distilled water. The action, though not the process, is identical to that of muscle fibers.

Long road ahead

There is a long road ahead in utilizing practically what we already have learned of the stuff of life. But it's not inconceivable that someday an unspecialized scientist or engineer will assemble the apparently random collection of life knowledge that already exists and construct a remarkable machine capable of duplicating the life process in total.

So, who says science is overspecialized? It can be, but in the life sciences alone, the best doctors are engineers and scientists and philosophers, etc., practically *ad infinitum*, just as always. And in the truest sense, we've just begun to apply the tools of the great technological revolution to all fields of science. It's quite possible that the trend now is not toward specialization but toward a greater recognition of the interlocking fundamentals of *all* science. **R-E**

Tape Recorder Tips and Techniques

A few tips on how to get the most out of a sound investment

by **EARL E. SNADER**

THERE ARE LOTS OF GOOD REASONS FOR recording sound. Besides being able to establish a more or less permanent record, the tape recorder can be made to serve businessmen, educators, entertainers and just about everybody. At home you can listen to yourself and hear how you sound to others. You can leave messages; send voice letters; record your favorite radio programs, important events, and the voices of your friends and family.

One way to make better recordings is to think the tape recorder is a camera. The sounds to be recorded are the people, the scenes, etc.; the tape is the film, and the microphone is the lens of the camera.

Making interesting and worthwhile tape recordings is in part a matter of employing certain accepted routine techniques and in part a matter of using your creative talents.

Preschool children have hearing tested by tape recorder as part of medical.

A battery-operated recorder is most useful for making candid recordings indoors or outdoors . . . you are not chained down to the nearest electrical outlet. It makes an excellent second recorder. The recorder should be a fairly good one and be equipped with a capstan drive. The capstan drive transports the tape at a constant speed regardless of reel size or the amount of tape on the takeup reel.

When all portions of the tape are recorded at the same rate of speed, it is possible to edit, reposition or transfer segments of tape from reel to reel just as a film strip is cut and edited to make a better show.

One precaution: When you have different programs on the 2nd, 3rd, or 4th tracks be aware that a correction for one track will throw you for a loss on the other. Also, be on the alert for compatibility of tape recorders when more than one is used. Just because two different machines can run at the same speed, and are capstan driven, is no guarantee that a 4-track stereo job will put out a suitable recording for a 2-track mono recorder.

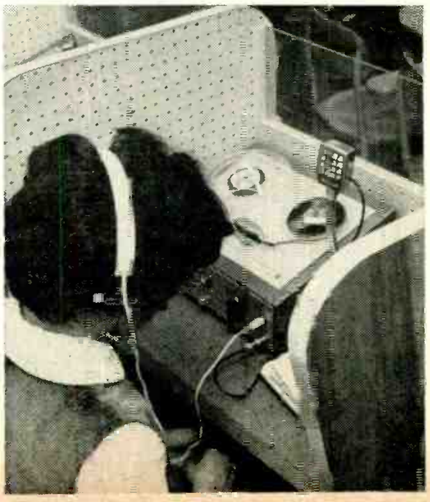
Modern tape recorders for home and non-professional use generally have 4 tracks on ¼-inch tape operating at one or more of 3 speeds . . . 1⅞, 3¾, and 7½ inches per second. Some machines have a 15-inches-per-second capability. Still another factor related to compatability is the cartridge versus other cartridges and just plain reel-to-reel types. Of course, the tape can be loaded on an appropriate reel. Size of the reel depends on the particular tape recorder.

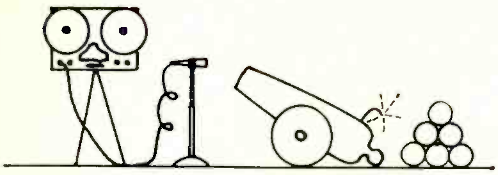
All compatability factors being equal, a mono program can be played back on a stereo recorder, but not vice versa. A stereo program will come out as a mono recording (with some deterioration) on a mono recorder.

Sound-on-Sound Recording

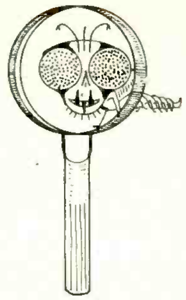
Trick photography has its counterpart in tape recording, too. One of

Language labs use tape recordings to teach students correct foreign accents.





Your tape recorder as a sound camera.



Close-ups are more interesting.

Get permission to make a recording.

the most interesting tricks you can perform with a stereo, 3-head tape recorder is the production of a sound-on-sound recording. You can record yourself singing with yourself as a duet, a trio, a quartet (ad infinitum) or you can accompany yourself on an instrument. If you have illusions of grandeur you can record yourself singing to the accompaniment of a symphony orchestra, but don't get carried away and try to sell the recording.

To make a sound-on-sound recording, such as a duet of your voice, first record on channel 1 only. Next rewind the tape and play it back into the second channel (channel 3 on a 4-track machine); at the same time repeat your performance. You should use a set of headphones to listen to channel 1, or monitor both channels while you are accompanying yourself. It's kind of tricky at first, but it could be a lot of fun. See Fig. 1 for a graphic illustration of this process. (Don't expect to do this on the battery-operated portables or on the older machines.) You can, of course, repeat this process to set up a trio by playing back the second channel and simultaneously feeding both your voice and the second channel into channel 1. Note that while making a recording on say channel 3, the previously recorded material only on channel 3 is erased. The recording on channel 1 is not erased. This could give you another interesting effect. Simply play back both channels (stereo-fashion). You might get a pleasant effect. The slight delay in the second channel may or may not be noticeable . . . depends upon your tape recorder.

If your tape recorder does not have provision for sound-on-sound recording you can use two tape recorders to do the job. The task of feeding and mixing signals and operating on both record and playback modes at the same time on a tape recorder not specifically designed to do so can be a major undertaking.

Do's and don'ts

Keep an eye on your recording level indicator. To overshoot the indicated maximum is to cause distortion. Too low a level increases the noise output from the tape. Get to know your tape recorder by sampling weaker and weaker sounds to determine the minimum recording level you can use.

Use headphones, where possible, to monitor your recording. The mike and your eyes may be pointing to different sound sources.

Get in close with your microphone to single out desired sounds and minimize undesirable background. However, make your sound "shots" more interesting; get the whole scene and then come in for a closeup. But don't stick the mike under a person's nose. Besides the blasting effects, mike fright might set in and all you'll hear is breathing. **R-E**

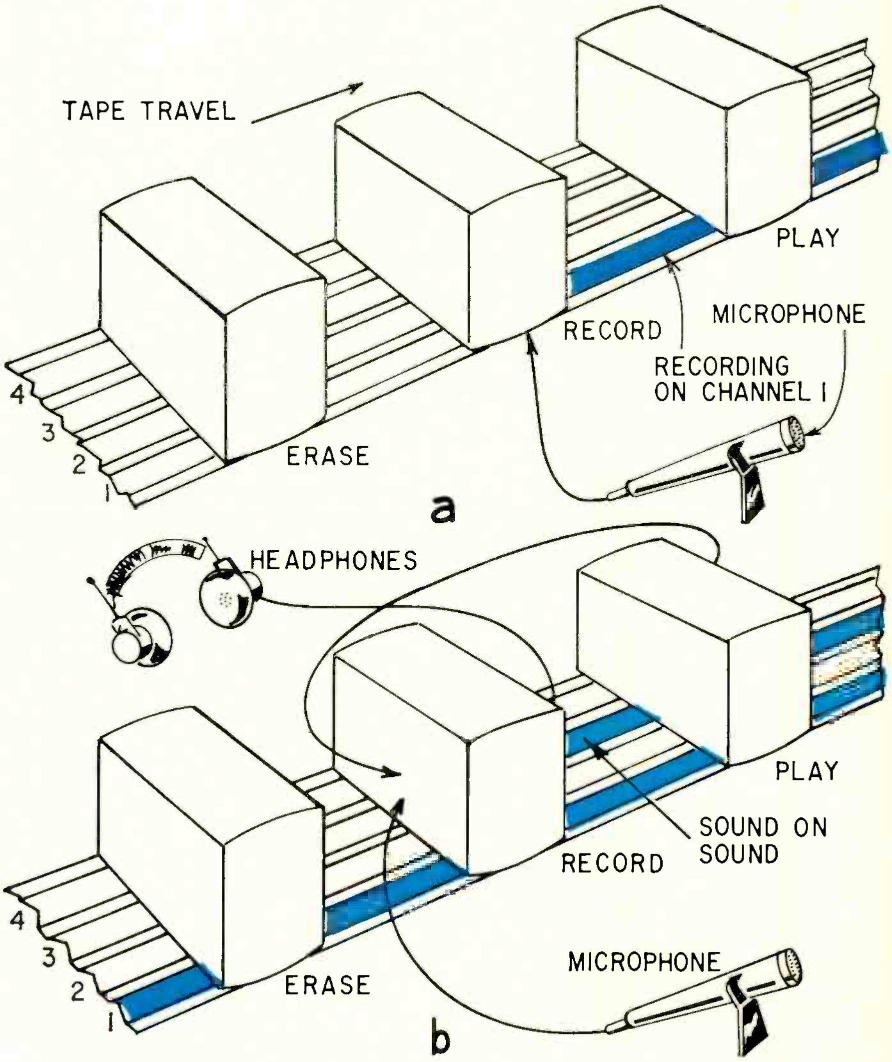
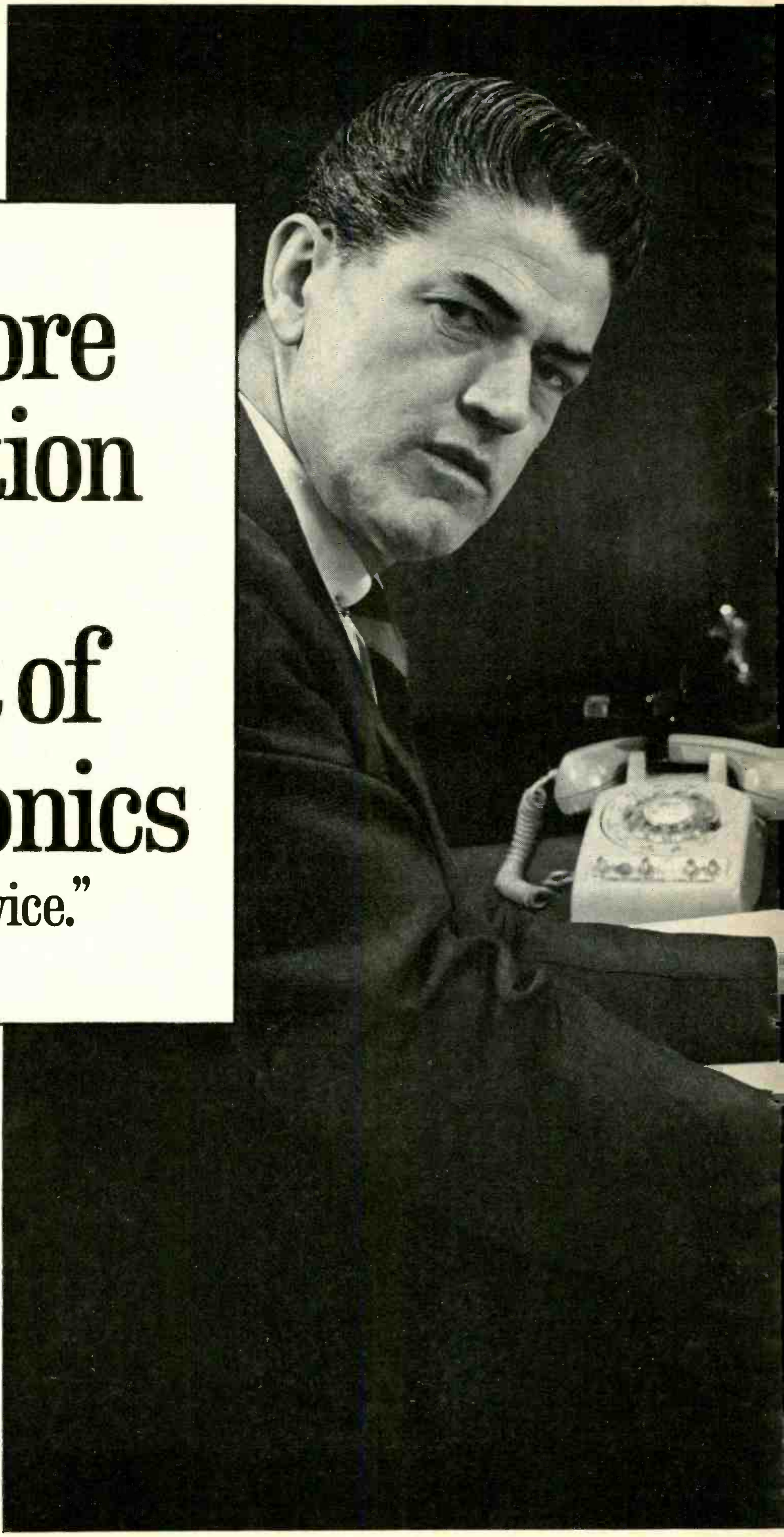


Fig. 1—Sound-on-sound technique with a stereo recorder. In Step 1, you record only on channel 1. In Step 2, you add a second track on another channel, combining channel-1 material with more live music or voice. You can sing with yourself!

