BUILD — Stereo Headset Amplifier

HUGO GERNSBACK, Editor-in-chief

50c ■ MAR. 1966

Radio-Electronics

TELEVISION & SERVICING

A GERNSBACK PUBLICATION

SPECIAL ISSUE Hi-Fi/Tape Recording

SPECIAL ISSUE Hi-Fi/Tape Recording

Stereo for Home Movies

Roundup: Battery Recorders

New IHF Amplifier Standard

24 WAYS TO USE YOUR RECORDER

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3CB6	6AL5	6DT6	6S4A	12AT7
3GK5	6AU4GTA	6EH7	6SN7GTB	12AU7A
3HA5	6AU6A	6EJ7	6U8A	12AX4GTB
4BL8	6AV6	6GB5	6U9	12AX7A
4EH7	6AX4GTB	6GJ7	6X9	15CW5
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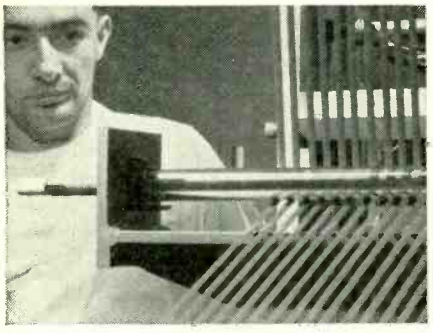
...AND ON AND ON. FOR THE COMPLETE LIST, WRITE
AMPEREX ELECTRONIC CORPORATION, HICKSVILLE, L.I., NEW YORK 11802.

Circle 1 on reader's service card

Some plain talk from Kodak about tape:

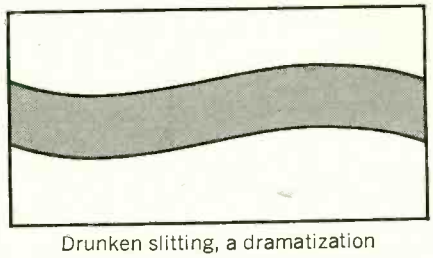
Sobering thoughts about slitting... and making the best basically better

A wise man once said, "Baloney's basic worth is unaffected by the manner in which you slice it." Maybe so for baloney...but certainly not for sound recording tape. Slicing, or to be technically correct, slitting quarter-inch ribbons of tape from the 42-inch-wide master web in manufacture takes a pretty sharp eye. This slitting operation is important to your pleas-



ure since the closer the tape comes to being dimensionally perfect, the better is the azimuth relationship between the recorded signal and the reproduce head. Like it in plainer English? Then consider some examples of poor slitting...and what they sound like.

"Drunken" slitting and others. Variations from the ideal occur if tape is too wide, too narrow, or if its width varies. If the tape is too wide, it may actually override the guides on your tape deck. If the tape is too narrow, it may see-saw as it passes by the head. Either way, you're in trouble. Variations also occur if the edges are not straight. One such variation goes by the name of "drunken" slitting. Sound bad? You bet. The edges snake even though the width is constant (see drawing). As a result, on playback the output varies as the tape weaves past the reproduce head...causes a warbling of the signal. This is a type of distortion the human ear is most sensitive to. You wouldn't like it.



Drunken slitting, a dramatization

Quality-control makes the difference. Standard industry specification calls for a tolerance on width of ± .002 inches. To start, we hold ours to ± .001 inches. And to make things more interesting we make our test over a twelve inch span to equal or exceed guide spacing on most tape recording equipment. Next, not relying on eyeball tests as others do, we test for drunken slitting or fluted edges by actually running the tape with a recorded short wavelength signal through a tape recorder. This "drunkometer" test helps us spot any tape that's had even one beer. The slightest whiff, and out it goes. Lastly, Kodak Sound Tapes have to go under the microscope where we watch for rough or dirty edges. When you buy Kodak Tapes, you know they're clean.

Best base better? Strength and toughness sound like they mean the same thing...but they don't quite when it comes to a tape base. Take a piece of spaghetti. It's stronger when it's dry...but tougher when it's wet—harder to break, that is, and not just because it's slippery. Designing a tape base, you're always up against the problem of making it strong so it doesn't stretch...and tough so it doesn't break. Today's DUROL base, the best there is, is now more resistant to shock abuse and carelessness. It's even tougher than before while it still retains the strength that made it famous.

Kodak tapes—on Durol and Polyester bases—are available at most electronic, camera, and department stores. To get the most out of your tape system, send for free, 24-page "Plain Talk" booklet which covers the major aspects of tape performance. Write: Department 8, Eastman Kodak Company, Rochester, N.Y. 14650.

EASTMAN KODAK COMPANY, Rochester, N.Y.

Circle 2 on reader's service card

The monster tape heads on our cover are really only a bit over a half inch high. Part of a Belcor tape recorder, they were photographed by Harry Schlack—who also designed the cover.

24 WAYS TO PUT YOUR RECORDER TO WORK

Your tape recorder is too valuable to bury in the back closet under a heap of old clothes! Put it to work for you in dozens of ways at home, at school, in business or in the shop and ham shack!

Turn to page 34 for these lively hints

MUSIC POWER REDEFINED

The chairman of the influential Standards Committee of the Institute of High Fidelity tells how the tricky and controversial "music power" concept has been redefined. A whole new set of standards has been developed for today's stereo amplifiers.

Page 39 carries this report

1966 BATTERY RECORDER ROUNDUP

See this comprehensive buying guide of better-quality, capstan-driven battery portable tape recorders. Big ones, pocketsize ones, mono and stereo. You'll want to clip this guide and keep it handy. Know how many speeds, what special features, who makes which—all spread out in easy-to-read style.

You'll find the guide on page 42

BUILD A STEREO HEADSET AMPLIFIER

Compact, versatile battery-powered amplifier is ideal for private listening through high-quality stereo phones. Works direct from any stereo pickup cartridge—and it can drive a tube or transistor stereo power amplifier, too.

This easy-to-build project is on page 59

Radio-Electronics

MARCH 1966 VOL. XXXVII No. 3

Over 55 Years of Electronic Publishing

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NEWS BRIEFS

FRANK ANDREA DIES AT 77

F. A. D. Andrea, radio and TV pioneer who popularized the neutrodyne receiver in the '20's, died Dec. 22, 1965.

Born in Italy, he was brought to the United States at the age of 18 months by his widowed mother. At 11 he had to leave school to go to work, but he spent his nights studying mathematics and drafting. He started a small radio parts business in 1918 and began to produce radio kits. One of the first designs licensed under the Hazeltine neutrodyne patent, his FADA radio was probably the best known of the neutrodyne receivers.

He sold FADA in 1932 and retired, but started again in 1934 by founding the Andrea Radio Corp. That company sold the first TV kit in 1938, and is today a producer of high-quality television receivers.

RADIO ASTRONOMERS HAVE OWN WHODUNIT

Strange radiations from outer space at frequencies between 1,650 and 1,750 MHz are puzzling astronomers so much that they attribute them to a phenomenon they call "mysterium". Whether "mysterium" is a substance or an activity is yet to be discovered, but astonomers suspect that the waves are due to the activation of hydroxyl molecules. (A hydroxyl molecule is like a water molecule except that it contains only one hydrogen atom instead of two.)

The sources of the emission seem to be very small astronomical objects strung like beads around the fringes of glowing gaseous nebulae within the Milky Way. The latest theory is that the hydroxyl molecules are being activated or stimulated like a maser, but on an astronomical scale.

NEW LONG-LIFE CATHODE FOR HIGH-POWER ELECTRON TUBES

Bell Labs scientists announced a new cathode that can withstand high current densities for long periods of time. It has a life expectancy of 20,000-30,000 hours when operated at a current density of 0.5 ampere/cm^2 and a temperature of 810°C.

Called a coated powder cathode, it differs from the ordinary oxide cathode in that each particle of the emitting layer is chemically coated with a thin film of nickel before it is sprayed onto the cathode base material. The nickel increases the conductivity of the cathode's coating and improves its ability to sustain high current densities. The total amount of nickel in the cathode coating is small, not more than about 2½%.

LASER USED FOR FIRST TIME IN COMMERCIAL MASS PRODUCTION

Western Electric is using a laser in its Buffalo plant to pierce and enlarge the holes in the diamond dies that are used for drawing fine copper wire.

The traditional method of making the dies is long, tedious and expensive: The diamond is pierced with a shaped steel tool and the hole polished with diamond dust and olive oil. As the die is used, the hole becomes worn. It then is reshaped and repolished to a larger size. By using the narrow and intense beam of light from a laser, the hole can be pierced in less than 2 minutes.

The first attempt with a laser caused fracture and damage to the diamond, due to the laser's high power. Subsequent tests proved that a pulse-type laser, producing one 10-watt pulse per second, worked well. Once the hole is pierced, it is finished and polished by conventional methods, with diamond dust and oil.

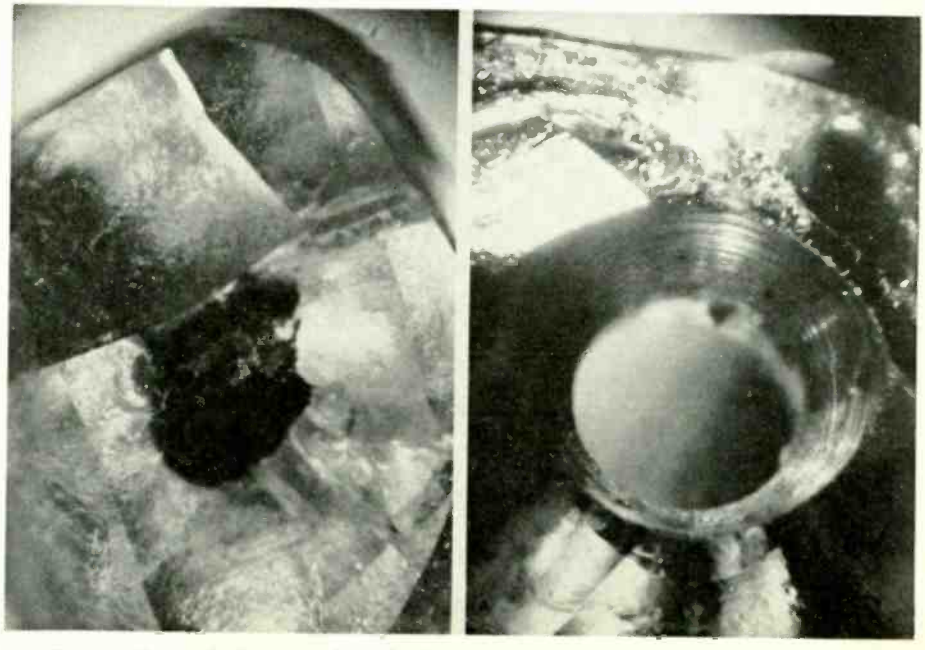
Since a laser beam can be dangerous to the operator's eyesight, the equipment is entirely enclosed, and closed-circuit television is used to view the operation in progress and between pulses or laser shots while the operator adjusts the position of the diamond.

KIDS AND LOW-POWER SETS GIVE FCC TROUBLES

Youngsters who got walkie-talkies for Christmas are giving the FCC a big headache. The kids' chatter has drowned out some Citizens-band transmissions, has interfered with TV sets in some cities, and their imitation grownup tough-guy talk is embarrassing the authorities. When the FCC finds the offenders, the FBI may have to move in and turn them off.

ELECTRONICS MOVES IN

The spread of electronics into household products will be an important factor in the increase of semicon-



Left: a diamond die pierced by the laser beam before polishing; right, how the die appears after being polished and finished by conventional methods.

ductor applications, predicts L. Berkeley David of General Electric Co.'s Electronics Components Div. Mass production and improved techniques have lowered unit costs, in turn opening new markets for electronic components.

The better cars now have "comfort conditioners," which operate with transistor controls and semiconductor temperature sensors. General Electric's new Hotpoint washers have solid-state "infinite motion control," enabling the housewife to machine-wash anything from delicate nylons to heavy wool dresses. Silicon-controlled rectifiers are making possible cheaper and better light dimmers, and are ready to replace mechanical controls in variable-speed household appliances.

Rechargeable batteries are bringing out a host of "cordless" electrical appliances, such as electric knives, home-workshop power tools and hedge trimmers.

Mr. Davis predicts for 1966 a market for more than $2 billion for semiconductors, capacitors, tubes, photocells, nickel-cadmium batteries and magnetic reed switches.

VIKING LADY OPERATES PIRATE TV OFF SWEDEN

Mrs. Britt Wadner of Malmoe, Sweden, is giving the Swedish Government communications administration trouble with transmissions from a small ship, the Cheetah II, anchored in international waters between Sweden and Denmark. The programs are said to be very popular with a section of the Swedish public.