"Get more education or get out of electronics

...that's my advice."



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Ask any man who really knows the electronics industry.

Opportunities are few for men without advanced technical education. If you stay on that level, you'll never make much money. And you'll be among the first to go in a layoff.

But, if you supplement your experience with more education in electronics, you can become a specialist. You'll enjoy good income and excellent security. You won't have to worry about automation or advances in technology putting you out of a job.

How can you get the additional education you must have to protect your future—and the future of those who depend on you? Going back to school isn't easy for a man with a job and family obligations.

CREI Home Study Programs offer you a practical way to get more education without going back to school. You study at home, at your own pace, on your own schedule. And you study with the assurance that what you learn can be applied on the job immediately to make you worth more money to your employer.

You're eligible for a CREI Program if you work in electronics and have a high school education. Our FREE book gives complete information. Airmail postpaid card for your copy. If card is detached, use coupon below or write: CREI, Dept. 1403G, 3224 Sixteenth Street, N.W., Washington, D.C. 20010.

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Please send me FREE book describing CREI Programs. I am employed in electronics and have a high school education.

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APPROVED FOR TRAINING UNDER NEW G.I. BILL

How to Deal with RF Interference
(continued from page 36)

Somewhat similar to fluorescent lamps are the neon tubes used in advertising signs. They arc and produce RFI incessantly, and can be completely cured only by encasing in transparent but conductive material, which is then grounded. This is an expensive procedure, however, and generally you can reduce the noise somewhat by using a power-line filter as well as series resistors in the high-voltage secondary of the stepup transformer. Generally some RFI from neon signs must be tolerated due to cost considerations. Repositioning the receiver and/or antenna will also help in neon-sign cases.

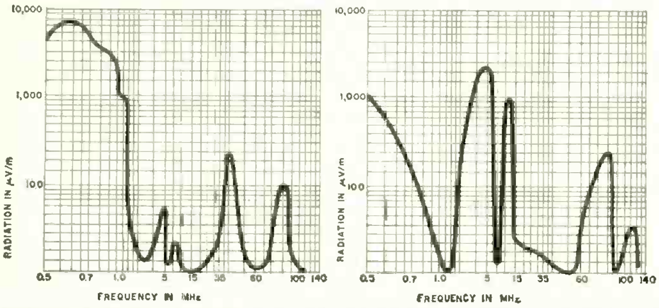

Fig. 6—Fluorescent lamp RFI. Curve at left is for a standard 40-watt 4-foot lamp, while that at right is for an 8-foot Slimline tube. RFI extends beyond 140 MHz, but its amplitude is much lower in upper-frequency range.

Commercial filters

Winding your own line filter can be done, but you must calculate current and seal the unit inside a box. It is much easier, in many cases, to simply purchase a ready-made model and install it. Among those available are the Aerovox IN Series, Cornell-Dubilier IF and NF Series, Lafayette 99H4005, and Sprague Filterol Series. Most of these are made in several sizes to handle various load currents. They are available with screw terminals or with wire leads. Since the case is usually the common point for the bypass capacitors, when it is grounded the filter works best.

For 117-volt line filters use capacitors rated at 600 working volts or better. The ceramic types are excellent for this purpose.

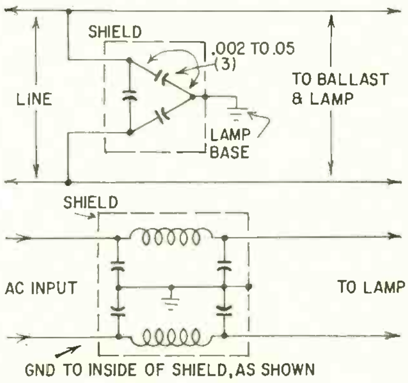

Fig. 7—Typical fluorescent lamp filters, simple (top) and more complete (bottom). An efficient shield and an electrical ground are essential.

One more point should be made about RFI suppression. In most cases shielding and filtering won't be very effective unless you ground the noise source properly. In some cases you can use a three-wire ac cord, *if* the ac outlet is properly grounded. If you aren't sure, you may want to run your own ground spike into the earth at a point as near as possible to the noise source. Remember that more than a few feet of "ground" wire can act as an antenna (depending on frequency) and thus radiate rf noise.

The noise you can't suppress is your neighbor's complaints when you're at fault. **R-E**

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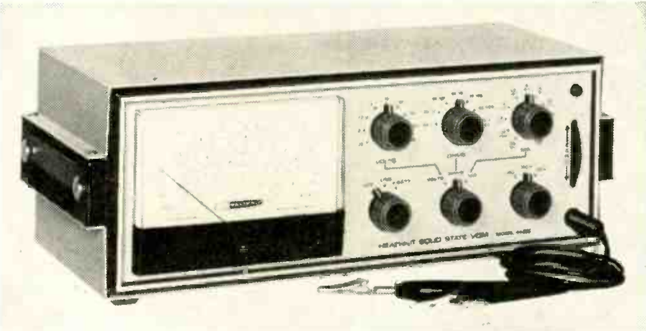
EQUIPMENT REPORT

Heathkit IM-25 Solid-State Vom

Circle 30 on reader's service card



RARELY DO DESIGN ENGINEERS CONSTRUCT A DEVICE THAT proves so correct it seems to last forever. Consider the Colt .45 pistol, the Douglas DC-3 airplane, the Ford Model T auto, and the RCA 630TS television receiver. Each became a classic in its time—and some are still in service.

Perhaps another classic design has been brewed, by unknown design engineers in Benton Harbor, Mich. The Heathkit IM-25 solid-state vom works so well and so easily I am now completely spoiled. It is in a class by itself.

Assembly

All good things have minor imperfections; the IM-25 is no exception. My kit arrived with a broken PC board, which Heath, promptly replaced free of charge. (If they have to replace enough of them, perhaps they'll redesign the shipping carton.)

The assembly manual is straightforward, and there are no loose diagrams—everything's in the book, for quick reference. An accompanying "Kit Builder's Guide" is useful.

I took 15 careful hours to assemble, test and calibrate the instrument. I aged the meter a week before buttoning it up, and it's been stable since then.

Advantages

A rare bird, the IM-25. It's a true vom (volt-ohm-milliammeter) with semiconductor amplifiers, and thus the input impedance of a vtvm. It measures ohms, ac and dc volts, dc current and—unlike nearly every other vom—*ac current!* With an input impedance of 11 megohms, and 2 FET's, 13 bipolar transistors and 7 diodes, it has low full-scale ranges of 150 mV and 50 μA, both ac and dc. Some transistors are diode-connected overload protectors; you can't burn out amplifier transistors or the meter movement with too much input voltage or current.

Reading the meter scale is simple for two reasons: The meter face is 6″ wide and has color-coded scales. Black is dc, red is ac, and green, ohms. There is even a separate dc zero-center scale with gradations from zero to 25 and 7.8, for bias or discriminator adjustments. Three separate range switches (volts, ohms, milliamperes) are selected by a function switch. The current-range switch indicates the amount of resistance inserted in the test circuit by the meter, so you can compute measurement error.

One of the nicest things about the IM-25 is its two-way power supply; it runs off the ac line *or* internal batteries. Replacing batteries can be a nuisance, so ac power is best for bench use. (Heath even includes a three-wire line cord

See MAY P12

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and grounding plug.) Take the meter out on a trip, though, and you can use battery power. Moreover, if you want to measure the drop across a plate, collector or drain resistor (above ground) just switch to battery and unplug the IM-25 from the ac line. The meter then floats—and you get a true, hum-free reading.

Heath's engineering wizards can be forgiven the following oversights—if they will correct them.

Batteries are difficult to replace; you have to, not only remove the cabinet back, but also open up a tubular plastic holder. However, the plastic holder will protect the meter and its components if the batteries spring a leak. (I recommend using manganese-alkaline cells, as they last longer than zinc-carbon.)

The OHMS control is hidden amidships, not on the front panel. Perhaps a hole in the cabinet top?

There is no ac line fuse—a most common omission among kit makers. I asked my IM-25 to inspect its own current drain, and it reported 15 mA. I installed a ¼-amp fuse and holder on the back panel.

Ever since someone invented the single voltmeter probe with the switchable dc isolation resistor I've been annoyed. Either the probe is too large for tiny transistor chassis or the switch is poor. The probe supplied with the IM-25 has a movable lever controlled switch to short out the 1-meg, 1% dc resistor. The switch on my probe was intermittent. (I must admit, however, that the threaded probe tip is a good feature; you can screw on a mating alligator clip for long-term measurements.)

How does it work?

Pretty doggone good. Like a wife, a vom should be faithful, true and stable. The IM-25 is.

Heath advises that in the ohmmeter function the probes put out a maximum of 7 mA at 70 mV. Thus you may safely check resistance in transistor circuits. But this also means (as Heath points out) that you can't check solid-state diodes for front-to-back ratio, since they won't conduct on such a low voltage.

In this age of miniature solid-state circuits with midget-sized knobs, the IM-25 is sensibly scaled. The instrument is no smaller than it should be; the controls and handles (two of them—at cabinet sides) are comfortably hand-size.

You can't go broke paying the electric company for 1.8 watts around the clock, I figure. So I leave my IM-25 on all the time. Why? No turn-on transients, little change in cabinet temperature, and ultimately (I hope) longer life. I like the IM-25 and recommend it.—*Thomas R. Haskett* **R-E**

Manufacturer's Specifications

Dc Voltmeter
Ranges: 0.15 to 1500 volts full scale
Input Resistance: 11 megohms all ranges
Accuracy: ±3% of full scale

Ac or dc Milliammeter
Ranges: 0.015 to 1500 mA full scale
Insertion Resistance: 10,000 ohms (0.015 mA) to 0.1 ohm (1500 mA)
Accuracy: ±4% (ac) or 5% (dc) of full scale

Ac Voltmeter
Ranges: 0.15 to 1500 volts full scale
Input Impedance: 10 megohms shunted by 175 pF
Accuracy: ±5% of full scale
Frequency Response: ±2 dB, 10 Hz–100 kHz

Ohmmeter
Ranges: 10 ohms to 10 megohms center scale

Power Supplies
Ohmmeter: 3 volts (2 C cells)
Ohmmeter bias: 1.35 volts (mercury reference cell)
Amplifier: 18 volts, from batteries (12 C cells) or ac line (120 or 240 volts, 50/60 Hz, approximately 15 mA or 1.8 watts)

Size: 13½" x 6¼" x 5⅛"
Weight: 9 lb
Price: $80.00 kit, $115.00 wired

Battling Bollworms With Ultrasound

By JAMES A. GUPTON Jr.

WAY DOWN YONDER IN THE LAND OF cotton, the familiar "Dixie" melody is being replaced with ultrasonic space-age music.

Bursts of high-frequency sounds, similar to those emitted by bats while hunting for night-flying insects, may become the most effective weapon in the bollworm wars. The cotton bollworm *(Heliothis zea)* also is known as the corn earworm and the tomato fruitworm, in dubious honor of the extensive damage caused these two plants. If the new sound technique proves successful, farmers would be able to cut down on the use of insecticides for protecting cotton, corn and tomatoes from the bollworm's destructiveness.