Cheetah II is overcrowded with transmitter, power supply and antenna, so the programs are taped on shore and the material delivered to the station by helicopter.

continued on page 12

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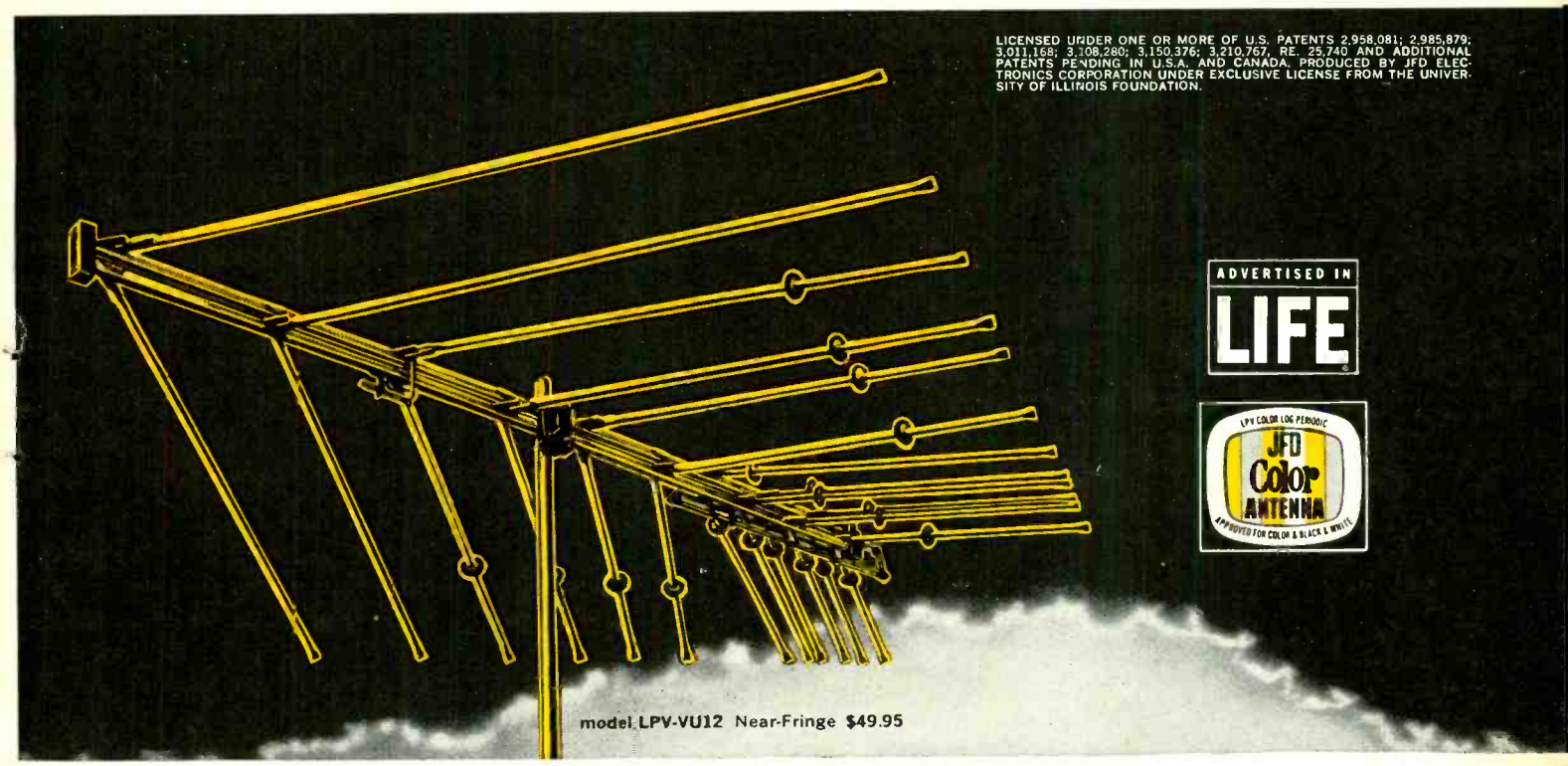

VHF/UHF/FM ANTENNA!

Because it delivers best 82-channel TV performance—COLOR or black/white—plus FM/Stereo—using only a single downlead!

No other antenna works like the 82-channel JFD LPV-VU Color Log Periodic...

■ **Only** the JFD LPV-VU is designed according to the patented **log periodic** design of the **University of Illinois Antenna Research Laboratories.**

■ **Only** the JFD LPV-VU utilizes **capacitor-coupled Cap-Electronic** dipoles for **higher** mode operation that achieves **higher** gain, **narrower** beamwidths on VHF channels 7 to 13 and UHF channels 14 to 83. (Our competition's copies of the JFD LPV-VU use only **fundamental** mode which resonate as simple dipoles with consequently limited gain.

■ **Only** the JFD LPV-VU offers true **frequency-independent** performance that insures brilliant **color** on any channel.

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You **bet** you can have everything you want in **one** antenna—VHF, UHF, FM—with a **single** down-lead, too! Start teaming up JFD 82-channel **LPV-VU** Color Log Periodics with all the 82-channel TV sets in your area—see the difference in profits and performance. Call your distributor or write for brochure 806.

32 million readers of LIFE will be seeing spectacular JFD LPV Color Log Periodic advertisements all season long. This unprecedented LIFE campaign will be preselling JFD LPV antennas for **you!**

Full-color television commercials will show millions more why the LPV's patented space-log periodic design works best on **any** channel—**color** & black/white.

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Circle 7 on reader's service card

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NRI has *simplified* Electronics by producing "bite size" lesson texts averaging only 40 pages each. Dozens of illustrations open wide a picture window through which you'll see and understand practical uses of Electronics. You start out with NRI's exclusive Achievement Kit, containing everything you need to get started fast. (Illustrated at right.)

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NRI has *dramatized* Electronics through the careful development of special training equipment that is *programmed* into your training systematically . . . beginning with your first group of lessons. Things you read about come alive in your hands as you build, experiment, purposely cause "problems" in circuits—and solve them. You learn to use test equipment, to build radios and TV sets, transmitter, or computer circuits. It's the priceless "third dimension" in NRI training . . . practical experience.

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Career? Part-Time Earnings? Hobby? Choose From 10 Training Plans

1. TELEVISION-RADIO SERVICING
Complete training from basic fundamentals of electricity to home entertainment equipment. You learn how to fix radios, hi-fi and stereo sets, black-and-white and color TV, PA systems, etc. A profitable field full or part-time.

2. COMPLETE COMMUNICATIONS*
Designed to teach and provide you with actual practice in operation, service and maintenance of AM, FM and TV broadcasting stations. Also covers marine, aviation, mobile radio, facsimile, microwave, radar.

3. INDUSTRIAL-MILITARY ELECTRONICS
From basic principles to computers. A comprehensive training plan that teaches you the fundamentals, then takes you into such modern-day miracles as servos, telemetry, multiplexing, pulse circuitry, data processing, other career-building subjects.

4. FCC LICENSE*
Specifically designed short course to prepare you for your First Class FCC Radiotelephone License examinations. You begin with a thorough background in fundamental Electronic principles, advance to required subjects covering equipment and procedures.

5. BASIC ELECTRONICS
A concise course to teach modern Electronics terminology and components. A wealth of practical, useful information to help you better understand the field, to give you some technical knowledge. For anyone who wants a basic understanding of Radio-TV Electronics.

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A brief course for engineers and technicians who need a quick review of the essential mathematics used in industry, in communications, in government jobs. Basic arithmetic review, short-cut formulas, modern digital numbers systems, much, much more.

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This course not for beginners. Offered for men with some fundamental knowledge of Electronics who want a better understanding of Automation in current use. Covers process control, ultrasonics, telemetering and remote control, electromechanical measurements, other key subjects.

8. AVIATION COMMUNICATIONS*
This course prepares you to install, maintain, service aircraft communications equipment. Covers direction finders, ranges, markers, Loran, Shoran, radar, landing systems. Earn your First Class FCC License with Radar Endorsement.

9. MOBILE COMMUNICATIONS*
Learn to install and maintain mobile equipment and associated base stations. Covers transmitters and receivers used by police and fire departments, public utilities, construction projects, taxis, etc. Prepares you for a First Class FCC License.

10. MARINE COMMUNICATIONS*
Covers transmitters, direction finders, depth indicators, radar, Sonar, other equipment used on commercial ships and thousands of pleasure boats. Prepares you for your First Class FCC License with Radar Endorsement.

* You must pass your FCC License exam (any Communications course) or NRI refunds in full the tuition you have paid.

NEWS BRIEFS continued

Sweden has a law against just such pirate transmissions by Swedish nationals, and Mrs. Wadner has already spent a month in prison for operating an earlier pirate radio station, also on Cheetah II. On the day her TV programs started, she was arrested and sentenced to a three-month term, which she appealed, remaining at least temporarily out of jail and carrying on her TV programs.

INERTIAL NAVIGATION SYSTEM NOW ON COMMERCIAL AIRLINE

The first inertial navigation system in commercial use has been installed in a Pan-American Boeing 707 and is being used in transatlantic service between New York, Rome, Paris, Istanbul and Teheran. Large numbers are expected to be installed in the near future. The manufacturer, Sperry Rand, states that commercial orders for the system, the SGN-10, now exceed $15 million.

SATELLITE-TO-HOME RADIO BEING STUDIED BY NASA

NASA has authorized a study of the practicability of transmitting FM programs direct from satellites to home receivers. As a preliminary, a number of private companies in the communications field were asked to present their views on the possibility of radio broadcasting from space, and to submit proposals on making studies of the subject. NASA expects to issue contracts for such study if the proposals seem suitable.

A moderate-power station with a radius of 50 to 100 miles on the ground could cover nearly half the globe if it were transmitting from a satellite far out in space. END

CALENDAR OF EVENTS

International Fair for Electronics, Automation, Instruments, Feb. 25–March 6; Forum Exhibition Hall, Copenhagen, Denmark

Institute of High Fidelity Paris Show, March 10–15; Paris, France

IEEE International Convention, March 12–25; Coliseum and New York Hilton Hotel, New York, N.Y.

Institute of High Fidelity Los Angeles Show, March 27–April 3; Ambassador Hotel, Los Angeles, Calif.

Institute of High Fidelity San Francisco Show, April 18–25; Civic Auditorium, San Francisco, Calif.

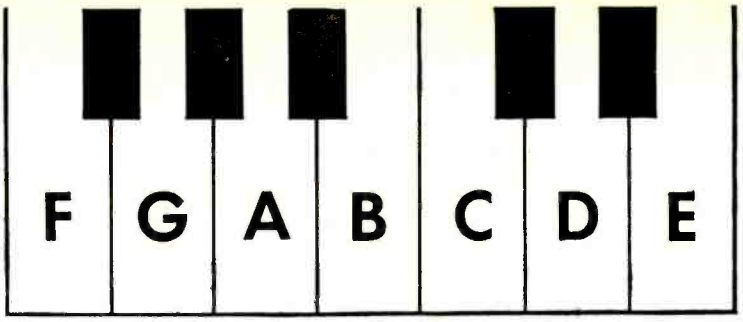
Radio-Electronics Adopts Hertz

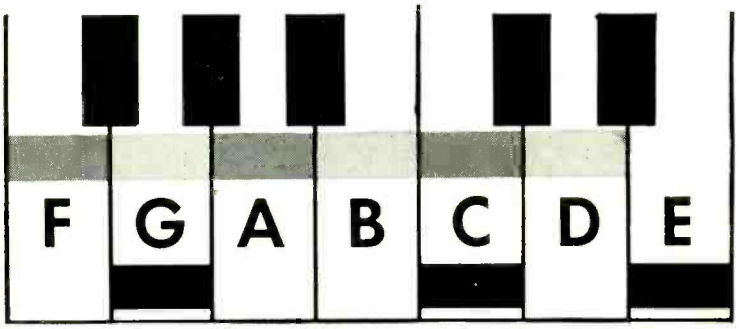
RADIO-ELECTRONICS is now using the term *Hertz*—recently adopted officially in the United States—in place of cycles in all references to frequency. This term has been used for many years in other countries. Hz, KHz and MHz, abbreviations for Hertz, kilohertz and megahertz, are replacing cycles, kc and mc in all recently edited material. You may run across the older abbreviations in copy set in type before the change.

← Circle 8 on reader's service card

Circle 9 on reader's service card

1. With 1 Finger Of Your Right Hand, Pick Out Key A, Key F, Etc.





2. Now Put 2 Fingers And A Thumb Of Your Left Hand On The Red Keys... The Green Keys... Or The Black Keys.

3. That's All It Takes To Play Complete Songs On The New Heathkit®/Thomas COLOR-GLO Organ

Play Complete Songs In Minutes . . . Instead Of Months! Color-Glo key lights on this new Heathkit/Thomas Transistor Organ show you the correct notes and chords. You play melody, harmony and bass notes *instantly* . . . even if you've never played an organ before!

Switch On The Color-Glo, And You're Ready To Play! Each key on the upper keyboard lights up with a letter. You simply match the key's letters with the letters on the music to play melody. For harmony, there are 3 red keys, 3 black keys and 3 green keys on the lower keyboard. Just press and hold the notes that match the background color in the Thomas Color-Glo music book (included). To add the bass, press the pedal that's marked with the same color as the harmony notes. That's all there is to it. Touch the switch again, and the Color-Glo keys disappear, leaving a beautiful spinet organ.

All Genuine Thomas Factory-Fabricated Parts! Other features include ten organ voices; repeat percussion; two 37-note keyboards; 13-note heel & toe bass pedals; variable expression pedal; 2 levels of vibrato; balance control; 12" speaker; 50-watt EIA peak music power amplifier; and hand-crafted walnut cabinet. The transistorized tone generators, the heart of the organ, are warranted for 5 years.

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Kit GD-325 Organ, 153 lbs. $349.95
GDA-232-1, matching walnut bench, 18 lbs. . . . . $ 24.95

Kit GD-325
$349.95
(less bench)

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Send 50c for 7", 33⅓ rpm demonstration record (see coupon). For full details on this, plus over 250 other Heathkits, mail coupon or write Heath Company, Benton Harbor, Michigan 49022 for FREE Heathkit Catalog.

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☐ Enclosed is $_____, plus shipping.
Please send model(s) _____
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Something For Everyone . . . In This Vast Heathkit Selection!

Kit GR-43
$159.95

New Heathkit 10-Band Transistor Portable!

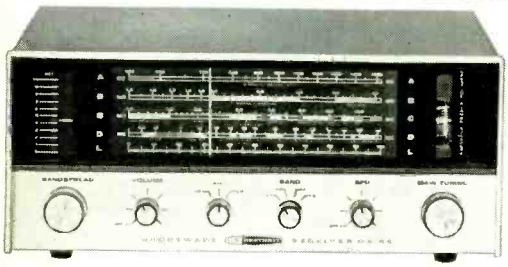
10 bands tune Longwave, Standard Broadcast, FM and 2-22.5 mc Shortwave. 16 transistors, 6 diodes, and 44 factory assembled and pretuned circuits. Two separate AM & FM tuners and IF strips. FM tuner & IF strip are same components used in deluxe Heathkit FM stereo gear. 2 built-in antennas. Battery saver switch cuts current drain up to 35%. Rotating tuning dial. Dial light. 4 simple controls for tuning, volume, tone, AFC and band switching. 4" x 6" PM speaker. Earphone & built-in jack. Optional 117 v. AC converter/battery charger available @ $6.95. Time zone map & "listener's guide." Man size: 13½" W x 5⅛" D x 10⅝" H. 17 lbs.

Kit GW-14
$89.95

Assembled GWW-14
$124.95

New 23-Channel, 5-Watt, Transistor CB Transceiver!

Your best 23-channel CB buy—bar none! Compare! 23 crystal-controlled transmit & receive channels for the utmost reliability . . . at lowest cost. All-transistor circuit for instant operation, low battery drain . . . only .75 A transmit, .12 A receive. Compact . . . 3" H x 7" W x 10½" D . . . ideal for car, boat, and 12 v. neg. gnd. mobile use. ½ uv sensitivity for 10 db signal plus noise-to-noise ratio. Includes "S" meter, adjustable squelch, automatic noise limiter, built-in speaker, ceramic PTT mike, gimbal mounting bracket, aluminum cabinet with die-cast chrome-plated front panel. 8 lbs. Kit GWA-14-1, optional power supply for AC operation, 5 lbs. . .$14.95. GWA-14-2, complete 23 channel crystal package (46 CB crystals)—$135.70 value. . .only $79.95



Kit GR-64
$37.95

Enjoy World-Wide Listening With This Low-Cost Shortwave Receiver!

Hear live broadcasts from hundreds of foreign countries, Voice of America, Radio Moscow, hams, ship-to-shore radio, weather and popular AM. Covers 550 kc to 30 mc—includes AM plus 3 shortwave bands; 5" speaker; bandspread tuning; signal strength indicator; 7" sliderule dial; BFO; 4-tube circuit plus 2 rectifiers; noise limiter; external antenna connectors; gray aluminum cabinet; AM antenna; 15 lbs.

Kit SB-100
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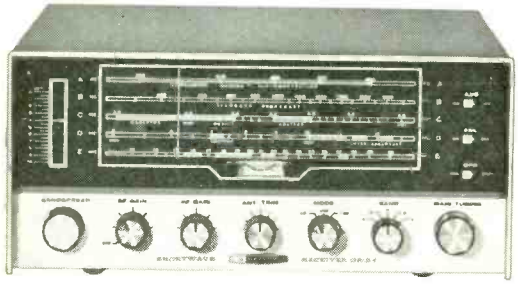

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Circle 10 on reader's service card

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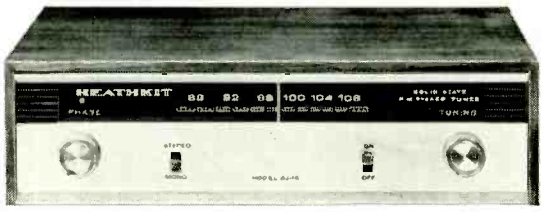

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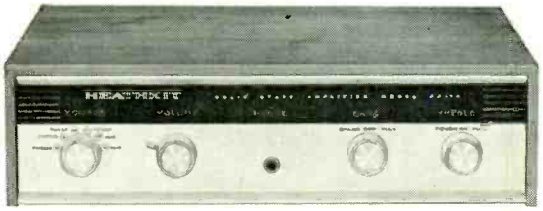

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Correspondence

WIN THE LADY OF THE HOUSE

Dear Editor:

About the cover story in the January 1966 issue of RADIO-ELECTRONICS titled "How We See Color":

You perhaps do not know of a spectacular way to demonstrate the red, green and blue phosphor dots of a color tube using only a common device found in most every home.

Service technicians would find this mighty handy in demonstrating to the housewife how the black-and-white picture is made up of colored dots.

Simply spray the face of the color picture tube with a window cleaner in a spray bottle (Windex, for example). The numerous tiny drops of cleaner act as magnifiers, and for a few seconds the very colorful display clearly demonstrates the triad of phosphor dots. (B & W picture, of course.)

KERMIT A. SLOBB

Northbrook, Ill.

[But then there's always the lady who looks up at you blankly and says, "Yeah? So?"—*Editor*]

GOOD OLD FIXED BIAS

Dear Editor:

I have a comment on the amplifier bias circuit shown under Noteworthy Circuits in the January issue.

First, the power increase is from about 40 watts to 48 and not from 20 to 48 as you have indicated. In the original, the author claimed "more than 20 watts" rather than 20. The difference in power is solely the difference which arises from the voltage shift across a cathode resistor.

Actually, the scheme is a more expensive and less effective means of obtaining fixed bias. If the conventional fixed bias is put in the grid circuit, with the cathodes grounded, the bias voltage adds to the B-plus, increasing the total power. The additional components for conventional fixed bias are less costly than the Zener-controlled regulator circuit used by Mr. Williamson.

We gave up the idea of using a Zener as a cathode resistor since it is not readily adjustable. We find that with fixed bias, the adjustment for *current* is much more important than setting a fixed bias voltage. With a fixed bias voltage, a change of output tubes will cause a change in distortion. If the stage is adjusted to a given current, the distortion can be kept at a minimum over a wide range of output-tube characteristics.

DAVID HAFLER

Dynaco, Inc.
Philadelphia, Pa.

HEARING AID: EXPENSIVE LUXURY?

Dear Editor:

I urgently need a good hearing aid. But a really good one, made by a firm of good reputation and properly fitted by a skilled technician, costs more than a new refrigerator, electric range or TV set. I simply cannot pay that much for *anything* at the present time!

I have been a professional radio and electronic technician for more than 25 years. I used to be very proud of my association with the industry, but now I am angry and ashamed. How can I explain to my wife or children or neighbors why a well-fitted hearing aid should cost as much as a color TV set?

The industry that can make equipment to take pictures of the moon and send them to earth can't make a hearing aid that can be fitted scientifically at a price a working man can afford!

A few small firms have tried very hard, and really good hearing aids *are* available. But a small company cannot put out a product in sufficient quantity to keep the price reasonable. Only about one person in ten who need hearing aids can afford one.

Because of hearing defects, quite a few people may be killed or permanently disabled through accidents. Others will lose their jobs. Still others will find life almost unbearably miserable.

Have the giants of the electronics industry got themselves so wrapped up in moon shots that they have forgotten all about people and their needs? They have deprived themselves of millions of potential customers who not only need hearing aids but without them can't enjoy the industry's entertainment products.

I hope that somebody "who is somebody" in the industry will read this letter and take up the challenge.

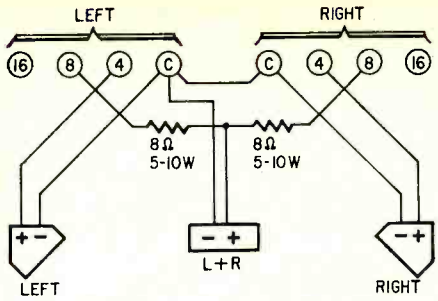
FRANK J. WILKERSON

Charleston Heights, S. C.

OBJECTION—! (OVERRULED)

Dear Editor:

The Hafler circuit of Fig. 1 on page 94, RADIO-ELECTRONICS, December 1965, produces a considerable dilution of one channel by the other, and the means for preventing that are complicated and apparently require adjustment. However well it may work, I'd aver the one below will work better on



Hafler's amplifiers and on loudspeakers which may be dissimilar by as much as 9 db in level and from 4 to 16 ohms in impedance.

PAUL W. KLIPSCH

Hope, Ark.

David Hafler replies:

Paul Klipsch's letter would seem to indicate that he is not completely familiar with the system.

It is true that the simple connection of the speakers, as shown in RADIO-ELECTRONICS, December 1965, will introduce crosstalk between the flanking speakers. However, the system goes further and includes a simple way to eliminate this. By using a single 10-cent resistor or a simple blend control, *all* crosstalk between the side speakers can be eliminated. Controllable blending is available on more than 100,000 Dynaco preamplifiers, and on many other brands, so it is relatively easy to use the system.

In contrast, Klipsch's hookup introduces only about 3% crosstalk, but it wastes half the power that should drive the center speaker.

Obviously, there are several approaches to obtaining a sum signal in the center speaker. I feel that ours is simple, efficient and fully satisfactory. Mr. Klipsch is entitled to his preferences, but I hope that he bases them on *all* the factors involved in the systems.

DAVID HAFLER

Dynaco, Inc.
Philadelphia, Pa.

IMPROVED "TRANSISTORIZATION"

Dear Editor:

I have made a worth-while improvement in the basic emitter-coupled circuit used in my tube-to-transistor radio conversion (December 1965) and would like to pass it along to R-E readers.

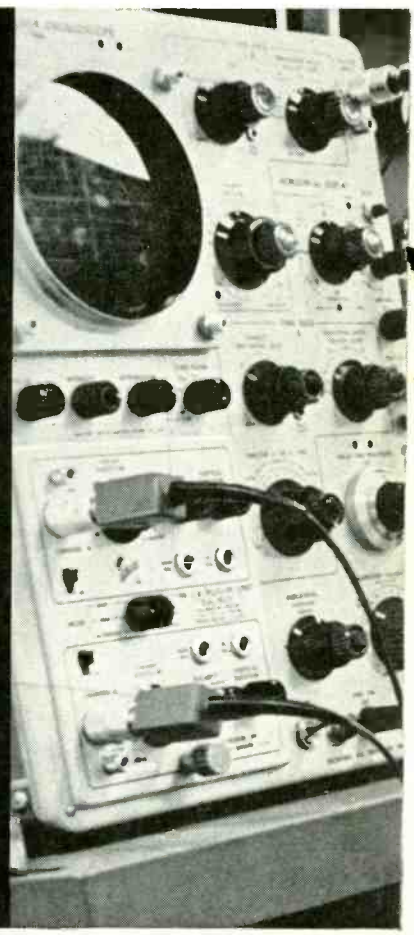
As mentioned in the text, the output impedance and capacitance of the emitter-coupled stage both approximated the characteristics of the tube being replaced. However, the input impedance was noticeably lower and the input capacitance higher than desirable for best results.

By using one extra transistor, the input characteristics can be made so

continued on page 22

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.

How to become a "Non-Degree Engineer"



The electronics boom has created a new breed of professional man—the non-degree engineer. Depending on the branch of electronics he's in, he may "ride herd" over a flock of computers, run a powerful TV transmitter, supervise a service or maintenance department, or possibly work side by side with distinguished scientists at the frontier of a new discovery.

In military-connected work alone, 80% of the field engineers are not college trained. Yet they enjoy officer status and receive generous *per diem* allowances in addition to salaries up to $11,000 a year.

In TV and radio, the Broadcast Engineer is the man with a 1st Class FCC License, whether he has a college diploma or not.

But even though you don't need a college education to become one of these non-degree engineers, you do need to know more than soldering connections, testing circuits and replacing components. You need to really know your electronics theory —to be able to calculate such things as resonance, reactance, inductance . . . and to know what to do with the numbers after you've figured them.

How can you pick up this necessary knowledge? Many of today's non-degree engineers learned their electronics at home. In fact, some authorities feel that a home study course is the *best* way to study Electronics. *Popular Electronics* said:

"By its very nature, home study develops your ability to analyze and extract information as well as to strengthen your sense of responsibility and initiative. Electronics technicians, even though they do not intend to work for themselves, must be 'self-starters.' Anyone who can satisfactorily complete a home study course in electronics need have no worry about his initiative."

Cleveland Method Makes It Easy

If you decide to advance your career through home study, it's best to pick a school that *specializes* in the home study method. Electronics is complicated enough without trying to learn it from texts and lessons that were designed for the classroom instead of the home.

The Cleveland Institute is such a specialist. It concentrates on home study exclusively. Over the last 30 years it has developed techniques that make learning at home easy, even if you once had trouble studying. Your instructor gives the lessons and questions you send in his undivided personal attention—it's like being the only student in his "class." He not only grades your work, he analyzes it. Even your correct answers can reveal misunderstandings he will want to clear up. And he mails back his corrections and comments the same day he gets your lessons, so you read his notations while everything is still fresh in your mind.

Students who have taken other courses often comment on how much more they learn from CIE. For example, here's what Mark E. Newland of Santa Maria, California says:

"Of 11 different correspondence courses I've taken, CIE's was the best prepared, most interesting, and easiest to understand. I passed my 1st Class FCC exam after completing my course, and have increased my earnings by $120 a month."

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The Cleveland method of training is so successful that better than *9 out of 10 CIE men who take the FCC exam pass it—and on their first try.* This is despite the fact that, among non-CIE men, 2 out of every 3 who take the exam fail! That's why CIE can promise in writing to refund your tuition in full if you complete one of its FCC courses and fail to pass the licensing exam.

This Book Can Help You

Thousands who are advancing their electronics careers started by reading our famous book, "How To Succeed in Electronics." It tells of many non-degree engineering jobs and other electronics careers open to men with the proper training. And it tells which courses of study best prepare you for the work you want.

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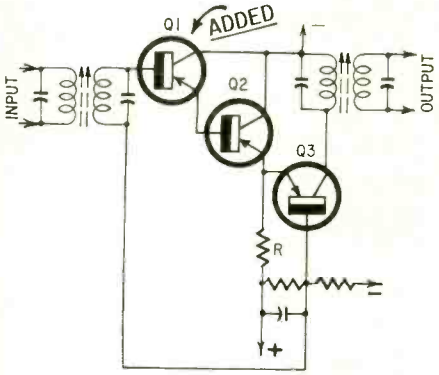
close to those of the tubes replaced that no appreciable readadjustment is required. Sensitivity and selectivity are both improved.



A diagram of the basic circuit is shown here. Simply open the input connection in the rf and i.f. stages and add one transistor (Q1) of the type used for Q2 and Q3. The same configuration is also suitable for af stages. Instability may require using internally shielded transistors such as 2N274, 2N370 or 2N1177.

JAMES E. PUGH

Winston-Salem, N. C.

(Please note correction on page 100—*Editor*)

APPRECIATES CURVE TRACER

Dear Editor:

Thank you for a fine article: "Component Curve Tracer" (November 1965, page 52). For something so simple and using hardly any parts, it certainly does a big job. And it shows up bad transistors in a hurry.

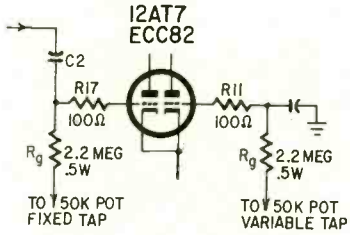
M. F. LABUDA

Salem, Ore.

MISSING GRID RESISTORS

Dear Editor:

Readers planning to modify their oscilloscopes according to the late Tom Jaski's article "Scope × 100" (November 1965, R-E) should make a minor correction to Fig. 3 in the article. It will be necessary to add two high-value grid resistors, marked R_g in the sketch above. Without these resistors the gain and low-frequency response would suffer, and it would be difficult to get full deflection on the CRT screen.



Mr. Jaski's comments on the placement of the two 100-ohm resistors (R11 and R17 in Fig. 3 parts list) imply that he intended them as "grid stoppers"—protection against possible oscillation.

JAMES E. RATHKE

Lawrence, Kan.