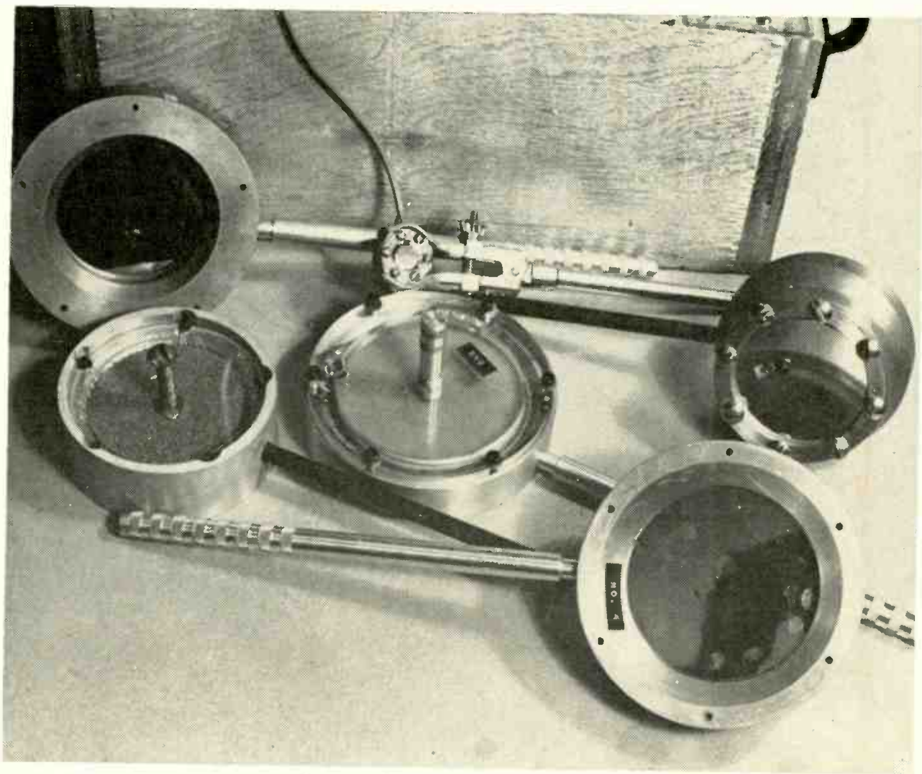
Bats, which feed on night-flying insects, emit high-frequency sounds in the 20- to 100-kHz region. This atmospheric sonar system helps bats to locate their prey. But, unfortunately for hungry bats, bollworm moths also pick up the sound pulses and are warned of a foraging bat's approach. Reception of the bats' signals sets the moths to spiraling, diving and zooming to escape being devoured. While in flight, the moths don't feed.

Entomologists working with the Agriculture Research Service, in cooperative research with the South Carolina Agriculture Experiment Station, are using electronic equipment to simulate bat sounds. In laboratory tests, the reactions of moths to frequencies generated electronically was quite similar to their reactions to actual bat sounds.

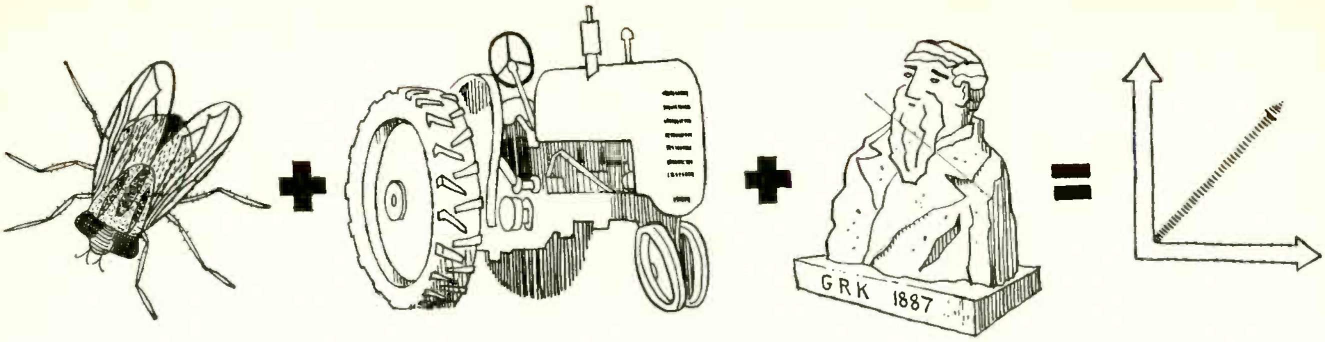
Amid an array of electronic generators, amplifiers and measuring equipment, entomologists experimented with various sound frequencies to determine the physiological response of moths, detected as electrical impulses. Microelectrodes were connected from the tympanic nerve fibers of several insect subjects to amplifiers so that the electrical impulse signal could be observed on an oscilloscope–audio-amplifier combination and recorded permanently on tape.

Test results indicate that a burst of sound in the 21-kHz region may be the most effective for field use. This frequency does not appear to affect any beneficial insects, nor does it disturb humans working in the fields.

Field tests were conducted by rotating 6-inch transducers, a form of electrostatic loudspeaker, which projected the ultrasonic energy over the entire field. During the tests, entomologists observed and recorded the evasive flight reactions of various moths. END



By attaching microelectrodes (left) to the bollworm's tympanum nerve, researchers determine its hearing-frequency range. Shown at right are ultrasonic transducers—½ to 6 inches in diameter—used to radiate sound and scare bollworms away from the crops.



Illustrated by Frank Salerno

Horseflies, Tractors and Mr. Kirchhoff

7 volts and 7 volts can add up to 10 volts!

By WAYNE LEMONS

"I'M A LITTLE SHOOK ABOUT MR. Kirchhoff* this morning," Jerry Whipple told his high school electronics instructor. "Did Mr. Kirchhoff know about ac circuits?"

The instructor—a short, balding, plump man named Bean—scratched his head and looked at the student. Jerry was a glasses-wearing, baseball-pitching senior who sometimes asked embarrassingly complex questions.

"I suppose you mean the Kirchhoff who developed some laws for electrical circuits?" Mr. Bean.

"That's right," Jerry said, "the guy we studied about in dc circuits. Do his ideas hold water in ac circuits?"

"Far as I know." Mr. Bean grinned. "What'd you have in mind?"

"See this circuit here?" Jerry pointed to an inductor and a resistor: "It's a 10,000-ohm resistor and a 10-millihenry rf choke in series. The experiment calls for putting a 160-kHz, 10-volt peak-to-peak signal across the circuit."

"Fine, so what's your problem?"

"Well, according to Mr. Kirchhoff the individual voltage drops across the components in a series circuit are equal to the source voltage. Isn't that so?"

"That's right."

"Then Mr. Kirchhoff better come up with something new, 'cause I think this circuit just repealed his law."

Mr. Bean chuckled. "Don't think Mr. Kirchhoff can do that; he died, I believe, in 1887. But I can't recall anyone ever disputing his conclusions about circuits. What makes you think you've found a flaw in Kirchhoff's rule?"

"I'll demonstrate. With an rf detector probe on the vtvm I measure across the inductor and resistor and I find 10 volts. See?"

"Yes."

"Now," Jerry said, "I'll measure the voltage across the resistor. The meter reads about 7.1 volts. And according to Mr. Kirchhoff I ought to have 2.9 volts across the coil. Right?"

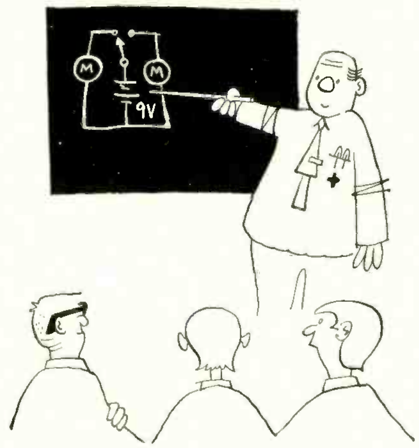
Mr. Bean avoided an answer by asking a question, "How much *do* you have?"

Jerry didn't reply. He moved the vtvm leads across the coil and the meter came to rest reading again just over 7 volts. "Look at that—just about the same as across the resistor."

"So what's wrong?" Mr. Bean appeared puzzled.

"Wrong?" Jerry blurted. "What's wrong is that 7 volts and 7 volts add up to 14 volts—*not* 10 volts. And that proves that Mr. Kirchhoff, may he rest in peace, was all wet."

"Interesting," Mr. Bean bantered. "I've made a quick check in your addition, and 7 and 7 are 14 if you're adding 7 and 7 of the same thing. But, if you'll excuse my farm-boy upbringing, 7 horses and 7 flies don't make 14 horseflies."



If the switch is moved back and forth between the two meters fast enough, the meters cannot read the full battery voltage, but only some lesser value.

"I understand that," said the boy. "But I'm measuring volts and volts and 7 and 7 ought to be 14."

"But obviously it isn't," said the instructor. "You said yourself that you had only 10 volts to start with. How do you explain that? Maybe we shouldn't be too hard on Kirchhoff until we look a little further into the matter."

"But how is it possible that the component voltage drops add up to more than the source voltage?" Mr. Bean went to the blackboard, motioning Jerry to follow him. He drew a battery symbol, connected one end to an s.p.d.t. switch, and drew two circles to represent meters.

"Look at this circuit," he said. "Assume this is a 9-volt battery. If I move the switch to the left, the left-hand meter will read 9 volts. Agreed?"

Jerry nodded.

"If I move the switch to the right, the righthand voltmeter will read 9 volts. Okay?"

Mr. Bean grinned a little and continued: "Now if I move the switch rapidly I will have both meters reading. Because the pointer can't return to zero very fast I will have both meters reading, let's say, 6 volts. Right?"

"I see that," said Jerry, "but I don't see what you're driving at."

"The point is this," said Mr. Bean. "Just because both meters can be made to read 6 volts doesn't mean that the battery voltage is 12—even though 6 and 6 are 12. Does it?"

"I think maybe I'm beginning to get a twinkle," Jerry said. "Has it got anything to do with the timing in the circuit? Could that current trailing along behind the voltage, you've been talking about, have anything to do

*Gustav Robert Kirchhoff, German physicist, 1824–1887.

with what we see on the meters?"

"Just about everything," the instructor said. "And if you understand just how you'll have gone a long way toward mastering ac circuits."

"Do you mean to say that the voltages in my circuit are being switched around and fooling the meter?"

"Right." Mr. Bean smiled. "Nobody can say that a meter has a lot of sense—it can be fooled."

"How?"

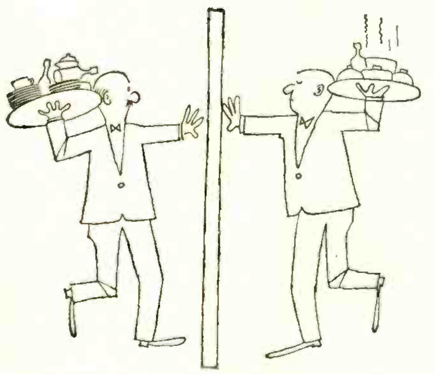
"If you put a certain voltage on a resistor, the current will go up at the same time the voltage goes up. Agreed?"

Jerry nodded.

"What do we say the phase angle of a resistor is then?"

"Zero degrees?"

"That's right—we say that because there is zero delay between the rise time of the voltage and current. Now what about an inductor?"



When two opposing forces meet, they produce a third resultant force. The strength and direction of the third force depend on the first two forces.

"In class yesterday you said the current lags the voltage by about 90°."

"And just what does that mean to you?"

"It means, I guess, that the current does not start until after the voltage has already been on the coil a little while."

"And, as I pointed out yesterday, the reason for that is that a coil tries to oppose any *change* in voltage across it by developing a 'back' voltage—called a counterelectromotive force—so long as the voltage is changing. The ac voltage starts to reverse after a quarter of a cycle—or 90°—and when that happens the current starts to flow in the coil. So, in a perfect coil, the current lag is 90°."

"But what happens when there's a resistor in series?"