SWELLING OUR HEADS

Dear Editor:

Just a word to let you know that RADIO-ELECTRONICS is a wonderful magazine and has been a great help to me; especially Jack Darr.

STAN WALY

Flin Flon, Manitoba

END

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SERVICE CLINIC

By JACK DARR Service Editor

"Tracking" Distortion In Tape Recorders

IF A HI-FI TAPE RECORDER HAS BECOME more "phoo" than "fi", take a close look at the heads. For some reason, many people who keep very detailed records on how long a phono stylus has played will calmly ignore the many hours piled up on their tape-recorder heads! Sad but true, any time we drag even high-quality tape across a head, both head and tape wear. The inevitable dust causes the process to speed up. (No dust in modern homes? Look at your furnace filters!)

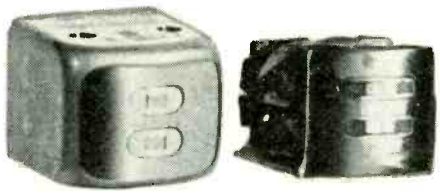

Fig. 1—Good head. Fig. 2—Worn head.

This is the first thing you should check when you get this kind of complaint. First, give the heads a good cleaning, and *don't use carbon tet.* Use a special head cleaner; you won't melt out any plastics that might be used, and you won't take a chance on poisoning yourself. Now, check the head with a powerful magnifying glass. A loupe of about 4–6 power is fine.

The gap in a modern tape head may be almost invisible, but it's there. Gaps of only a few ten-thousandths are common. It isn't a real gap, just a magnetic one; it's filled with plastic. If the head is worn to the point where you *can* see the gap, look out. Look for a *very* smooth surface, evenly polished. Fig. 1 shows a rough idea of what it ought to look like. Fig. 2 shows a badly worn head, obviously out of alignment. Notice the trapezoidal ("keystone") shape of the worn patch. Normal wear on a properly aligned head will make a very shallow groove, exactly straight across the head.

It's a very good idea to check head alignment on *all* tape recorders being serviced. The head must be exactly right in azimuth and perpendicularity. Fig. 3 shows what these words mean. The head must be set so that the tape crosses it at exactly 90°, or a right angle. This is the azimuth. As the tape runs between the reels, the head must be exactly aligned with it, as seen in the side view in Fig. 3. If the head leans forward or back, the tape will not run "centered" on the head; it will tend to ride up or down, and the head will wear unevenly. This is skew, although you'll find other names used.

For azimuth adjustment, small screws are used at each end of a bracket. A quick and accurate way to check azimuth is to play a prerecorded test tape with a continuous high-frequency tone on it (7,500 Hz is common). Vary the azimuth adjustments for maximum output. One major tape-head maker says that as little as ⅓° of misalignment will reduce the output of a 7,500-Hz tone by *one half!*

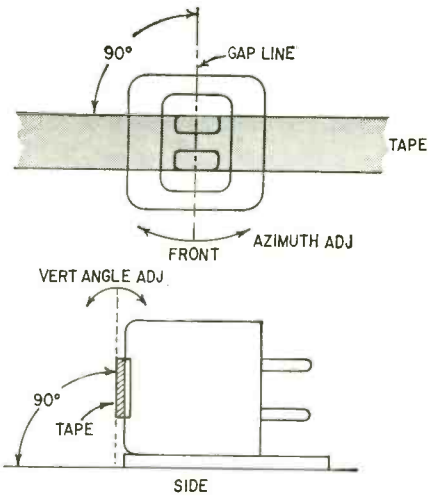

Fig. 3—Alignment of tape head is important for long life and good sound.

Azimuth troubles can also be due to worn reels, bearings, tape guides, and such things. Reel wobble can cause the tape to jump up and down in worn guides and really cause trouble!

To check skew, look to see if the tape rides up or down on the head. As you can see from Fig. 3, a head that leans too far forward or back will make

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

If you're really stuck, write us. We'll do our best to help you. Don't forget to enclose a stamped, self-addressed envelope. Write: Service Editor, Radio-Electronics, 154 West 14th Street, New York 10011.

the tape run off, out of the right groove, and away we go. Head wear will show this up, but often too late. The worn head will have to be replaced, and the new one checked very carefully for both skew and azimuth, to prevent a repeat of this trouble.

Many tape-head makers scream loudly at the words "pressure pads". They are common, though, in low-priced recorders, because they are a simple way to keep tape and head in intimate contact. Check pad surfaces to make sure that they aren't gummy or rough, or that they haven't lost their felt entirely (this has happened!). Pad pressure should be kept as low as possible for least head and tape wear. Specially curved ("hyperbolic") heads can be obtained which are designed for use without pads; the tape-transport system is built to hold the tape against the heads with the correct pressure from tape tension only.

Don't replace pressure-pad heads with this type unless the machine has a *very* good transport mechanism, though. This demands a very well-built drive and extremely good regulation speed *and* tape tension! It would be impossible to convert some of the low-priced machines to this system, because of the "frail" drives used.

Amplifier switching at mikes

I've got two mikes on a system, with preamps at each one. I want to switch the output of either preamp into the main amplifier, individually, and at either mike. No. 1 on and No. 2 off, and vice versa. How can I do this?—P. H., Marysville, Pa.

At first, this looked simple. Then I saw that you want to switch at *either* mike! This gets more complicated. However, by using the same circuit as in the common "three-way" light switch, you can do it (Fig. 4). Switching at the amplifier would be simple. However, to do it remotely, the best way would be to use a relay as shown.

Use intercom cable, of the type with a shielded wire plus 3 wires for relay control. If you use a low-voltage relay, you can use the shield as one of the control leads. Use terminal strips or connectors at the relay to join the control leads.

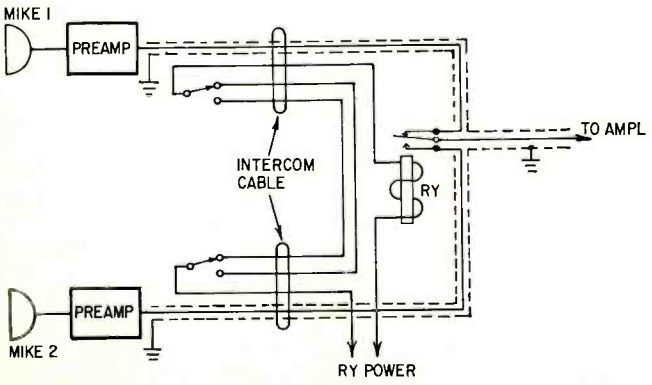

Fig. 4—Borrowing a circuit from electricians solves this reader's mike-switching problem.

Feedback howl on recording

I get a terrific feedback howl on a Webcor EP-2001-10 recorder whenever I set it on RECORD. *The mike has been changed, and I'm not sure if it is hooked up right. Playback OK. What's the matter?—O. H., Akron, Ohio*

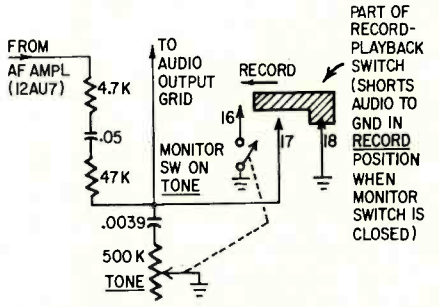

Fig. 5—Webcor speaker cutout prevents acoustic feedback during recording.

There should be a speaker cutoff on the RECORD control somewhere. If there isn't, there'll be feedback between speaker and mike.

Check this on the schematic. You ought to have a MONITOR switch on the tone control. Turn this off and the feedback should stop (Fig. 5).

Engine noise in FM auto radio

I have just installed a Blaupunkt AM/FM radio in my car. It works very well, but I have a lot of trouble with electrical noise when I get a little way out in the country. The dealer has checked it, and says that the radio is OK. —G. A. McP., Renfrew, Ont.

One of two things is the most likely problem. You either have insufficient signal to the radio, which would not let the FM limiter and detector block the AM noise, or you have a very high noise level in the car itself.

Be sure that the usual noise-suppression devices are installed: resistor spark-plugs or wiring, or resistor suppressors at each plug; bypass capacitors on generator armature; battery terminal of voltage regulator, and battery terminal on the ignition coil. (Coaxial bypasses are best.)

Also, and very important, be sure that your antenna is right: shield on coaxial lead-in properly grounded at *both* ends, and antenna trimmer in radio

Circle 17 on reader's service card

Circle 18 on reader's service card

(if any) tuned for maximum signal strength. The symptoms sound as if you could have some trouble with shield grounding at the antenna itself; check this to be sure. Try another antenna on the set; plug it in and hold it out the window, keeping your hands off the rod and grounding the base to a metal part of the car.

Finally, check electrical bonding of the hood and engine. They should be well grounded to the car's chassis.

Bass boosting in stereo preamps

I've just got a Heathkit AA-11 stereo preamp for my outfit. I can't seem to get adequate bass boost unless the loudness control is brought in. With conventional volume control, the bass is there, but it isn't enough. The thing seems to play perfectly. The rest of the system is OK.

Why doesn't the Baxandall circuit give more bass boost? None of them seem to give more than 10 db without loudness compensation.—G. B., Alexandria, La.

Oh, boy! Here we go! In something like this, we're getting into individual preference in tone control settings, and that's always difficult! In my own venerable half-stereo, I play it with maximum bass, for that's the way *I* like it. Others prefer flat positions. At any rate, the loudness control circuit is intended to give you a degree of control over tone as well as volume. By juggling settings on the two knobs (bass and loudness), you can add or remove bass, since the loudness control is frequency-compensated according to the Fletcher-Munson hearing curves. Mine runs about 40% open on the loudness, with the level at whatever point can be tolerated (by my wife).

The Baxandall tone control is a selective-feedback circuit. In the original circuit, maximum bass boost (or I should say "bass lift," since this is a British circuit!) is 16 db. However, judging the level of boost or cut by ear is a tricky thing. The only way to get an accurate idea of this would be to make frequency runs, with a meter on the output.

The whole idea behind the Baxandall circuit is that it also varies the *frequency* at which boost and cut start, not just the amount of boost or cut. With it, you can get, say, 10 db boost at 50 Hz, and almost none at a few hundred, unlike the more common bass control, which starts boosting from 1,000 Hz down. This keeps speech and music from sounding boomy, but it makes a less obvious bass boost. END

Circle 19 on reader's service card

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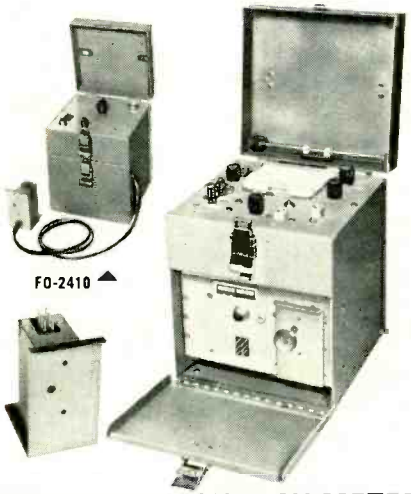
Equip your lab or service bench with the finest



FM-5000 FREQUENCY METER

25 MC to 470 MC

The FM-5000 is a beat frequency measuring device incorporating a transistor counter circuit, low RF output for receiver checking, transmitter keying circuit, audio oscillator, self contained batteries, plug-in oscillators with heating circuits covering frequencies from 100 kc to 60 mc. Stability: ±.00025% +85° to +95°F, ±.0005% +50° to +100°F, ±.001% +32° to +120°F. A separate oscillator (FO-2410) housing 24 crystals and a heater circuit is available. Shipping weight: 18 lbs.

FM-5000 with batteries, accessories, less oscillators and crystals.

Cat. No. 620-103.....$375.00

Plug-in oscillators with crystals $16.00 to $50.00

C-12M FREQUENCY METER

For Marine Band Servicing

The C-12M is a portable secondary standard for servicing radio transmitters and receivers in the 2 mc to 15 mc range. The meter has sockets for 24 crystals. Frequency stability is ±.0025% 32° to 125°F, ±.0015% 50° to 100°F. The C-12M has a built-in transistorized frequency counter circuit, AM percentage modulation checker and modulation carrier and relative percentage field strength. Shipping wt. 9 lbs.

C-12M with PK (pick-off) box and connecting cable, batteries, but less crystals.

Cat. No. 620-104.....$235.00

Crystals for C-12M (specify frequency) $5.00 ea.

Model 7212

FREQUENCY METER

The International Model 7212 portable secondary frequency standard is a self contained unit designed for servicing radio transmitters and receivers used in the 400 kc to 500 kc range (can be modified for other frequencies on special order). Frequency accuracy is ±.01% from 32°F to 104°F (0°C to 40°C). The meter holds eight crystals. Features include the transistorized frequency oscillator and built-in battery charger. Shipping weight: 18 lbs.

Model 7212 complete with crystals.

Cat. No. 620-105.....$575.00

CRYSTAL CONTROLLED

C-12 ALIGNMENT OSCILLATOR

The International C-12 alignment oscillator provides a standard for alignment of IF and RF circuits 200 kc to 60 mc. It makes the 12 most used frequencies instantly available through 12 crystal positions 200 kc to 15,000 kc. Special oscillators are available for use at the higher frequencies to 60 mc. Maximum output .6 volt. Power requirements: 115 vac. Shipping wt. 9 lbs.

C-12 complete, but less crystals.

Cat. No. 620-100.....$ 69.50

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Model 1110 SECONDARY

FREQUENCY STANDARD

The Model 1110 is an economy portable secondary standard for field or bench use. The unit contains a rechargeable battery eliminating battery expense over the life of the cell. A one (1) mc crystal provides long term stability of plus or minus 10 cycles over range 40°F to 100°F. Short term stability of better than 1 part in 10^7 can be obtained. All transistor circuits provide outputs at 1 mc, 100 kc and 10 kc. A switch selects the desired frequency. More than 8 hours operation is available on one charge. The Model 1110 may be left on charge at all times when not in use. Shipping weight: 12 lbs.

Model 1110 complete.

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

C-12B FREQUENCY METER

For Citizens Band Servicing

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

C-12B with PK (pick-off) box, dummy load, connecting cable, crystals, batteries.

Cat. No. 620-101.....$300.00

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*"Scientists, Engineers, and Technicians in the 1960's" U.S. Dept. of Labor Bureau of Labor Statistics, 1964.