"Just what happened to you. The phase angle shifts to somewhere between 0° and 90°. In your case the voltage drops are almost identical across the resistor and the coil, so the phase angle is approximately 45°."

"How do you know that?" Jerry asked.

"I'm afraid my farm-boy upbringing is still showing, but in one way or another you've been dealing with this phenomenon all your life," said Mr. Bean. "Suppose two tractors with the same power pull cables attached to the same tree. One tractor pulls north and the other, east. Where will the tree fall?"

"Halfway between the tractors," Jerry said. "To the northeast."

"Right," agreed Mr. Bean, "and if we consider the tractor heading east to be at zero phase angle, then the tree will fall at a 45° angle to it. Agreed?"

"Yes, I'm beginning to see. If one of the tractors went farther or faster than the other, then the tree would fall toward it and that would change the phase angle."

"Yes. And that's what happens in an electrical circuit when the voltages aren't pulling in the same direction. If the circuit has more voltage across the resistor than across the inductor then the circuit phase angle will be less than 45°. If there is more voltage across the inductor then the phase angle will be more than 45°."

Mr. Pythagoras

"But," mused Jerry, "I'm still not sure I understand how to figure the total voltage in the circuit."

"Sure you do," said Mr. Bean. "You probably learned it several times in elementary school. Ever hear of Mr. Pythagoras* and his theorem?"

"You mean the one about a right triangle where the square of the hypotenuse is equal to the sum of the squares of the other two sides?"

"That's exactly what I mean. And in our example here if these tractors each had 7.1 pounds of pull on the treetop then the total pull would be $\sqrt{7.1^2 + 7.1^2} = \sqrt{50 + 50} = 10$ lb. Does that suggest anything?

"Unfortunately it looks like you're going to get Mr. Kirchhoff out of my dilemma," laughed Jerry. "Anyway it seems that my roughly 7.1 volts across each component is going to have a hypotenuse of 10 volts. I'm still not sure, though, why the meters don't tell me."

"Remember the switch analogy I used earlier?" Mr. Bean asked.

"You mean this circuit is a kind of electronic switch?"

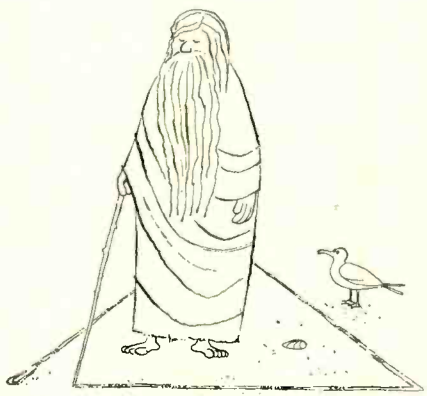
"You might call it that," said Mr. Bean. "You see your meter can't respond to that 160-kHz signal, so it just finds the peak voltage across the component and stays there."

"Then you mean I really never have 7.1 volts across either the coil or the resistor?"

"No, I don't mean that." Mr. Bean grinned. "It's just that if you want Kirchhoff's law—or for that matter Ohm's law—to work in ac circuits, you have sometimes to be concerned with instantaneous values, and not with values taken over a period of time.

"The meter reads the highest voltage that is ever across the circuit components but at the *very* instant that the voltage is 7.1 on one component, at that very instant it is only 2.9 across the other."

"In other words," Jerry said, "the meter can't fall back to 2.9 volts that fast, so it just stays up at the peak."



Pythagoras and friend contemplate his theorem. He didn't know it, but his formula would work for electronics as well as for many other fields of science.

"That's pretty close," said Mr. Bean. "So we have to let Pythagoras take over and do the mathematics, but rest assured that Kirchhoff knew what it was all about."

"But what about Pythagoras?" Jerry demanded. "He must have been in his grave a long time before anyone discovered electricity."

"Yes, as far as anybody knows, Pythagoras never dreamed of such a thing as electricity. But like a lot of other people who discover basic truths, he supplied the answers before we invented the problems."

"And you can't hardly get smarter than that," Jerry said and headed for the door as the class bell rang.

Mr. Bean grinned affectionately after his best student. It was nice to have someone who cared enough to question other people's conclusions . . . even his own. **R-E**

*Pythagoras. Greek philosopher and mathematician, 582–500 BC.

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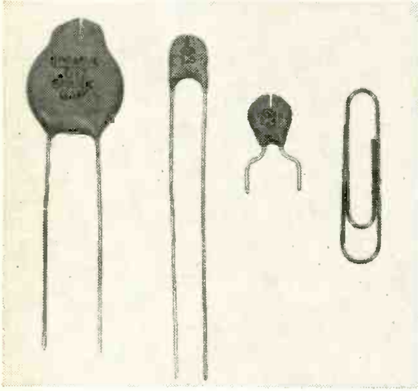
ZENITH (Pg. 26) — Circle 24

NEW PRODUCTS

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

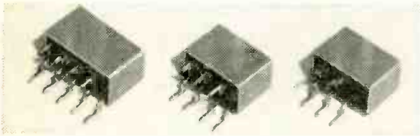
SPARK GAPS AND GAP CAPACITORS. Both are available in arc voltage ratings of 1.5 kV and 2.5 kV. Spark gaps come with either conventional radial leads or truncated crimped leads spaced at 0.375" for printed-wiring boards. All spark gaps have a maximum capacitance



of 0.75 pF. Gap capacitors, which contain a 0.01 μF ceramic capacitor section in parallel with the spark gap, are available for those who want a unit that contains both a capacitor and spark gap as integral parts of a single unit.—**Sprague Electric Co.**

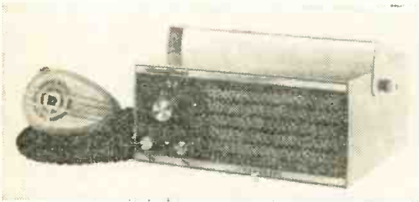
Circle 46 on reader's service card

COLOR TV CONVERGENCE RECTIFIERS. Available in 3-, 4-, and 5-cell models, they provide an exact replacement part for any set. Cross-reference part numbering guide correlating part number with original equipment



number is provided. Each part is packaged individually. Also comes in master pack of 10 rectifiers with counter display card. Complete information and prices are available.—**GC Electronics**

Circle 47 on reader's service card



CITIZENS BAND TRANSCEIVER, *The Commodore.* Made for mobile applications, this 23-channel solid-state transceiver uses a pulse eliminator to eliminate interference and permits reception of weak signals without distortion. 5-watt transmitter is capable of 100% modulation for maximum intelligible power. Sensitivity: ½ μV for 10 dB; adjacent-channel selectivity down more than 60 dB; agc, 4 dB max. rise in audio for input signals from 1 μV to 0.1 V; squelch sensitivity: adjustable from 1 V to 50 μV. Includes 350C microphone. Housed in a beige cabinet with a walnut wood panel and gold trim. $199.95—**Squires-Sanders, Inc.**

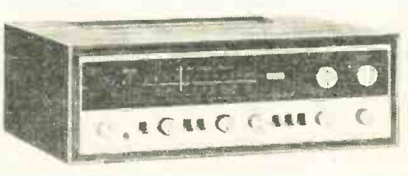
Circle 48 on reader's service card

PREAMPLIFIER, *the PT.* Covers 6 through 160 meters and is designed for use with ham transceivers in that range. *PT* uses a frame-grid tube permitting a wide range of gain control with high sensitivity for flexible usage of the unit over

a wide range of signal conditions. Control circuitry allows the unit to be added to virtually any transceiver without modification. Comes complete with built-in power supply and connecting cables to the transceiver.—**Aerotron, Inc.**

Circle 49 on reader's service card

STEREO AM/FM RECEIVER, *Model 300.* Uses 82 semiconductors in the solid-state circuit. FM circuit has 4 dual-tuned i.f. stages, two limiters, automatic stereo–mono FM switching and interstation muting. Power output: 244 watts peak, 122 watts total IHF; power band-



width: 15–40,000 Hz; response: ±1 dB, 18–60,000 Hz; sensitivity: less than 1.5 μV; selectivity: 45 dB; power requirement: 110–120 volts, 50–60 Hz ac. $299.95. Optional walnut wood case is $19.95.—**Allied Radio Corp.**

Circle 50 on reader's service card

STEREO RECEIVER, *Nocturne 520.* Employs metal oxide silicon field-effect transistors (MOSFET) in the FM front-end to reduce crossmodulation and overload. Sensitivity 1.95 μV and music-power output 70-watt I.H.F. Frequency response is virtually flat from 8 to 60,000 Hz at normal listening level. Highly regulated power supply assures clean, transparent sound.—**Harman-Kardon, Inc.**

Circle 51 on reader's service card

COMPACT STEREO SYSTEM, *Scott 2502.* Features 3-speed automatic turntable with magnetic cartridge and diamond stylus, direct-coupled silicon output circuitry, microphone/guitar inputs, and stereo headphones. Also has a field-effect transistor AM/FM stereo tun-

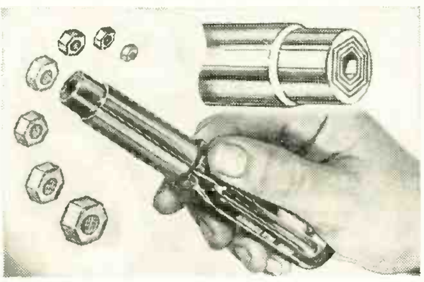
er, integrated circuit i.f. amplifier and precision signal-strength meter. Smoky-gray plastic dust cover is optional. There are three other models to choose from in this series.—**H. H. Scott, Inc.**

Circle 52 on reader's service card

CB TRANSCEIVER, *Traveller.* Adjacent-channel selectivity is better than 50 dB. Incoming signal indicator activates with a white light when receiving signals of 10 μV or more. Comes with auxiliary speaker jack, modulation indi-

cator, dc cord, microphone and safety circuit which protects against mismatched antenna, overload or incorrect polarity. Includes mounting bracket and 23 crystals. $149—**Courier Communications, Inc.**

Circle 53 on reader's service card



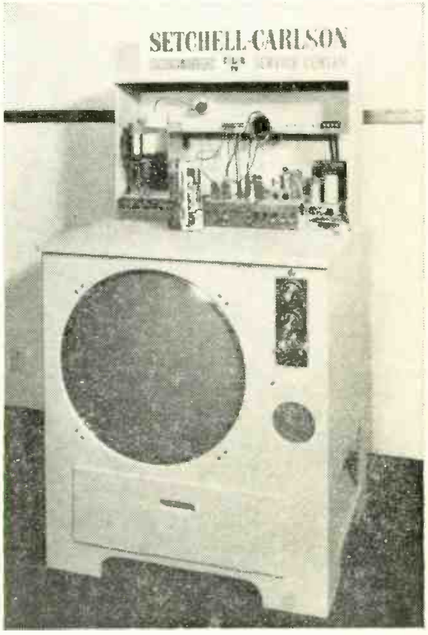
SELF-ADJUSTING NUTDRIVER. Automatically adapts itself two ways: First, the driver shaft sockets adjust themselves to the size of the hex nut involved (1/4" to 7/16"). Second, the hollow shaft of the driver enables it to accommodate bolt extensions to 1 7/16". One driver does it all, eliminating the need for an array of individual drivers of various sizes. $3.85.—**Vaco Products Co.**

Circle 54 on reader's service card

NIBBLING TOOL cuts holes to any shape or size. You start with a 7/16" hole and "nibble" to size required. It cuts clean without adding strain or distortion to the edges or to original form. Capacity—

steel 18 gauge (.046) max.; aluminum, copper, plastic 1/16". This easy-to-use tool cuts sheet metal like a punch and die. Ideal for templates, shims, model parts, radio chassis, air ducts, mechanical parts and plastic sheets.—**Adel Tool Co.**

Circle 55 on reader's service card



SERVICE CENTER, *Model 135-SC80X.* Features picture tube connections, yoke connections up front, adapter unit for servicing early Setchell Carlson color units, jumper cables, antenna connections to tuner on main panel and tuner power socket. It contains a 17" x 31" work space, test equipment storage drawer and shelf and comes with an operating chassis, tuner and all picture tube hardware. Complete instruction manuals and unit cross-reference charts are included. $250—**Setchell Carlson, Inc.** **R-E**