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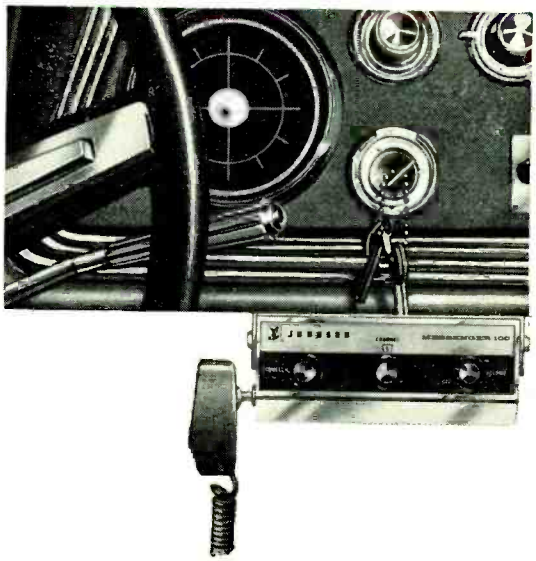

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Radio-Electronics
Hugo Gernsback, Editor-in-Chief

THE NEW IHF STANDARD: WHAT NOW?

PETER E. SUTHEIM, *Associate Editor*

On Sept. 28, 1965, the Standards Committee of the Institute of High Fidelity approved the final draft of the IHF standard, Methods of Measurement for Audio Amplifiers.

In many ways the standard is an impressive achievement: a series of test and measurement procedures that are not only efficient and repeatable, but in most cases highly valid. They measure what they are expected to measure with a respectable consistency and reliability. The minimum standards for instruments to be used have been upped. The language is clear.

Many still differ with the committee on the subject of Music Power (now named *Dynamic Power*, to divorce the newly tightened definition [see p. 39] from the derogatory semantics acquired by the old term). But there is no doubt that the new approach is tougher and more logical. It is a closer strike at the problem of gaging the performance of an amplifier when it passes nonsinusoidal material, like music or speech. The old Music-Power definition, from the 1959 standard, accumulated ridicule like barnacles here and abroad, from everyone but the ad men. The new Dynamic-Power measurements should silence much of that—though certainly not all.

The new standard goes one step further in another direction. It prescribes a list of measurements to be quoted, and the order in which they shall be given, without which a manufacturer may not call his product "IHF-rated" or anything similar. The maker can no longer measure frequency response according to IHF methods and say so, then in the same listing use his own (perhaps arbitrary) standard for power bandwidth. So we now have a standard with at least a fiery breath and strong gums, if no real teeth.

The IHF does not have the respect or power it needs to enforce a really strict standard. Its members can join or withdraw as they wish, without the public's knowing or caring. At the moment, not 1% of the hi-fi buying public knows whether a particular manufacturer is in the IHF or not, or whether he complies with IHF procedures. Very few are even aware that an IHF exists.

The only practical way for the IHF to gain the public recognition it needs for the job of enforcing its standards is to advertise itself to the public and explain its standards in terms meaningful to the layman. The IHF will have to become as well known as the FCC. At that point it may become embarrassing for a manufacturer to remain outside the organization, but to join he will have to comply with the IHF's rules. With that kind of enforcement, hi-fi component specs will be considerably more meaningful than they are now. It will be far easier to compare one manufacturer's figures with another's. Manufacturers who wish to call on the IHF's coming prestige and recognition to lend weight to their claims will also have to insure that their published specifications are derived according to IHF standards.

The IHF ought to do more to promote itself, its purposes and, most of all, its hard-won measurement standards, on which so much time, money and energy are lavished. (In December, the first steps were taken toward a revision of the FM tuner standard—an undertaking that will again stretch over several months. Standards on turntables, speakers and other components are expected to follow in the next two years.)

The IHF has been doing a manful job of trying to persuade the public to buy "component" high fidelity (separate tuners, amplifiers, receivers, turntables, speakers, etc.), rather than "package" goods or —in the words of at least one member—"pretty furniture." However, in not making the public clearly aware of the new standard, in layman's terms, the IHF is neglecting a valuable—and completely sincere —tool for moving public opinion in that direction. It is also getting a lot less than a full return on the Committee's investment of time and labor. In those few dozen pages of printed matter lies the essential difference between component hi-fi and "furniture": a rigorous, well-defined standard of measurement.

This approach is by no means foolproof; the business genius that made America great will undoubtedly find generous loopholes. It is too much to ask a manufacturer-sponsored association to assume the responsibility of a public watchdog like Consumer's Union. But it will help. It may start to untangle the jungle which at present hampers efforts of quality-hi-fi manufacturers to gain and hold the confidence of the ever-fickle buying public. END

24 WAYS TO PUT YOUR TAPE RECORDER TO WORK

By FRED BLECHMAN

THE TWO DOZEN USES SUGGESTED HERE ARE ONLY A FEW OF the many dozen possible applications for a tape recorder. (In fact, I cut the original article down from "38 Ways" because our space was limited—and even that only began to cover the range!)

I didn't include the obvious uses that everybody thinks of (like transcribing records and radio programs, or bugging a party or dinner-table conversation). This collection of ideas was put together to show how versatile even the simplest recorder is. None of the tips involves stereo, echo or sound-on-sound, although of course those special facilities will expand your horizons even more.

Your tape recorder can save you time, money and effort, improve your performance in all sorts of activities—and put some fun in your life, too.

. . . *in the home*

1. Recording music, comedy or speeches directly from radio or television is very popular. Most recorders have a "radio" input jack just for that. By setting a clock timer before you leave home, you can record programs you might otherwise miss. Also, you can record one program while watching or listening to another.

2. "Tape-respondence," or corresponding by tape, is catching on as more people get recorders and try it. Worldwide clubs have been formed to exchange tapes. Small 3-inch reels can carry a great deal more information than a letter written in the same time, and the voices of friends and relatives are a much closer link across the miles. Most people use short tapes that record for about 15 minutes on a reel at 3¾ ips. First-class postage in the US is only 10¢.

3. Live, on-the-spot recordings of speeches and musical performances can enrich your tape library, and may become collector's items. These can include interviews with local businessmen or politicians expressing local views for playing at meetings or conventions, or for later radio broadcast.

4. Exchanging unusual tapes is a hobby many people enjoy. Tapes of local entertainers, old "classic" radio shows and other memorable items can be exchanged for just listening or for duplication. (Making a "dub" or duplicate calls for a second recorder, but you can make as many copies as you like without hurting the original.)

5. Going on vacation? Take a tape recorder along to preserve the exciting moments. A battery recorder can capture airplane takeoffs and landings. You can describe flight routes. Send daily summaries back home so others can share your enjoyment. Descriptions of local points of interest can be played months later to relive the vacation, especially with movies or slides.

See the roundup of battery portable recorders in this issue!

6. When you send movies and slides to relatives, send a tape along with the pictures and let them have the *whole* story. With an audio mixer you can even put background music under your commentary, complete with professional fade-ins and fade-outs.

For more details, see "Stereo for Home Movies," in this issue! (Also "Electronic Slide Changer", June 1964, and "The Pushbutton Projectionist," January 1965)

7. The talented children in your family can speed their progress if you (or they) make weekly tapes to show improvement—or stubborn flaws. Even if your children aren't pursuing one of the "performing arts," you'll want a permanent record of their progress in learning to talk. Like photos, these "sound pictures" will increase in value as your children grow.

8. Mothers who work or are busy elsewhere can use a tape recorder to leave messages for the children when they come home from school, or leave instructions for a maid, baby-sitter or delivery man.

9. Your youngsters can make tape-recorded "trips to outer space." Using home furniture and appliances to create sound effects, and taking advantage of the two or three speeds on most machines to create weird new sounds, they'll have plenty of opportunity to exercise their imaginations.

. . . *in business*

10. A tape recorder equipped with a push-to-talk mike for recording and a foot switch for playback is a natural as a dictating machine. Most better battery-operated portables

have these features, as well as an ac power supply to save the batteries when transcribing the recording.

Check the Battery Recorder Roundup in this issue to see which machines can be used for dictation!

11. Taking inventory can be speeded up considerably by using a tape recorder and transcribing the information later.

12. For the first draft of a letter, technical paper, presentation or magazine article, a tape recorder will allow you to collect your ideas much more quickly and efficiently than you can by writing them down so slowly you lose your train of thought.

13. A battery-operated recorder with a push-to-talk mike is handy in a car. You can record spur-of-the-moment ideas while driving, or summarize conferences just attended, customer reactions, etc.

14. Does your company sometimes have "open-house" tours, or displays at industrial shows? A continuous-loop tape cartridge like the Cousino Audio Vendor in the photo, usable with most recorders, can be placed at each stop on the tour, or at each display booth at a show. Prerecorded messages insure accurate and complete information.

15. Self-criticism and group discussion of recorded telephone solicitations develop the technique of presenting the product and handling the difficult customer.

. . . *in school*

16. In learning a foreign language, the tape recorder allows immediate comparison between the recorded lesson and the student's pronunciation, inflection, grammar, understanding and expression.

17. Faulty speech can be overcome by letting students listen to their recordings and having their deficiencies in diction, grammar or pronunciation pointed out to them.

18. Students absent from school due to sickness or other causes will find a recorder useful for making up work. Lessons can be recorded by the teacher and sent to the student. [Teachers would, of course, have to make a habit of recording all lessons for use of absentees.] The student's assignment and questions can be returned on the same tape for the teacher to play.

19. Students can organize tape clubs in their schools, and trade tapes with other schools, locally, out of state and even in foreign countries, to exchange ideas.

20. When students go on a field trip, a portable recorder can be used to "take notes" on points of interest for later discussion in the classroom.

21. Students can record lectures or descriptions of lab demonstrations for later study and more leisurely note-taking. (Better get permission from the instructor first; also, some schools may have regulations against unauthorized classroom recording.)

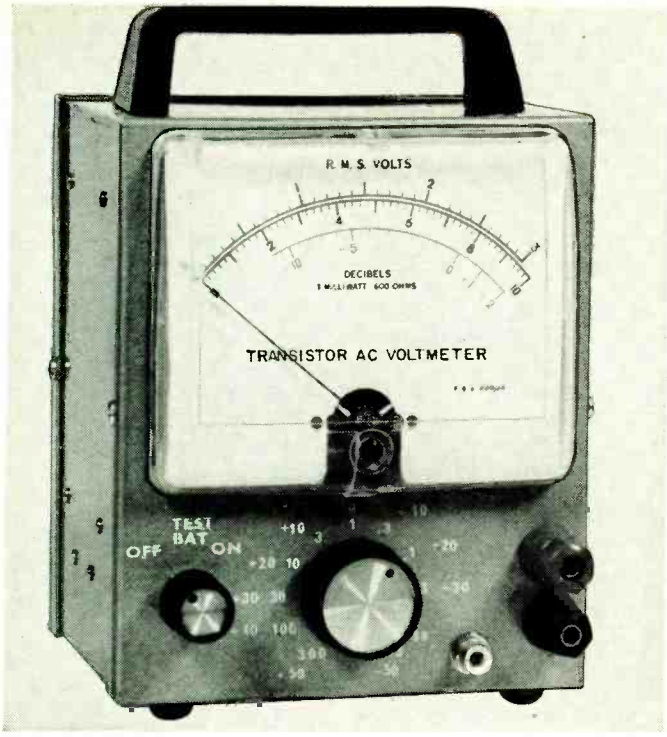
. . . *in the shop and ham shack*

22. Playing back another fellow's signal recorded off the air will give him a good idea of what he sounds like, especially if his modulation is faulty.

23. For code practice, a recorder is hard to beat. Professional code tapes are available. You can also tape good code off the air for study, or make your own practice tapes.

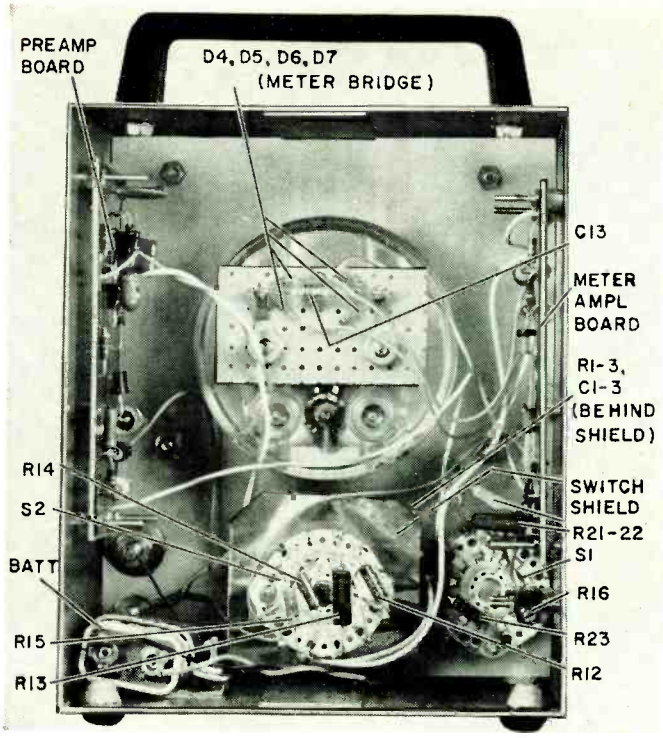
24. In troubleshooting equipment, use a recorder to take verbal notes on problems, attempted corrections and results, disassembly sequence and the like. Use it also when developing new circuits. You can play the tape days later to brief yourself on what you've already done and ideas you meant to try.

END



Photos by P. E. Sutheim

Voltmeter uses ready-made movement used in Heathkits—a 200-μa, 1,400-ohm dc microammeter. Movement is available from Heath. Other types can be used.



Removing back cover shows layout of major components. Wiring is done in sections—preamp board, meter amplifier board, rectifier, range switch. Sections are interconnected later.

Transistor Audio Voltmeter

High-performance lab-quality instrument has high input impedance, wide range

This four-transistor wide-band ac voltmeter costs no more to build than kit types using tubes. It performs as well or better, and is completely free of problems caused by capacitive coupling to the ac line. Battery drain is very low (0.7 ma), and changes in battery voltage have a negligible effect on accuracy. The voltmeter is virtually safe from damage by electrical overload. A battery test position on the power switch gives an immediate indication of the battery condition. Eleven ranges from 3 millivolts to 300 volts full scale meet the needs of any normal audio application. All ranges are arranged in root decade steps. That is, they change by a factor equal to the square root of 10 which is also equivalent to a voltage change of 10 db. This is very convenient in making decibel measurements. Meter frequency response extends from 10 Hz to 100 KHz ±0.5 db.