Circle 56 on reader's service card

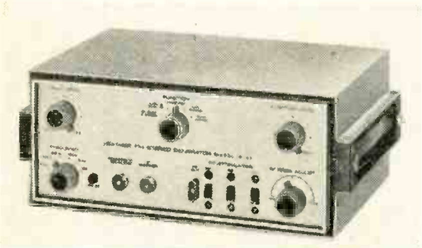
NEW TEST EQUIPMENT

SINE/SQUARE WAVE GENERATOR, *Knight-Kit Model KG-688.* Sine-wave frequency ranges from 20 Hz to 2 MHz; square-wave frequency ranges from 20 Hz to 200 kHz. Uses silicon semiconductors with a field-effect transistor in the oscillator circuit. SINE WAVE SECTION: source impedance 600 ohms; output attenuator to 41 dB in 1-dB steps (6 switches). Accuracy is ±5%; distortion less than 0.25% across entire audio range;

frequency accuracy ±3% except ±5% below 100 Hz and above 1 MHz. SQUARE WAVE SECTION: Frequency coverage 20 Hz to 200 kHz in 4 ranges; output voltage adjustable 0–10 V p-p into high-impedance loads; source impedance 200 ohms nominal; rise time less than 0.1 μsec at 20 kHz. GENERAL: power requirements 100–130 V, 50–60 Hz ac; power consumption 15 watts. $75.00—**Allied Radio Corp.**

Circle 57 on readers service card

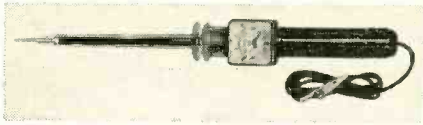
NEW LOOK. 1968 Heath instruments feature new shape and utility in cabinets, new style in front panels and a new high in functional performance and appearance. Feature ultra smart beige front panel framed with chrome and black die-cast bezel. Meter and dial calibrations are easier to read. Top and bot-



tom cabinet shells easily removed to expose top and bottom circuitry and a large portion of side areas. Instruments are entirely functional when top and bottom shells are removed. The word for Heath in '68 is definitely NEW.—**Heath Company**

Circle 58 on readers service card

HIGH-VOLTAGE TEST PROBE, *Model 2900.* This test probe with a built-in voltmeter is small enough and light



enough to be carried in a tube caddy. It may be used on any color or black-and-white TV. High-voltage adjustments can be made at home without need for extra equipment. All you do is ground the instrument, contact the high-voltage anode with the probe tip and read voltage (up to 30 kV) from self-contained meter. No batteries used. $19.95.—**Pomona Electronics Co., Inc.**

Circle 59 on readers service card

VOLTOHMMETER, *WV-500A.* This solid-state, battery-operated voltmeter and ohmmeter instrument requires no warm-up time and eliminates zero-shift.

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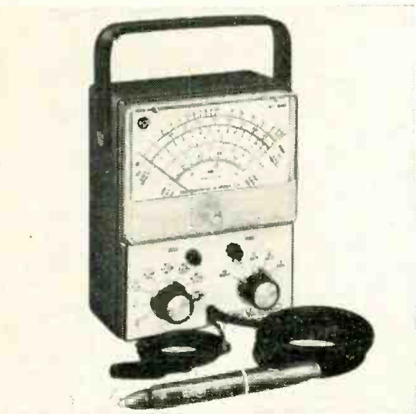

Unit is portable and thus ideal for home and shop servicing. Provides 7 overlapping resistance ranges to allow measurements from 0.2 ohm to 1000 megohms. Eight dc ranges measure from 0.02 volt to 1500 volts, ac peak-to-peak voltages of waveforms from 0.5 to 4200, and ac (rms) voltages from 0.1 to 1500. Input impedance in dc range is 11 megohms. Single unit probe has a shielded input cable. $75.00—Radio Corp. of America

Circle 60 on readers service card

DIGITAL OHMMETER, *Model DMS-3200/DP-170,* provides direct digital readout of resistance measurements from 0.001 ohm to 1000 meghoms in 10 ranges with accuracy capability of ±0.1%

FS ±0.1% of reading. Power applied to resistor under measurement is 1 milliwatt maximum. Nixie type display tubes are used for readout, and decimal-point indication is automatically displayed. 100% overrange capability is provided. Display time is variable, and is able to hold a reading indefinitely. $560—Hickok Electrical Instrument Co.

Circle 61 on readers service card

TEST LIGHTS, *Nos. 5110 and 5105.* Provide quick, efficient means of locating the presence of ac or dc voltages in the 5–50V range, they facilitate countless electronic, industrial, automotive and in-home test procedures. *Model 5105* is

supplied with test prods and *5110* with insulated alligator clips. Feature a lamp that brightens as the voltage in the product increases. Designed for the test needs of the radio–TV service tech, but hobbyists and do-it-yourselfers will also find them useful.—GC Electronics R-E

Circle 62 on readers service card

IEEE 1968 CONVENTION will be March 18 through 21 in New York City. More than 50 technical sessions and 200 papers will be presented. All sessions will be held at either the New York Coliseum or the New York Hilton hotel.

As usual, many manufacturers of electronic equipment will display samples of their latest gear.

NEW LITERATURE

All booklets, catalogs, charts, data sheets and other literature listed here with a Reader's Service number are free for the asking. Turn to the Reader's Service Card facing page 72 and circle the numbers of the items you want. Then detach and mail the card. No postage required!

NEW SEMICONDUCTOR CATALOG. Lists new devices suited for the hobbyist, experimenter, ham and service dealer. Featured are the *HEP 178* silicon bridge rectifier, *HEP 240 NPN* silicon power transistor, *HEP 452, HEP 802* N-channel rf FET and three integrated circuits, *HEP 570, 571* and *572*. Gives costs, watt dissipation, voltage and uses.—**Motorola Semiconductor Prods., Inc.**

Circle 63 on reader's service card

NEW CATALOG *RC-100 and Bulletin RCP-22.* This 26 page catalog on relays, switches, pushbutton stations and reversing drum controls presents complete electrical and mechanical specs and features for each product line. A pocket-sized replacement guide for potential-type motor-starting relays with over 1400 listings is also included.—**Relay and Control Corp.**

Circle 64 on reader's service card

ELECTRONIC HARDWARE COMPONENTS. A 1967 catalog of specs, dimensions and prices of several thousand electronic hardware components, including wired assemblies, fasteners, terminals, heat sinks, insulators and small enclosures. It is geared for the specifying designer and engineer.—**Technical Accessories Co.**

Circle 65 on reader's service card

QUICK-REFERENCE GUIDE TO POWER TUBES. *Booklet B9431.* Easy-to-read guide describes high-vacuum amplifiers, pulse tubes and diodes. Included in this 20-page booklet are triode and tetrode amplifier and pulse tubes. Dimensional diagram for every tube is included. Tubes are grouped according to preferred application.—**Westinghouse Electric Corp.**

Circle 66 on reader's service card

THYRISTOR GUIDE. Offers a key to more than 300 devices available for stepless power-control designs. Covers SCR's up to 35 amps and voltages from 25 to 1000. Includes data on plastic and metal unijunction transistors, plastic bilateral triggers, SCR's and many more.—**Motorola Semiconductor Products, Inc.**

Circle 67 on reader's service card

INFRARED THINISTORS, *Bulletin MFN-173.* Describes infrared spectrum and traces the history of infrared detectors. Also discusses deposited-film thermistors. Contains a glossary of terminology and a table listing typical applications for infrared radiation with wavelength bands.—**Victory Engineering Corp.**

Circle 68 on reader's service card

PLANAR THYRISTOR GUIDE. 8-page bulletin offers descriptions of thyristor packages with a breakdown of characteristics for silicon-controlled rectifiers. Also contains a listing of sales offices and distributors.—**Fairchild Semiconductor.**

Circle 69 on reader's service card

COAXIAL CABLES, *9800 Series.* New 8-page catalog makes it possible to select a coaxial cable designed for a broad range of communication, TV and commercial applications including CATV, color and black-and-white TV, CCTV, MATV, FM, ETV and amateur and Citizens-band radio.—**Alpha Wire**

Circle 70 on reader's service card

DESIGN IDEAS FOR ENGINEERS. *Catalog AS-68.* 12-page catalog features an expanded section for miniature remote-control relays, switches, readout indicators and pilot lights, ceramic terminal strips and machined aluminum knobs. Each product section has complete listings and prices, drawings and specs.—**Alco Electronic Products, Inc.**

Circle 71 on reader's service card

WIRE STRIPPERS, *Bulletin No. 6.* 8-page brochure offers suggestions on how to select the right wire stripper for your requirements. Describes mechanical hand, bench-mounted and thermal strippers with specs, operational drawings and ordering information.—**Ideal Industries, Inc.**

Circle 72 on reader's service card

COIL REPLACEMENT GUIDE. *Catalog No. 167.* Details over 2800 coils and components, including specs and prices. 56 of the 157 pages are a general catalog section which lists over 200 new items and 3000 replacement parts. —**J. W. Miller Company**

Circle 73 on reader's service card

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

FALL AND WINTER CATALOG, *No. 12.* Gives detailed specs and information on a variety of products and offers a guarantee to meet or better any price published for the same merchandise. Includes electronic kits, test equipment, amateur radio and CB equipment, tools and accessories.—**Conar, Div. of National Radio Institute,** 3939 Wisconsin Ave., N.W., Washington, D.C. 20016 **R-E**

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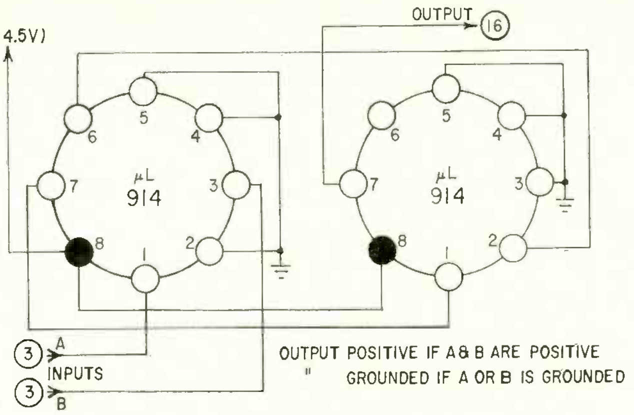
MISS-Q
"30 Basic IC Projects" (January 1968) Fig. 14 should be modified as shown here.



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Build An IC Calibrator

(*continued from page 34*)

can make a table of dial settings for each 100 kHz across the band.

The crystal calibrator is especially useful if you have a two-dial receiver. The bandspread dial will have more accurate tuning than the main dial by a factor of 10 or so, provided the main dial is set accurately. The calibrator allows you to set the main dial precisely on any 100 kHz marker.

Vfo's and signal generators. Calibration of rf generators is best done using a receiver to listen to both the generator and the crystal calibrator. First set the receiver to a known frequency with the calibrator. Keep the calibrator running and tune the signal generator (or vfo) to zero beat. Repeat this at as many frequencies as necessary.

Coupling of the calibrator and the generator to the receiver should be such that their strnegths are about the same. It is important to keep the signal levels low so that the receiver is not overloaded.

Oscilloscopes. Once the crystal calibrator has been adjusted precisely to 100 kHz it follows that its period (the time of one cycle of oscillation) is precisely 10 μsec. This accurate time period can be used to check the sweep speed of a triggered oscilloscope.

Set the oscilloscope time base to 100, 10 or 1 μsec/cm. Connect the calibrator to the vertical input. If the sweep timing is correct you'll see exactly 10 cycles/cm, 1 cycle/cm or 1/10 cycle/cm of the calibrator waveform display.

Sweep linearity can be checked by setting the oscilloscope to display a number of cycles of the calibrator waveform. If the sweep is linear, the waveforms will be evenly spaced across the face of the CRT. If they appear closer together in one portion of the trace than elsewhere, the sweep is not linear.