By EARL T. HANSEN

Circuit description

The input attenuator (S2-a with R1, R2 and R3) has a resistance of more than 5 megohms and is frequency-compensated by C1, C2 and C3. The first four steps of S2 (3-mv through 100-mv ranges) connect the input of the preamplifier directly to the input terminals; S2-b, the other deck of the range switch, between preamp and meter amplifier, provides four 10-db steps (3, 10, 30, 100 mv full scale). In the fifth (0.3 V) step, the input is divided down by 100:1 (40 db) to prevent overloading the input stage, and S2-b goes through the same four 10-db steps as before, giving ranges of 300 mv, 1, 3, and 10 volts full scale. Between the 10- and 30-volt ranges, S2-a selects a further 100:1 tap, and S2-b again repeats, giving three more ranges of 30, 100 and 300 volts full scale.

This actually simplifies the design of the atttenuator, because the "fine" (10-db/step) attenuator (S2-b) can be put at a low-impedance point in the circuit and thus does not need frequency-compensating capacitors. If the whole attenuator string were at the input, as many as 10 separate trimmer capacitors might be required.

In the topmost switch positions (lowest ranges) the 30-megohm input impedance of the preamp parallels the 5-meg attenuator for a combined input impedance of greater than 4 megohms. At the two lower sets of taps, the amplifier loading on the very much lower values of R2 and R3 is negligible. The preamplified has a voltage gain of approximately 5, as determined by the ratio of R7 and R8.

The high input impedance is made possible by the characteristics of the silicon planar transistor. High beta (current gain) at very low collector current, and extremely low leakage make the high-impedance design practical. Emitter resistor R7, already relatively high for this function, is effectively increased by heavy negative feedback through R8. This in turn reflects a very much higher input impedance at the base. The effective value of base-bias resistor R5 is increased several times by the bootstrap action of the signal through C5 from the output collector.

Dc bias is stabilized by two feedback paths, R7–R8 and R6–R5. D1 and D2 protect the input circuit from overload voltages. They are normally reverse-biased and have a negligible effect on the input circuit. They both conduct in the forward direction during the negative half of an excessive input signal. For the positive half of an excessive signal, the Q1 base–emitter junction conducts in the forward direction, and D2 in the reverse Zener mode, before the base-to-collector voltage of Q1 becomes dangerous. The current to these protective elements is limited to a safe value

by R4 and C4. Emitter capacitor C7 is very large, and C4 and C5 relatively small. This avoids low-frequency instability due to a cumulative phase-shift (oscillator) effect. As it is, gain rises below 10 Hz, down to approximately 2 Hz. C6 aids high-frequency stability by eliminating ringing on square waves.

The effective output impedance of the preamplifier is very low compared to the four-step attenuator resistance R12, R13, R14, R15). The relatively low impedance of the attenuator and low stray capacitance in the switch eliminate the need for high-frequency compensation.

The meter amplifier has very high open-loop (without-feedback) gain. When the current feedback path (through the meter to the emitter of Q3) is closed, the gain is reduced greatly and made very stable, regardless of battery voltage or temperature variations. The feedback also increases the input impedance to approximately 1 megohm. This puts negligible loading on the four-step second attenuator. About 15 mv rms at the input of the meter amplifier (Q3 and Q4) causes full-scale deflection.

R16 adjusts the amount of feedback (and therefore the gain) and is the overall calibration adjustment. C10 is a relatively low value, chosen to compensate for the rising low-frequency response (below 10 Hz) in the preamplifier. D3 provides a conduction path for negative half-cycles during overloads and prevents a negative charge from accumulating on C10. Otherwise a severe overload could cause Q3 to become mostly nonconducting and reduce the output of the meter amplifier. This would show a misleadingly low scale

AN R-E EDITOR WRITES:

"The transistor voltmeter was compared to a newly calibrated commercial instrument and agreed with it within less than ¼ db from 10 to 120,000 Hz. Decading is accurate; temperature and mechanical stability, excellent. Input impedance falls slightly at high frequencies because of the capacitive component, but up to about 100,000 Hz this will have small effect on voltages with a source impedance of 30,000 ohms or less."

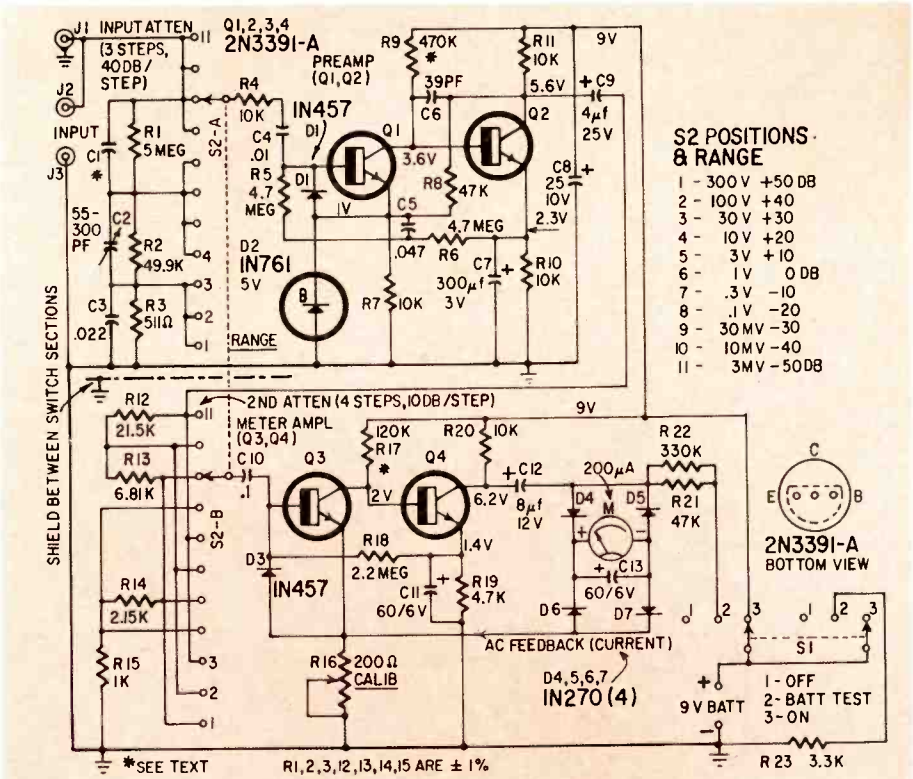
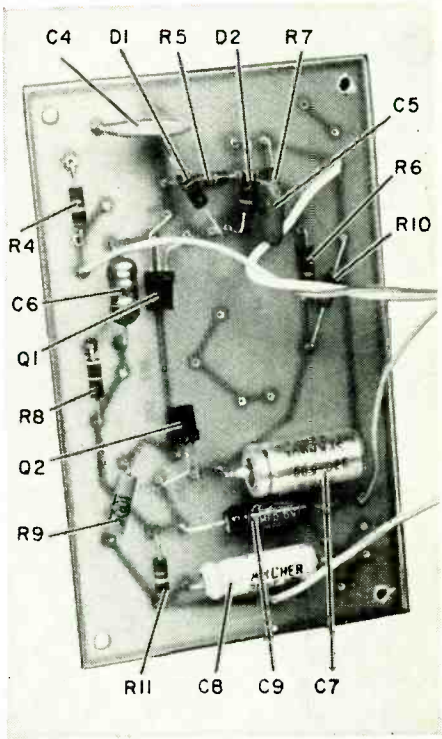
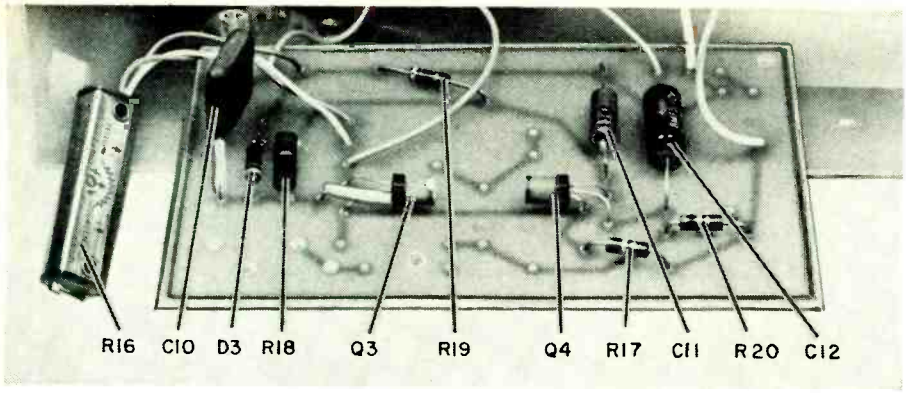


Fig. 1—Complete circuit of the transistor audio voltmeter. It is extremely stable.



Preamp board, wired on printed-circuit designed for different job. Perforated phenolic board with push-in terminals would be more suitable.

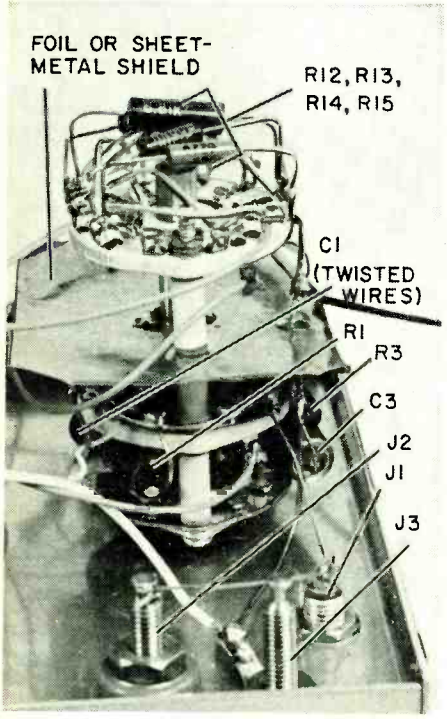
BATT—9-volt battery
C1—twisted-wire "gimmick", 1½ twists
C2—55 to 300-pf trimmer (Vitramon 427 or equivalent—Allied Radio Corp stock No. 17 U 084)
C3—.022 µf, 100 volts
C4—.01 µf, 400 volts, paper or ceramic
C5—.047 µf, 100 volts, paper or ceramic
C6—39 pf, ceramic or mica
C7—300 µf, 3 volts, electrolytic
C8—25 µf, 10 volts, electrolytic
C9—4 µf, 25 volts, electrolytic
C10—0.1 µf, 100 volts, paper or ceramic
C11—60 µf, 6 volts, electrolytic
C12—8 µf, 12 volts, electrolytic
C13—60 µf, 6 volts, electrolytic
D1, D3—1N457 (silicon; Sylvania)
D2—5-volt, 400-mw Zener diode (1N761, Texas Instruments)
D4, D5, D6, D7—1N270 (germanium; Ohmite, Sylvania)
J1—RCA-type phono jack (optional)
J2, J3—"5-way" jack-top binding posts
M—meter, 200 µa dc. approx 1,400 ohms (Heath stock No. 407-85; $10.40. Heath Co., Benton Harbor, Mich. 49023. Address orders to Mr. C. A. Robertson, Technical Product Mgr. This meter has the special 0-10 and shorter 0-3 scales desirable for this type of instrument, as well as a standardized db scale. Electrically similar movements will work equally well, however.)
Q1, Q2, Q3, Q4—2N3391-A (General Electric)
R1—5 megohms, 1 watt, 1% (Continental-Wirt type NR-25; Allied stock no. 26 Z 301C, $1.05)
R2—49,900 ohms, 1%
R3—511 ohms, 1%
R4, R7, R10, R11, R20—10,000 ohms
R5, R6—4.7 megohms
R8, R21—47,000 ohms
R9—470,000 ohms
R12—21,500 ohms, 1%
R13—6,810 ohms, 1%
R14—2,150 ohms, 1%
R15—1,000 ohms, 1%
R16—pot, 200 ohms (Bourns E-Z Trim 3067-S or equivalent)
R17—120,000 ohms
R18—2.2 megohms
R19—4,700 ohms
R22—330,000 ohms
R23—3,300 ohms
All resistors ⅛ watt or more, 10%, except as noted
S1—2-pole, 3-position rotary switch, nonshorting (Centralab 1003 or equivalent)
S2—3-pole, 11-position rotary switch, modified (see text and photos), shorting contacts (Centralab 1008 or equivalent)
Cabinet—aluminum, 4 x 5 x 6 in. (Bud CU-2107A, AU-1029 or similar)
Perforated boards (Vector G) and push-in terminals (Vector T-28)
Cabinet handle, rubber feet, knobs, wire, small hardware.



Meter amplifier board, also on "borrowed" etched-circuit board.

reading instead of one "against the peg" as it should and does. For all normal signals D3 is reverse-biased and has no effect on operation.

The transistor operating points are stabilized by dc bias feedback from the emitter of Q4 to the base of Q3 through R18. Ac output current is coupled through C12 to the bridge rectifier and meter. The bridge return carries the signal current back to the emitter of Q3 to complete the loop. C13 across the meter provides some damping, both in use and when the meter is being transported. It also bypasses high frequencies to prevent the meter coil inductance from being a factor in the overall bandwidth and reduces the force with which the meter hits the peg when overloaded. However, maximum current to the meter is limited to a safe value.



Details of RANGE *switch, S2. It began life as 3-deck switch; center deck was removed and replaced with shield (5-mil copper foil here; sheet aluminum will also work, though copper is easier to solder to). Front deck is S2-a (nearer panel); read deck is S2-b.*

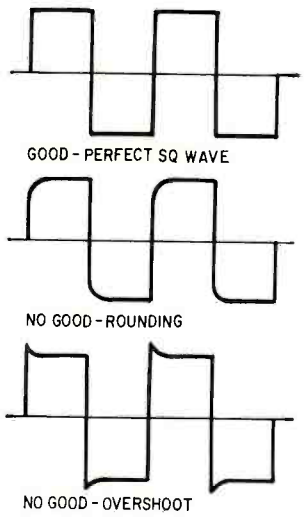


Fig. 2—Adjust C1 and C2 for perfect square wave on scope connected to C9.

The battery-test position (TEST BAT) routes the battery voltage through the bridge and meter. It also applies R23 across the battery, which tests it at about four times normal load (2.7 ma.).