Audio oscillators. Calibration of audio oscillators is best done with the aid of an oscilloscope. Lissajous patterns make calibration easy at submultiples of the 100-kHz calibrator frequency. If your oscilloscope has a triggered sweep, use the calibrator to trigger it (in the "external trigger" mode). Display the audio oscillator signal through the vertical amplifier. At submultiples of the calibrator frequency the display will stand still. If the audio oscillator frequency is low, the display will drift to the right. If its frequency is high, the display will drift to the left. **R-E**

Crossover Network

(*continued from page 46*)

is shown in Fig. 4—a "constant-resistance," series-connected crossover. This is a widely used arrangement, giving good fidelity and providing an attenuation of 12 dB per octave, which strikes a happy medium.

While no calculations are required to use the accompanying nomograph, the following formulas are presented to give you an opportunity to double check your work. Component values are computed with the aid of equations taken from m-derived filter equations, where m = 0.6 (m-derived filter design permits either impedance or the attenuation characteristic to be predetermined . . . a factor of 0.6 favors impedance match for a little more than about 80% of the audio band of frequencies, hence the reason for this particular network's "constant-resistance" characteristic). The low-pass network (feeding the woofer) consists of series inductor L_L and shunt capacitor C_L. The high-pass network (feeding the tweeter) consists of series capacitor C_H and shunt inductor L_H. The equations are:

$$L_L = \frac{R_o}{2\pi f_c} \qquad C_L = \frac{0.8}{\pi f_c R_o}$$

$$L_H = \frac{R_o}{3.2\pi f_c} \qquad C_H = \frac{1}{2\pi f_c R_o}$$

where f_c is the crossover frequency and R_o is the nominal speaker impedance (assumed to be a pure resistance and equal for both speakers) and the output impedance of the amplifier.

The solutions to these equations are rapidly found in the nomogram by merely drawing two lines.

(1) From the value of f_c, located on its scale, draw a straight line to the value of R_o on the outer left-hand scale. The values of L_H and L_L are found where the line intersects their scales.

(2) C_H and C_L are similarly found by extending a line from the same point on the f_c scale to the same value of R_o, this time on the outer right-hand scale.

Note that the left-hand R_o scale is labeled R(L). This is used for the solution of the inductance values. Similarly, the right-hand R_o scale is labeled R(C). This is for the solution of capacitance values.

In the example shown, $R_o = 8$ ohms, $f_c = 400$ Hz, $C_H = 50$ μF, $C_L = 80$ μF, $L_L = 3.1$ mH and $L_H = 2$ mH.

R-E

81

Computers Go To Sea

(continued from page 53)

commodations for 34 scientists. This complement of scientists is larger than normal and will permit a greater number of complex projects to be carried out on the cruises, most of which will be long.

Facilities are modern and extensive, with special labs for chemical, biological, and geological work. Drafting rooms, a photo lab, an electronics shop and meteorological labs also are included.

The most valuable and useful tool on the *Bent* is the *Integrated Shipboard Survey System* developed for the Navy by Texas Instruments, Inc. This versatile system is designed to accomplish most of the tasks necessary for an oceanographic survey, furnishing the data in digital form. It operates both under way and while the ship is at the test site. Under-way measurements include specific gravity, depth, magnetic field, sea temperature and sea-floor reflections. On-site measurements include temperature, sound velocity, salt content and ambient light levels down to 20,000 feet. A sister ship, the *USNS Kane*, now undergoing initial trials, will be similarly equipped.

The equipment, ships and digital-recording concepts described briefly here have been chosen to show the increasing tempo of modern oceanographic research. Several companies are producing digital systems for sea work, and the research institutions mentioned are planning various significant projects employing digital equipment. Other institutions, too, have similar projects under way. In short, the broad and virtually undiscovered oceans are the focal point of ever-increasing scientific activity. So far, most of the effort has gone into equipment development, but now the pace is changing as the new equipment moves out to sea. A new and exciting era in oceanographic instrumentation lies just ahead. **R-E**

References

"The Monster Buoy," Geo-Marine Technology, Vol. 2, No. 4, April 1966.
"R/V Silas Bent," Geo-Marine Technology, Vol. 2, No. 3, March 1966.
"Oceanographic Instruments," Oceanology, June 15, 1966.
"DIVEAR—An Unmanned Acoustics/Oceanagraphic Research Vehicle," Ocean Science and Ocean Engineering, 1965.

NEW PATENTS

ELECTRONIC SIREN

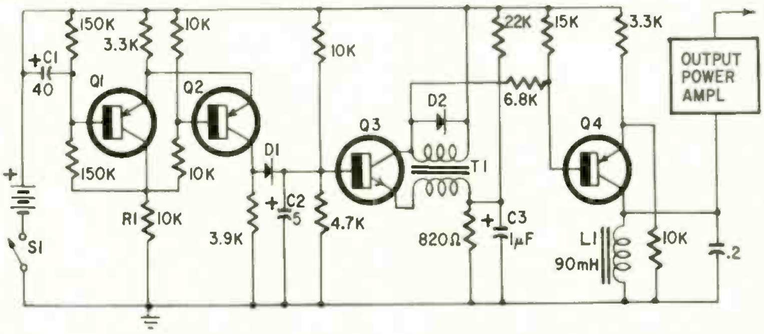
PATENT No. 3,324,408

Ronald H. Chapman, Wheaton, Ill., and Chas. W. Stephens, Huntington, Ind., (Assigned to Motorola, Inc., Franklin Park, Ill.)

This siren is probably more complicated than most. Unlike simpler types, it sounds just like the mechanical sirens used on fire engines and ambulances.

Transistors Q1 and Q2 form a Schmitt trigger, in which one and *only* one transistor can conduct at one time. When S1 is closed a positive pulse (through C1) prevents conduction of Q1, so Q2 is *on*. As the capacitor charges, this reverse bias sooner it cuts itself off. Thus, the frequency rises with signal drive.

The charge of C2 is much more rapid than its discharge. As a result, the frequency rises quickly, then drops more slowly, just as from a mechanical siren. Furthermore, the output level is greater for the higher frequencies. The frequency range is from about 100 Hz to about 1 kHz.



disappears. Then Q1 conducts, and Q2 goes *off*. This square wave from Q2 is rectified by D1 to charge C2. As it charges, then discharges, a sawtooth wave is applied to Q3, a blocking oscillator, that is normally nonconducting.

Transformer T1 is connected for positive feedback to Q3. When the sawtooth drives the transistor into conduction, it oscillates. Emitter flow charges C3 positive, and since this is *reverse* bias (for an npn) oscillations are quenched quickly. The more fully Q3 conducts, the

Diode D2 damps out transient or high-frequency oscillations.

Transistor Q4, a ringing amplifier, shapes the final wave from this siren. The untuned tank in its collector return is resonant at 2 kHz. Normally Q4 is blocked, but when driven by the pulses from the blocking oscillator, it generates a series of damped sinusoid waves. The result is a series of damped waves occurring at a frequency that rises and falls periodically. The output power amplifier raises the level as desired.

ELECTRICAL FENCE

PATENT No. 3,325,717

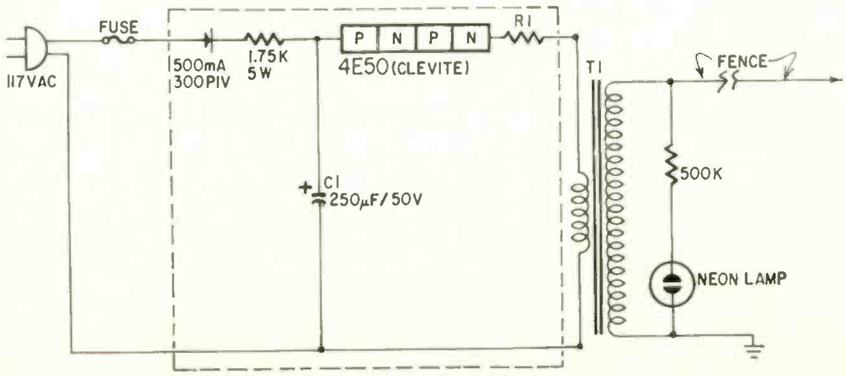
Wm. M. Nellis, St. Paul, Minn. (Assigned to International Electric Fence Co., Inc., Albert Lea, Minn.)

This very efficient device has no moving parts. The fence is charged to a high voltage, but since the available current is weak, there is no real danger to humans or animals. It can be used to keep intruders out or to keep animals from straying.

Pulsating dc charges C1, in about 1 second, to the critical breakdown voltage of the four-layer pnpn diode. Discharge occurs in about 3 msec through the primary of T1. The transformer has a turns ratio of 60:1, and is supplied with about 50 volts.

R1 is a protective resistor. Its value depends upon the resistance of the primary winding. The neon lamp indicates when the fence is charged. Components shown within the dotted lines may be encapsulated with an epoxy resin such as type 241 or 250, made by the 3M Co., leaving four exposed terminals.

R-E



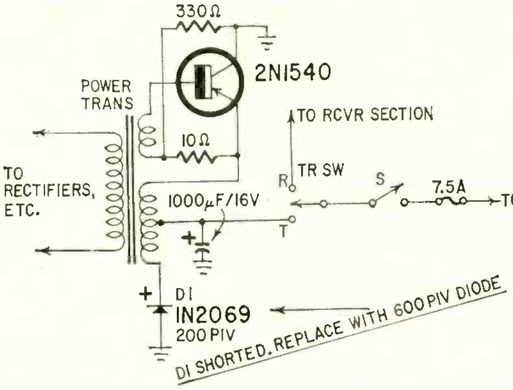
CB Troubleshooter's Casebook

Compiled by
Andrew J. Mueller

Case 1: Transceiver blows fuses on transmit but receive is okay.

Common to: Pearce-Simpson **Sentry**

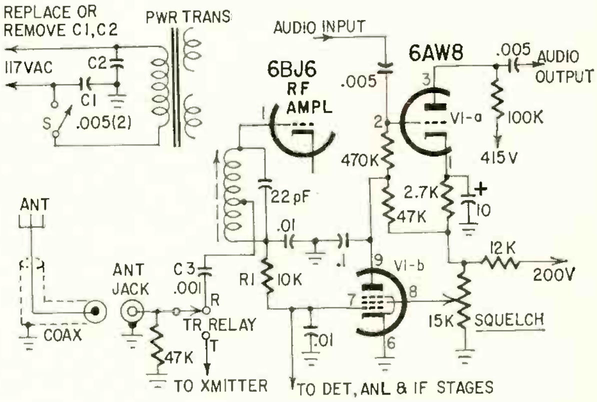
Remedy: Replace diode D1 with one that has a 600-piv rating.



Reasoning: Transient voltage surges across the diode during transmit cause it to break down and short. This shorts the A line and blows the fuse. Increasing the diode piv rating prevents future trouble.

Case 2: While operating this unit on the ac line, there is a hum on receive. This occurs only when the antenna is connected. The hum becomes worse when the squelch control is advanced.

Common to: Johnson **Messenger II**



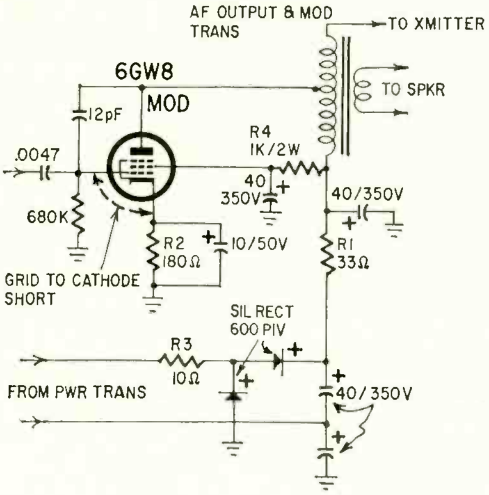
Remedy: Replace or remove the ac line bypass capacitors, C1 and C2.

Reasoning: If C1 and C2 are leaky, 60-Hz ac is present on the chassis. When the antenna is connected, this 60-Hz leakage is returned to ground via the coaxial cable shield. Some of the ac is coupled to the center conductor by the capacitance of the coaxial cable. This small amount of 60-Hz signal feeds through C3 into the rf input tank and avc line. Some also feeds through R1 and modulates the avc line. As can be seen by the schematic, 60-Hz ac gets into almost every part of the receiver. This can be a tough trouble to find, as the unit develops a bad case of ac hum that bridging all filter capacitors and replacing all tubes fails to cure.

Case 3: Smoking chassis; weak audio; plate of the 6GW8 modulator tube becomes red hot.

Common to: Hallicrafters **CB-19**

Remedy: Replace 6GW8 tube and resistors R1, R2 and R3.

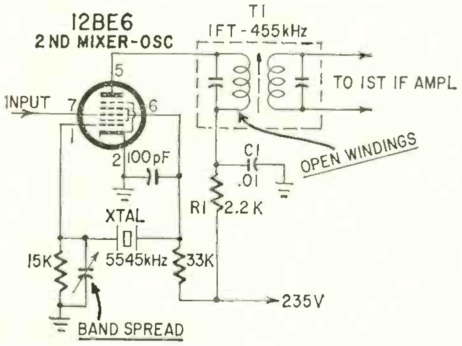


Reasoning: The modulator tube frequently shorts between cathode and grid. This removes the bias from the tube and causes a large increase in its plate current. This increase in current causes R1, R2 and R3 to overheat, discolor and change value. Be sure to replace the tube with a new one before turning on the unit or the same thing will happen again. Also check R4 as it may have gone bad.

Case 4: No receive. Transmit and modulation are okay.

Common to: E.C.I. **Courier 23**

Remedy: Replace i.f. transformer T1.



Reasoning: A check shows no voltage on the plate of the 12BE6 second mixer/oscillator. There is voltage, however, at the junction of R1 and C1. A resistance check of T1 shows an open primary winding. **R-E**

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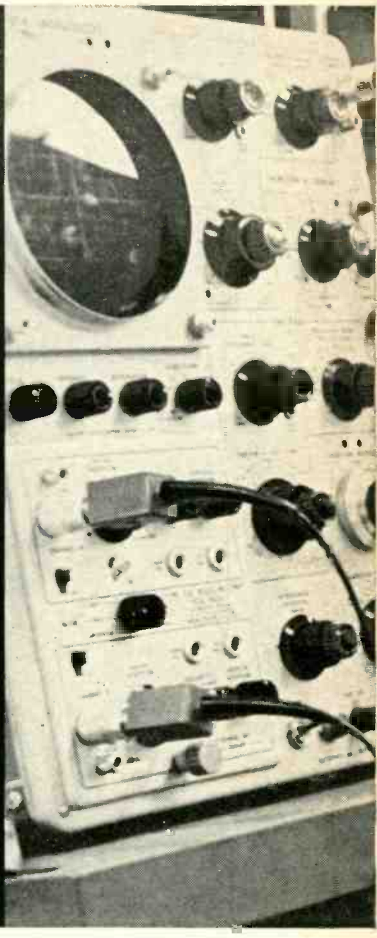
How to become a "Non-Degree Engineer"



In today's electronics boom, the demand for men with technical education is far greater than the supply of graduate engineers. Thousands of real engineering jobs are being filled by men without engineering degrees—provided they are thoroughly trained in basic electronic theory and modern application. The pay is good, the future is bright... and the training can now be acquired at home—on your own time.

Circle 122 on reader's service card

TECHNOTES

G-E TC CHASSIS

Some cases of Q21 failure in the power supply of this chassis may be due to a broken solder connection at the point where the series regulator (Q20) collector heat sink is fastened through the circuit board. This point is located behind the vhf tuner, next to the large electrolytic capacitor (C401). If the solder breaks loose, Q20's collector becomes disconnected from the circuit, forcing Q21 to carry the full output load and causing it to fail.

The remedy is completely to fill with solder the slot where the heat sink passes through the hole. Use a fairly high-wattage iron to make a good solder bond to the heat sink, thus insuring a good electrical connection between Q20's collector and the circuit board.

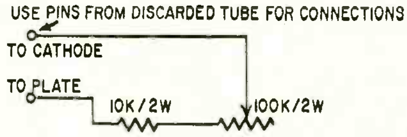
It is recommended that you resolder this point on all TC chassis which come in for service, to prevent future Q21 failure.—*G-E Portafax*

VARIABLE-SPEED DRIVES

Troubles in Reliance and similar variable-speed drives of the motor-generator type which are inoperative or do not control properly can be traced with a 100,000-ohm potentiometer and a 10,000-ohm resistor.

Remove the tube that controls the dc winding of the saturable reactor associated with the generator-field thyratron and connect the potentiometer and resistor as shown.

Open the armature loop circuit and turn on the drive. If varying the potentiometer has no effect on the brilliance of the thyratron, the trouble is in the phase-shift bridge or the



thyratron itself. If the brightness of the thyratron changes as the potentiometer is rotated, the trouble lies between the reactor and the manual speed control. Repeat if necessary for the motor field thyratron.—*R. C. Roetger*

RADIO PLAYS ON BENCH BUT NOT IN CAR

Complaint: A transistor or hybrid auto radio plays OK on the bench after repairs but is inoperative when reinstalled in the car.

Remedy: Check the car battery for reversed polarity—particularly if the repairs were made in the radio's audio output section. *Use your meter. Don't rely on battery terminal markings.* A transistor radio is about the only polarity-sensitive device in a car so you won't find any others inoperative.

Cause: The polarity of the car's electrical system has been reversed inadvertently by a mechanic who installed a battery or generator incorrectly or reversed the battery cables. In the past three years I have found five cars with reversed battery polarity.—*R. J. Turner* **R-E**

Underwriters Labs

"Tapping the picture tube will often cure an intermittent heater . . ."

 (*continued from page 40*)

which can be adjusted to optimum by the gain control on the main amplifier.

Selecting the equipment

Two factors are decisive here: the conditions to be met and the equipment that is available. Thus the minimum amplifier size depends on how much system gain is needed. Amplifiers should always have plenty of gain. It is better to have an oversized amplifier loafing along than a small amplifier working at full output.

Likewise amplifier size is set by what is manufactured. If you need 35 dB, and find that amplifiers are made for 30- and 40-dB output, you are going to buy the larger one. There are some opportunities for choice, and some limitations. For instance, one company has no preamplifier with the 20-dB gain listed in our plan. But it does have a 12-dB preamp and a 40-dB main amplifier, the sum of which is approximately the same as the 20- and 30-dB combination shown. Get all the catalogs from companies making MATV equipment and familiarize yourself with their lines.

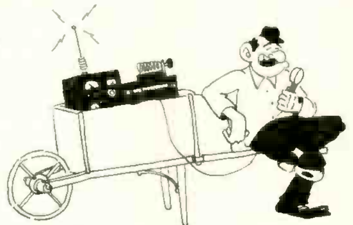
Signal conditions impose limitations, too. Near the TV station the direct signal may be so strong that it can be picked up on the lead between the wall tapoff and the set. This produces a "leading ghost." The answer is 75-ohm wall tapoffs, with coaxial cable right to a 75–300-ohm balun installed on the back of the receiver. Another solution is to put more rf through the cable—say 10 or 15 dBmV (instead of 0 minimum) at the set. In some New York City installations, signals are so strong that the short lead between antenna terminals and tuner (in the chassis) picks up too much signal. Some technicians bring the coax right up to the tuner. (This constitutes modification of the owner's receiver, however, and creates legal problems as well as diplomatic ones.)

Special problems

In most parts of the country the problem is to get enough signal. In Fig. 2, we had plenty for the last receiver. But what if the lines had been a little longer, or the signals a little weaker? What if Building Nos. 2 and 4 had contained 32 apartments each instead of 8?

If more signal had been needed, we could have supplied it. If it had been due to weak or distant stations, we could have used higher-gain antennas. Or we could have beefed up the main amplifier, if the problem had been losses in the distribution line. But it is not good practice to use more than about 50 dB—though amplifiers can be obtained with outputs up to 66 dB. Possibly a better way would be to insert another line amplifier at the beginning of each of the 200-foot lines. Then Building Nos. 2 and 4 would get 24 dB instead of 14. We could then run 16 tapoffs on each of two lines, or better, use a 4-way splitter and 4 lines of 8 tapoffs each.

There are, of course, an almost infinite number of possible problems (and solutions) and we have been able to indicate only a procedure that will (we hope!) solve most of them. As in every other field, every once in a while an absolutely insurmountable difficulty arises—and shortly afterward a way to lick it! If you have one you haven't been able to conquer—yet, let RADIO-ELECTRONICS hear about it. We might know how (or where) to get the answer. **R-E**



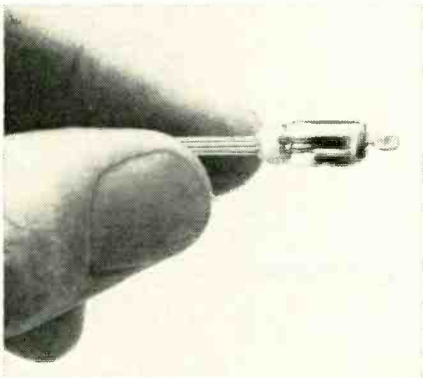
"Yeah, I've gone mobile!"

91

NEW SEMICONDUCTORS

COLD-CATHODE TRIGGER TUBES

The ZC1031 is one of a new family of gas-filled trigger tubes featuring high brightness and sensitivity. Designed as a switching and indicating device, its single starter circuit makes it ideal for use in shift registers for moving-text displays. A spluttered molybdenum cathode and precisely controlled gas content give it a narrow



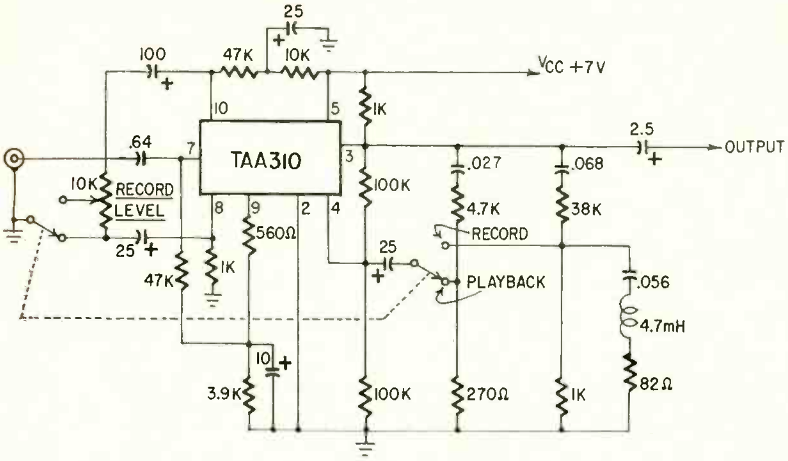
ignition-voltage range. The ZC1031 has high light output (approximately .0018 foot-candle), which makes it clearly visible at a considerable distance under high ambient light. Complete specifications on this and other cold-cathode tubes in the line can be obtained from Amperex Electronic Corp., Tube Div., Hicksville, N. Y. 11802.

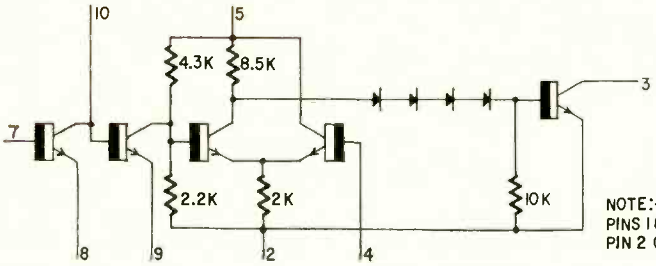
IC AUDIO PREAMP

The Amperex TAA 310 is a silicon monolithic integrated-circuit amplifier designed for use as a high-gain audio preamplifier. It has a noise figure of less than 4 dB and a minimum voltage gain of 90 dB with a 1,000-ohm load impedance. These factors along with its high input impedance make the TAA 310 especially suited for use as a recording and play-back preamplifier for tape recorders.

The diagram shows the TAA 310 in a practical tape-recorder preamp circuit. Gain is around 64 dB in the record and playback functions. Total distortion is less than 0.5% with 0.5 volt rms output. The TAA-310 comes in a 10-lead TO-5 package. Unit cost is $4.90. **R-E**

AND MICROCIRCUITS





NOTE:-
PINS 1 & 6 NOT CONNECTED.
PIN 2 CONNECTED TO CASE.