Construction

The two sections of S2 must be shielded from each other. I did this by obtaining a three-deck switch, and replacing the center deck with a 2-inch square of sheet metal drilled for the shaft and screws. (Heavy copper foil is shown in the photos.) Wiring at the input jacks, the S2-a wafer and the preamplifier input should be kept short and isolated from S2-b and the meter amplifier board. The meter diode bridge may be mounted on the meter amplifier board. Except for the 1% attenuator resistors, components are not critical. I used some "universal" printed-circuit boards designed for another purpose for the amplifiers, but perforated boards with push-in terminals are recommended.

C13 should be "formed" before installation by connecting it to a 3 to 6-volt dc source for a few minutes. C1 is made by lightly twisting two wires 1½ turns. Most of the capacitance of C1 (2.2 pf) already exists in the switch wafer and wiring.

Checkout

Connect the battery and set S1 to TEST BAT position. The meter should read 9 volts or whatever is the actual battery voltage. Change R22 if desired, to obtain the exact reading. Set S2 to the 300-volt position, S1 to ON, and check dc transistor voltages with an 11-megohm vtvm. The collector voltage on Q4 should be between 5 and 7. If not, change the value of R17. Increasing R17 will increase the Q4 collector voltage. The collector voltage on Q2 should be 5 to 6. Adjust the value of R9 if necessary.

Set R16 to about mid-position. Apply a known 60-Hz voltage to the input. Set the range switch (S2) to the proper position and adjust R16 for the correct meter reading. Use a full-scale voltage such as 3 volts or 10 volts for best accuracy.

Connect a square-wave generator to the input. Connect a scope at C9. Set C2 to approximately two-thirds full capacitance. With S2 at the 10-volt position, apply a 10-volt peak-to-peak 1-KHz square wave to the input. Adjust C1 for the best rise time on the scope, without overshoot (Fig. 2). With S2 in the 300-volt position, increase the scope sensitivity and the square-wave generator output. Adjust C2 for the best rise time without overshoot. Repeat the two adjustments (at 10- and 300-volt positions of S2) until there is no interaction. The meter is now calibrated on all ranges and for all frequencies. Meter operation is still satisfactory when the battery voltage drops to 8 or even less. Severe overloads such as 120 vac on the 3-mv range will not cause damage or affect calibration.

SPECIFICATIONS

Ranges: 11 root-decade (10-db) steps, 3 mv to 300 v full scale (−50 to +50 db; 0 db = 1 mw in 600 ohms)

Input impedance: greater than 4 megohms on all ranges, shunted by approx 5-pf capacitance

Frequency response: 10 Hz to 100 KHz, ±0.5 db

Battery drain: 0.7 ma (9 volts)

Stability: 20% change in battery voltage changes reading less than 2%. Multiple feedback paths stabilize gain (accuracy) and dc bias levels against variations in temperature and battery voltage.

Overload protection: meter will withstand 120 vac on 3-mv range without damage or loss of accuracy

Size: approx 4 x 5 x 6 in., depending on case used

Weight: approx. 12 oz.

Other features: convenient built-in battery test via front-panel switch; lack of connection to ac line reduces ground-loop hum problems and increases versatility

Construction cost: approx. $40

END

WHAT'S IN THE NEW IHF AMPLIFIER STANDARD?

A stiffer definition of music power, new tests for stereo amplifiers, and tighter requirements for instruments are the main features of the 1966 standard

By DANIEL R. von RECKLINGHAUSEN

This article was written especially for RADIO-ELECTRONICS *by the chairman of the IHF Standards Committee, who is also chief research engineer of H. H. Scott, Inc. The committee, composed of engineers from the major high-fidelity component manufacturers, met at approximately monthly intervals from March through September, 1965.* RADIO-ELECTRONICS' *associate editor was present at all the meetings.*

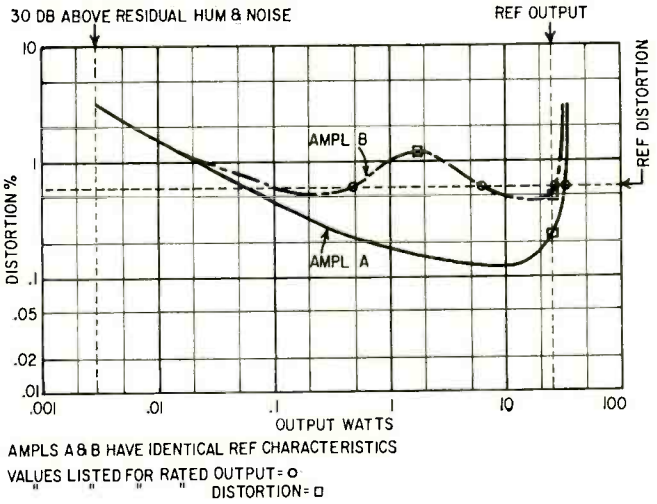


Fig. 2—Output and distortion curves for two (imaginary) amplifiers. "Reference" is used throughout new standard to mean maker's specification. Here, manufacturer has given dashed-line values of 0.6% distortion and 25 watts output. "Rated" output is figure determined in test.

THE NEW IHF AMPLIFIER STANDARD corrects a number of deficiencies that cropped up when the old standard was used to measure present-day amplifiers. The old standard was written when single-channel amplifiers were popular. The new standard also covers multi-channel amplifiers—which includes all stereo amplifiers.

The new standard is the first to describe any measurements for stereo amplifiers. It also defines the measurement of more kinds of amplifier characteristics than ever before. It even alerts engineers to interaction between characteristics.

The revised standard contains approximately 10,000 words, and several diagrams of test circuits. When applied to the measurement of a relatively simple power amplifier, a total of 31 graphs of performance (such as frequency response) can be made, and 25 meter readings are recorded. The old standard would have resulted in one graph and 9 meter readings.

With all these data, almost everything is defined, but you can spend a considerable amount of time in making the tests. Therefore, most of them are optional. The most important factors obtained in the tests are used to rate an amplifier.

As Table I shows, nine meter readings are required to give the minimum required specifications and ratings for a simple (mono) power amplifier, and an additional eight readings (Table II) would give the complete specification. A description of a stereo amplifier would require the same data for each channel, and some additional figures to show the interaction between channels.

The new standard contains several figures, such as Fig. 1, of a typical test circuit. The heavy lines beween the amplifier and the test equipment would normally be ground connections when a normal hi-fi amplifier is tested, since one side of the inputs and outputs is grounded here. In each circuit block is a number which calls out the section of the standard that describes the performance requirements of the test equipment.

A typical result of the test is a curve of *distortion* against *power output* (see Fig. 2). This curve is then used to determine the power and distortion ratings of the amplifier, using the manufacturer's *reference* data. *Reference* is used to mean the figure (such as percent distortion) at which the manufacturer wishes to have his equipment tested and rated. If amplifier "A" is tested, then the *distortion* at the *power output* claimed by the manufacturer, and the *power output* at the *distortion* claimed by the manufacturer, are shown as amplifier ratings. For amplifier B, additional figures have to be given to show where the amplifier did not meet its specifications. Now, an amplifier that was vaguely accused of having crossover distortion is clearly "shown up" in the test results.

The new standard defines two different output-power ratings of an amplifier. *Continuous power* is the power an amplifier is capable of delivering for at least 30 seconds with a sine-wave signal. Audio engineers have recognized for many years that an amplifier can deliver higher power for a shorter time. In

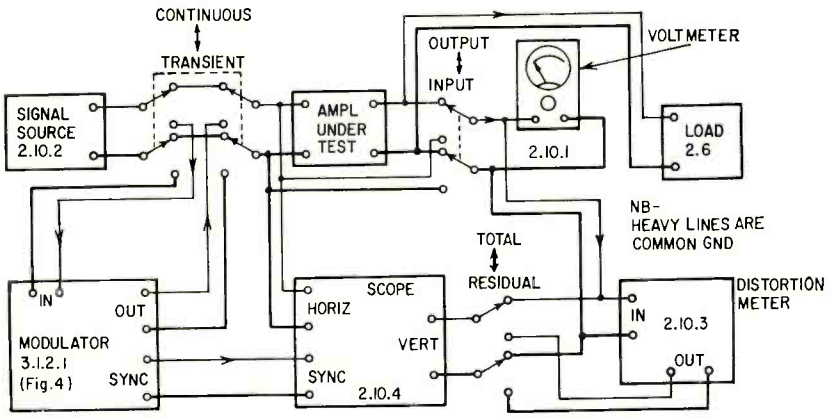


Fig. 1—Typical circuit for carrying out tests described in new standard. Numbers in boxes refer to sections of standard.

I. Minimum Specs for an IHF-Rated Amplifier

Unit of measurement	Single-channel amplifier	Two-channel stereo amplifier
Watts; percent	Dynamic output; distortion	Same, per channel, both channels operating
Watts; percent	Continuous output; distortion	Same, per channel, both channels operating
Hz (cycles per second)	Power bandwidth	Same, per channel
Millivolts	Sensitivity for: highest-gain input lowest-gain input	Same, per channel
Decibels	Signal-to-noise ratio for: highest-gain input lowest-gain input	Same, per channel

II. Complete Specs for an Amplifier

Unit of measurement	Single-channel amplifier	Two-channel stereo amplifier
Decibels, Hz (cycles per second)	Frequency response for: highest gain input lowest gain input	Same, per channel
Millivolts Volts	Maximum input for: highest gain input lowest gain input	Same, per channel
A statement	Stability	Same, per channel
Kilo-ohms, picofarads Kilo-ohms, picofarads	Input impedance for: highest-gain input lowest-gain input	Same, per channel
Pure number	Damping factor	Same, per channel
Watts; percent	——	Dynamic and continuous output and distortion per channel, single channel operating
Decibels	——	Difference of frequency response betw. channels
Decibels	——	Tracking error for ganged controls
Decibels	——	Separation between channels

the old IHF standard, it was assumed that the supply voltages of an amplifier would not change when music, speech or other program material was the input signal. The measurement of music power with respect to distortion was made by holding all supply voltages of the amplifier constant by some external means, such as auxiliary power supplies. This was described in detail in another article.*

* "How to Make Music-Power Measurements", by D. R. von Recklinghausen, *Electronics World*, Vol. 65, No. 6, June 1961.

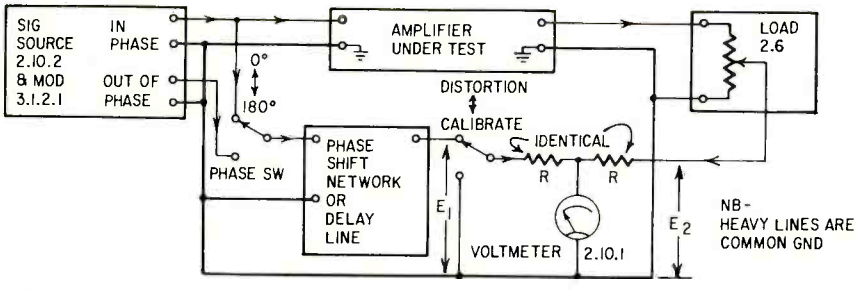


Fig. 3—Frequency-insensitive bridge for distortion measurements. Adjust phase switch and phase-shift network, and voltage tapped off load, for lowest voltmeter reading. Then E1 = —E2 and residual reading is combined noise and distortion. Distortion percentage is ratio of voltmeter reading with switch in DISTORTION *position to reading with switch in* CALIBRATE *position.*

The new standard retains this measurement and adds a second measurement, the "transient distortion" test, to account for supply voltage changes and other transients that affect the power output as the input signal is turned on. For this purpose, a modulator (as shown in Fig. 1 or 3) shapes the input signal to simulate the attack time of musical instruments and speech (typically 10 to 20 milliseconds). A circuit of a low-distortion modulator is shown in Fig. 4.

If a dc signal is applied to the input of this modulator, the output waveform of Fig. 5 results when the switch is set to START. The modulator specifications require a rise time of 10 to 20 msec. The output and distortion measurements are then made from 10 to 20 msec after the output signal has reached 90% of its final amplitude. Fig. 5 shows that the signal then is very close to its final value (100%).

With an audio signal applied to the input of the modulator, the output will be the waveform of Fig. 6, shown here for a 500-Hz input signal. To check the behavior of an amplifier with an input signal of this nature, the output waveform of a null type distortion meter is displayed on an oscilloscope and the horizontal sweep of the scope is triggered by the turn-on voltage of the modulator. This oscilloscope can be calibrated with measured sine-wave voltages, and therefore the peak-to-peak readings on the oscilloscope screen are output voltage and distortion.

A waveform like Fig. 7 might result from testing an actual amplifier. This particular amplifier can deliver output signals for a short time with less distortion than under continuous-signal conditions, but a low-frequency transient is also created (the wavy base line). Here, not only the harmonic-distortion components produced by the amplifier, but also any low-frequency transient, power supply ripple or modulation distortion is recorded as distortion, since all of them are undesired outputs.

The measured distortion percentage in this test is 100 times the ratio of the oscilloscope peak-to-peak readings in the "distortion" and "calibrate" positions of the distortion-meter switch, all measured in the same measuring interval as shown in Fig. 6 and 7. A distortion meter or a frequency-insensitive bridge can be used for these transient distortion measurements. This is shown in Fig. 3.

To arrive at the *dynamic power* ratings of the amplifier, curves have to be drawn of power output against distortion for the constant-supply *and* the transient-distortion methods. *The curve that results in the higher distortion or lower output of the amplifier determines the rating of the amplifier.*

The power test of a stereo amplifier is made with a single channel operat-

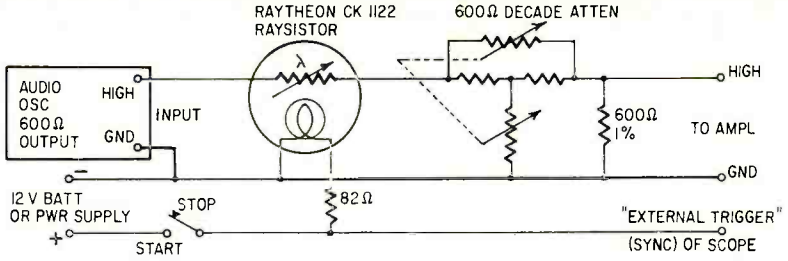


Fig. 4—Simple modulator for dynamic power measurements. Raytheon CK1122 Raysistor is listed in 1966 Newark Electronics catalog for $4.

ing for the single-channel ratings. The new minimum IHF specifications for such an amplifier also require tests with the input fed to both channels. Measurements for power and distortion, etc., are made on the output of each channel, and the ratings are made on a per-channel basis. This is done, not only for the "continuous" power output, but also for "dynamic" power. Again, any transients generated by the operation of one channel that appear in the output of the *other* channel are measured as distortion.