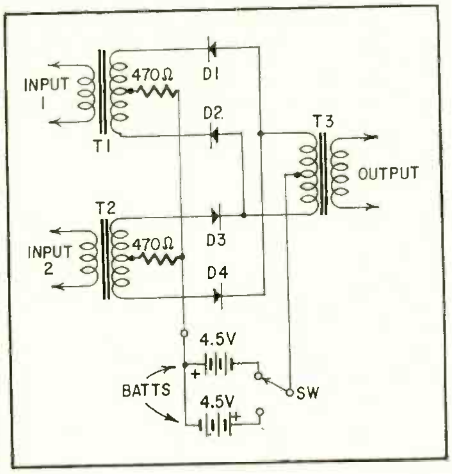
TAA310 EQUIVALENT CIRCUIT

NOTEWORTHY CIRCUITS

AUDIO SWITCHING CIRCUIT

A novel circuit for remote switching of high-impedance audio inputs was described in this column in the September issue. Here is a circuit (from *Das Elektron,* Austria) for switching low-impedance lines.

D1 and D2 are in series with the signal path from T1 to T3 and D3 and D4 are in the circuit between T2 and T3. When the switch is in one position,



D1 and D2 are reverse-biased so the signal cannot pass from input 1 to the output. At the same time, D3 and D4 are forward-biased so they conduct and provide an easy path for the signal fed to input 2 to pass from T2 to T3. Throwing the switch to the other position reverses the polarity of the control voltage to select the signal fed to input 1.

SOLID-STATE SQUELCH CIRCUIT

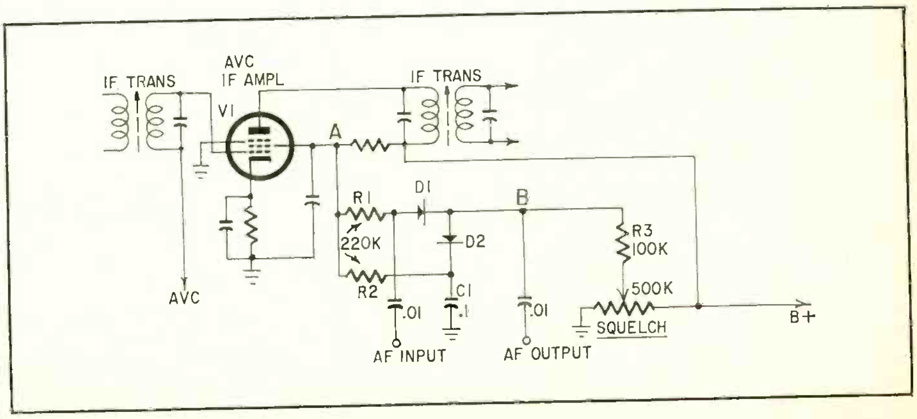
A semiconductor diode is often substituted for a vacuum-tube type to eliminate a hum problem. However, this approach often causes signal leakage which was not present previously. The back resistance of a germanium diode is so low that it permits noise to leak through. On the other hand, a back-biased silicon diode has a high enough back resistance but it acts as a capacitor which permits noise to break through. A solution to the latter problem was shown in *Break-In,* a New Zealand ham magazine.

The circuit is shown. Resistors R1 and R2 and D1 form the usual series-type avc-controlled squelch using a silicon diode. Audio is fed in at the anode and taken off at the cathode. Resistor R2, D2 and C1 have been added to the basic circuit to prevent noise break-through when no signal is being received.

The anode of D1 and cathode of D2 are connected to V1's screen grid (point A) through isolating resistors R1 and R2. The cathode of D1 and anode of D2 are connected to a B-plus voltage from point B at the arm of the SQUELCH control. R3 is an isolating resistor.

The SQUELCH control is set to bias D1 slightly beyond cutoff (cathode slightly more positive than the anode) in the absence of an incoming signal. When a signal comes in, the avc reduces V1's conduction. The screen current drops and D1 conducts because its anode is now more positive than the cathode. The received signal now passes without opposition from the AF INPUT to the AF OUTPUT terminal.

Note that D1 and D2 are connected, with reverse polarity, between A and B. Thus, when either is conducting the other is always cut off. Therefore, when D1 is cut off, D2 is conducting and any noise or audio signal leaking through will be shunted to ground through C1. When a signal comes in, D1 is turned on and D2 is turned off to effectively remove C1 from the circuit. **R-E**



TRY THIS ONE

CONDUCTIVE PAINT HAS MANY USES

Besides repairing breaks in printed-circuit boards, conductive paint has many uses. The paint is a solution of fine particles of silver or copper in a liquid base. In the liquid form the paint is non-conductive, but when the solvents evaporate it hardens and forms an amazingly good and flexible conductor. Remember that the chemicals in the fluid can dissolve many plastics. The paint can be removed with acetone (common fingernail polish remover).

Electrostatic shielding can be applied to practically any insulator by painting it with silver paint. One photo shows a .047-μf capacitor shielded for use in the input of a high-gain preamp stage. To prepare a shielded capacitor, wrap a few turns of bare bus wire around the capacitor and paint over the wire, coating the body. Don't paint too close to the leads, or you may cause noisy shorts.

Erratic photoflash tubes can be given new life by increasing the trigger conductive area. The other photo shows a small dab of silver paint on the rear of a flash lamp, contacting the trigger wire.

Metallic ends can be painted onto recording tape to activate automatic stop relays. Paint 3 inches of the oxide side of the tape about 2 feet from the end. Let the paint dry before you use the tape, as butyl acetate (in the base of the paint) may dissolve the binder or the tape itself.—*Steve P. Dow* **R-E**

Circle 130 on reader's service card

Circle 131 on reader's service card

For 46 years the symbol at left has identified the Radio Corporation of America. As part of new corporate communications program, company has adopted new symbol at right.

Circle 132 on reader's service card

95

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• 10 Silicon Rectifiers, 750 AM., 50 to 300 p.i.v. Cat. # 330F, 99¢ each.

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• 2 Silicon Controlled Rectifiers, 1 amp. general purpose units with instructions. Cat. # SCR 1, $1.00.

• 5 Transistor Circuit Boards containing up to 6 transistors, plus diodes, resistors, capacitors, etc. Cat. # TB10, 99¢.

• Needles: values such as # AS22 Sapphire, 39¢; Diamond, 99¢.

• Color Yokes. 70 Degree for all round color CRT's. Cat. # XRC70, $12.95. 90 degree for all rectangular 19 to 25 inch color CRT's, Cat. # SRC90, $12.95.

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

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

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

• Flyback Transformer in original carton. Made by Merit or Todd. Most with schematic drawing of unit. Please do not request specific type. Cat. # 506, 99¢ each.

• Flyback Transformer Kits, 2 flybacks per kit. # 502E, Emerson; # 502Y, Silvertone; # 502W, Westinghouse; # 507, Philco; # 502, RCA. Any kit, $2.99.

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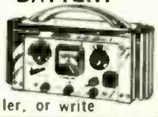

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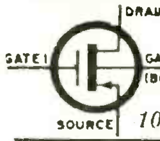

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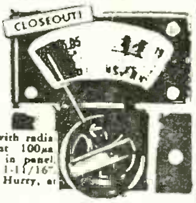

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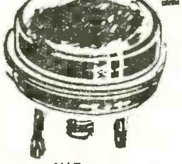

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PIV	Sale	PIV	Sale
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100 ☐	25¢	800 ☐	69¢
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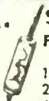
PRV may be exceeded without the rectifier breaking down.



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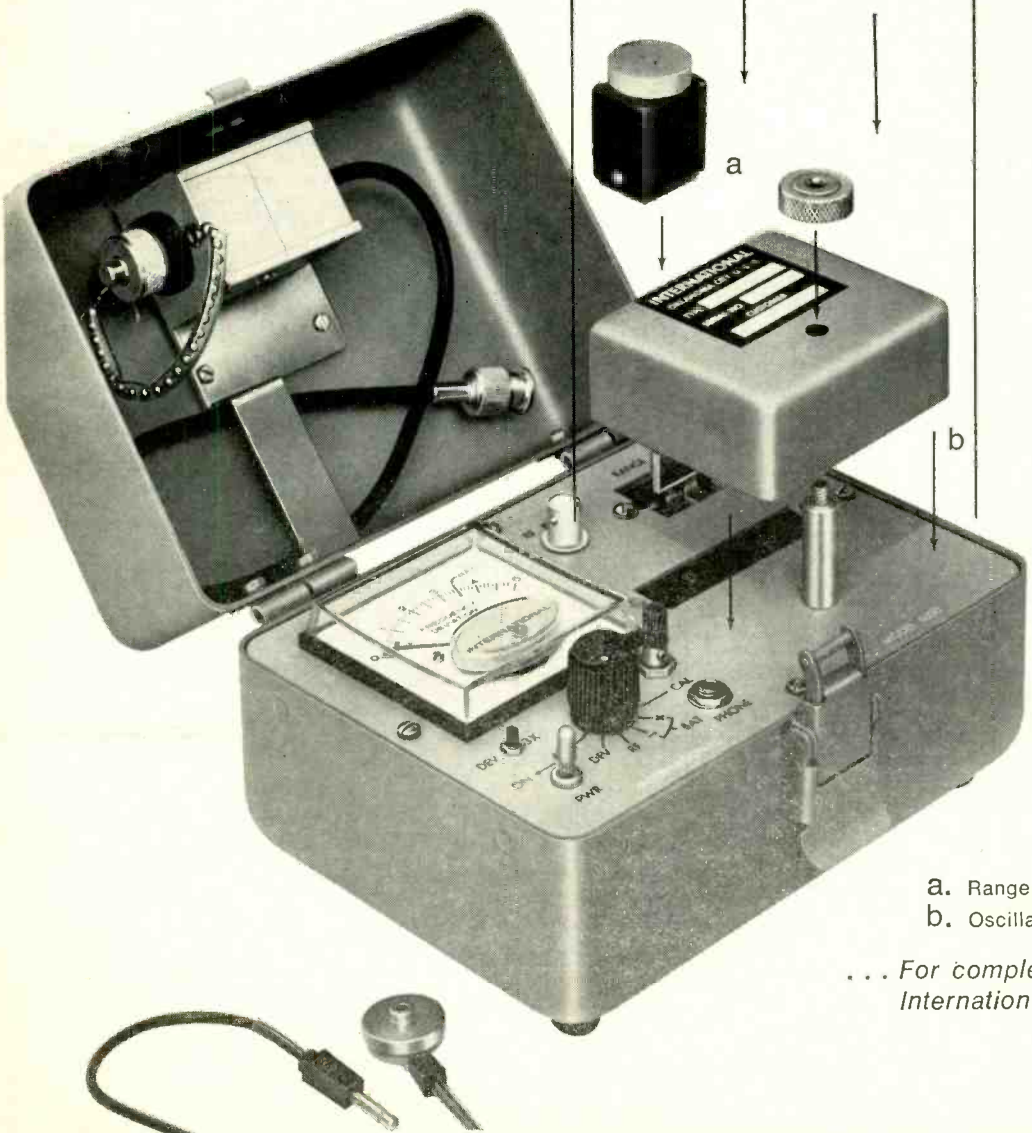

a. Range Modules
b. Oscillator Modules

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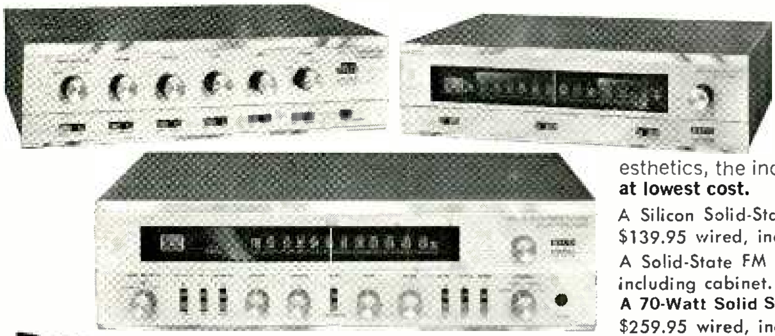

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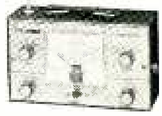

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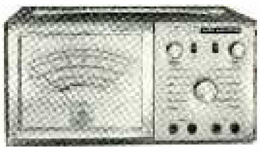

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