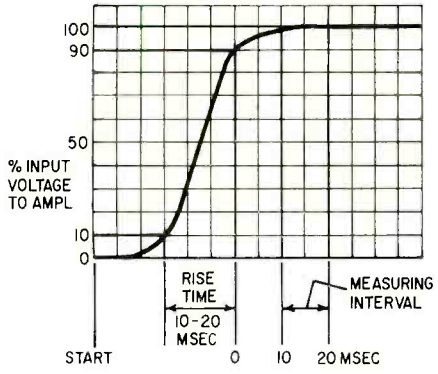


Fig. 5—Specifications for signal envelope in dynamic power test.

Since there was no previous test standard for stereo amplifiers, the IHF Amplifier Standards Committee had to develop them. A number of tests other than power should be made to find out how well a stereo amplifier behaves. For example, it is worth knowing how much interference there is between the two channels. The degree of channel isolation in tuners is known as "separation". The same term is now applied to amplifiers. *Separation is measured by feeding an audio signal to the input of one channel, measuring the ratio of the output voltages of the amplifier sections,* and expressing that ratio in decibels.

Since separation usually varies with frequency, the full test requires the tester to draw a curve of separation with frequency. The rated separation is measured at 1,000 Hz (cycles). The measurement is then repeated with the amplifier channel connections interchanged to obtain the reverse separation.

A lack of separation in an amplifier may not affect its sound qualities

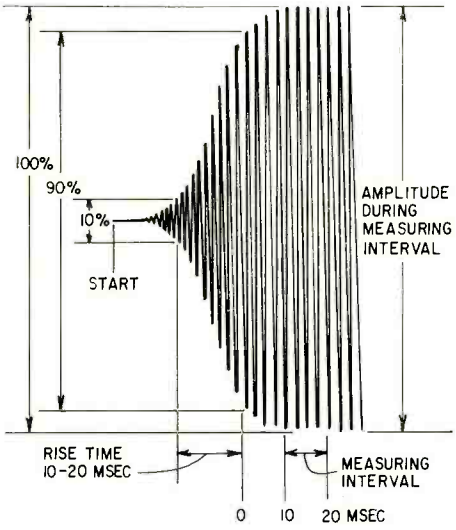


Fig. 6—Signal envelope shown with 500-cycle test signal.

seriously because all that happens is that the stereo image is shifted. This can be intentional, as in the case of "blend" controls which were popular some time ago. These controls just decreased the separation between the two channels. But it is annoying to have *distortion* components in one channel of the amplifier when the other channel delivers a signal. This interference is measured in the *crosstalk* test. Here, *the ratio of the desired output signal of one channel to the hum, noise and distortion products of the other channel* is measured and expressed in decibels. Again, the curve of crosstalk with respect to frequency is drawn, and the 1,000-Hz figure is used for rating the amplifier.

Another item of interest in a stereo amplifier is the match between the two channels, as shown by the test for difference in frequency response. Here, inputs of the amplifier receive identical input signals; the ratio of the two output voltages is expressed in decibels and is shown as a curve with respect to frequency. The rating is then stated as a plus-and-minus decibel error over the frequency range.

How well are the two channels matched as the various controls are operated? This test is made in the same manner. For example, for a volume or loudness control, a measurement is made at 1,000 Hz with the input to both channels of the amplifier adjusted for identical output signals with the control set at maximum. As this control is then turned to reduce the gain, the ratio of the two output voltages is measured at various spots on the control.

Since the construction of some potentiometers results in mechanical backlash between the two sections, this test is made twice: once with the control operated clockwise, and once counterclockwise. For the readings, the manufacturer specifies an acceptable *tracking error*, such as 2 db. The maximum error occurs at some point of reduced gain. This test will show how many db of attenuation can be obtained with this control before the tracking error of 2 db is reached. Such a figure might be 50 db.

The IHF Standard of Measurement for Amplifiers contains all these tests and many others, such as stability, damping, input impedance. You can get a copy by writing the Institute of High Fidelity, 516 Fifth Ave., New York, N. Y. 10036. The cost is $2 with an additional small charge for mailing. END

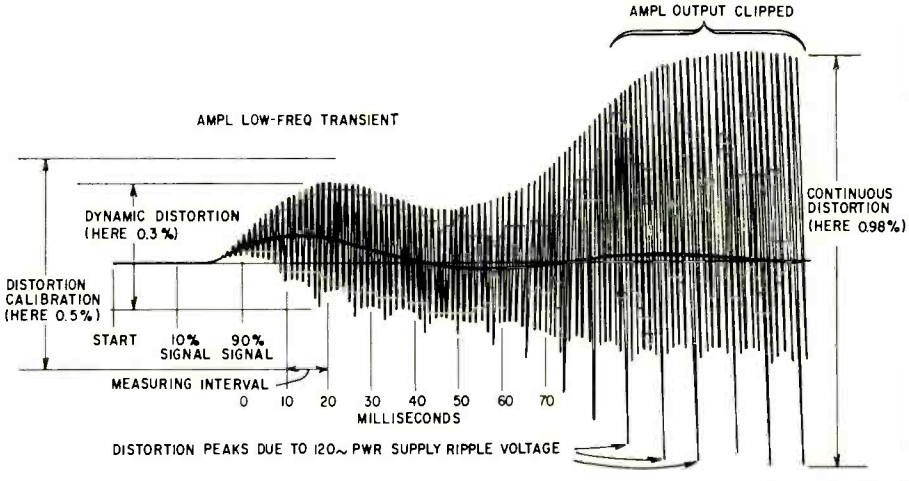


Fig. 7—Distortion-meter output plotted against time as input signal of type shown in Fig. 6 is applied. "Caterpillar" indicates distortion, which rises from nearly zero at left to a maximum value as amplifier begins to clip.

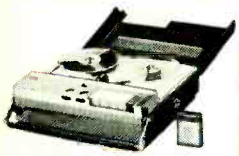
Spring Roundup of Battery Recorders

Here's a comparison chart of battery-powered, capstan-driven portable tape recorders. Not every make under the sun has been included, but most of the more widely available ones are here. Prices range from less than $30 to more than $400.

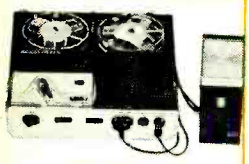
What should you look for? The best machines will have ac bias and ac erase, and their specifications will be more complete than those of more modest recorders. A wide range of accessories suggests a versatile recorder, but not necessarily a top-fidelity one. Note whether a particular recorder has an ac power supply (built in or external) or whether you must buy one as an accessory. That will make for a more meaningful comparison of prices.

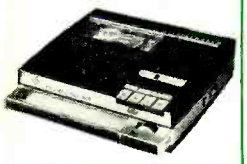
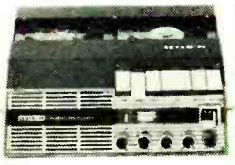
All these recorders are (or soon will be) available at audio stores, department stores or electronics mail-order houses. Why not consider one for your coming vacation?

NS = not specified. Notes are at the bottom of page 45.

Make, Model, Price	Speeds; (Flutter, wow %)-	Max. Reel Size	Tracks; Mono or Stereo	Freq. Resp.	AC Operation	Bias Type	Erase Type	Level Ind.	Batteries	Size & Weight (in.; lb.)	Features; Included Accessories *Optional Accessories in italics*
APOLEX RC-600  **(Price NS)**	1⅞ 3¾ (flutter & wow NS)	4	2M	NS	yes[1]	dc	pm	m[2]	4 "C"	9¼ x 9⅛ x 2½ 6.6	Dynamic mike with remote control switch Earphone Pushbutton control
CHANNEL MASTER  **6464—$119.95**	3¾ 1⅞ (flutter & wow NS)	5	2M	100–4,000 @ 1⅞ 100–7,000 @ 3¾	yes[3]	NS	dc	m[2]	6 "D" One 9-v	11¼ x 10 x 3½ 8½	Remote-control mike jack Foot-switch jack Pushbutton control *Dyn mike with remote control* *Carrying case* *Monitor earphone*
CHANNEL MASTER  **6545—$109.95**	1⅞ 3¾ (flutter & wow NS)	3¼	2M	NS	yes[4]	ac	dc	m[2]	6 "C"	8 x 10 x 2¾ 5¾[5]	Magnetic earphone Vinyl carry case Phone pickup Dyn mike with remote control *Ac adapter* *Foot switch* *Tie-clip mike*
CHANNEL MASTER  **6549—$79.95**	1⅞ 3¾ (flutter & wow NS)	3¼	2M	NS	yes[4]	ac	dc	m	6 "D" One 9-v	10½ x 8½ x 3 5	Dyn mike with pause control 3¼-in. reel tape Splicing tape Mag earphone Patch cord *Ac adapter* *Foot switch* *Tie-clip mike*
CONCORD 320  **$129.95**	1⅞ 3¾ (flutter & wow NS)	5	2M	50–10,000	yes[3]	NS	NS	m[2]	6 "D"	12 x 8¾ x 3¾ 6	Auto reverse Stop-start mike Leather pouch Earphone Sensing tape *Foot switch* *Phone pickup* *Voice-operated mike*
CONCORD 350  **$199.95**	1⅞ 3¾ (flutter & wow NS)	5	2M	50–10,000	yes[1]	ac	NS	m[2]	6 "D"	11½ x 11 x 4 10	Voice-operation built in Same features & accessories as model 320' above
CONCORD F-85  **$49.95**	1⅞ (flutter & wow NS)	2⅜	2M	NS	yes[1]	ac	NS	m[2]	4 "C"	7 x 5 x 3 2	Dyn mike and pouch Reel of tape *Earphone, patch cord, ac adapter, phone pickup*

Make, Model, Price	Speeds; (Flutter, wow %)-	Max. Reel Size	Tracks; Mono or Stereo	Freq. Resp.	AC Operation	Bias Type	Erase Type	Level Ind.	Batteries	Size & Weight (in.; lb.)	Features; Included Accessories *Optional Accessories in italics*
CONCORD F-88  **$79.95**	1⅞ (flutter & wow NS)	2⅜	2M	NS	yes[4]	ac	NS	m[2]	4 "C"	7 x 5 x 3 2	Voice-operated microphone control Patch cord Earphone Carrying pouch 3 reels tape *Ac adapter* *Phone pickup*
CRAIG PANORAMA  **VISTA 212 $39.95**	1⅞ 3¾ (0.3%)	3¼	2M	150–3,500 @ 1⅞ 150–7,000 @ 3¾	yes[4]	ac	dc	none[6]	6 "C"	7⅞ x 9¾ x 3⅛ 4½	Automatic recording-level control Microphone Earphone *Ac adapter* *Phone pickup* *Foot switch* *Tie-clip mike*
CRAIG PANORAMA  **TR-520 $59.95**	1⅞ 3¾ (0.4%)	5	2M	200–7,000 @ 3¾	yes[4]	dc	dc	m[2]	4 "D"	11½ x 9½ x 4½ 10	Remote-control mike Earphone Reel of tape *Ac adapter, foot switch* *Phone pickup* *Tie-clip mike*
GELOSO (Stenotape)  **TR-T11—$199.95**	1⅞ 3¾ (0.5%)	3¼	2M	100–6,000 @ 3¾	yes[4]	NS	NS	m[2]	6 "AA"	2 x 6 x 7 4	*Partial list of optional accessories:* *Desk-pen mike* *Lapel mike, mono & stereo stethoscope* *Headsets, telephone* *Pickup, ac adapter;* *Leather carry case*
GELOSO (Stenotape)  **G-540—$149.95**	1⅞ (0.5%)	3¼	2M	80–10,000	yes[3]	NS	ac	m[2]	see note 7	10 x 8 x 4½ 6	1-watt audio output Remote-control mike Self-loading reel tape *Lavalier mike* *Foot control* *Crystal earphone* *Phone pickup* *Mike mixer*
MARTEL 201  **Less than $100**	1⅞ 3¾ (flutter & wow NS)	5	2M	NS	NS	NS	NS	m[2]	NS	size NS; wt. 7	Universal pickup device for recording from radio, telephone, by vibration
MAYFAIR 157-A $32.97	3¾ 7½ (flutter & wow NS)	5	2M	NS	no	NS	NS	none	NS	8	Earphone Pushbutton controls
MAYFAIR 305 $29.27											Same as 157-A but with vinyl carry case; 7 lb
MAYFAIR 600 $35	3¾ 7½	5	2M	NS	yes[4]	NS	NS	m	NS	NS	*Ac adapter*
MAYFAIR 1024-B $55.12	3¾ 1⅞ (flutter & wow NS)	NS	2M	NS	yes[5]	NS	NS	yes	NS	NS	Can be used as PA system Remote-control mike Phone pickup
MAYFAIR JV-1 $32.97	3¾ 7½	5	2M	NS	yes[4]	NS	NS	no	NS	NS	*Ac adapter*
MIRANDETTE C  **$169.95**	1⅞ 3¾ (0.3%)	3	2M	200–6,000 ±5 db overall	yes[3]	ac	NS	m[2]	4 "D"	9⅝ x 8¼ x 3¼ 7¼	Projector sync disc Remote-control mike Reel of tape Strap with shoulder grip Digital tape counter *Leather case* *Phone pickup* *Foot switch*

Make, Model, Price	Speeds; (Flutter, wow %)	Max. Reel Size	Tracks; Mono or Stereo	Freq. Resp.	AC Operation	Bias Type	Erase Type	Level Ind.	Batteries	Size & Weight (in.; lb.)	Features; Included Accessories *Optional Accessories in italics*
NORELCO 101  **Less than $100**	1⅞ (flutter & wow NS)	NS	2M	80–8,000	yes[4]	NS	NS	m[2]	NS	11 x 3¾ x 8 7	*Leather or leatherette case* *Remote switch for mike* *Ac adapter* *Headset* *Phone pickup*
NORELCO 150  **Less than $99**	1⅞ (0.35%)	see note 9	2M	120–6,000 ±3 db	yes[4]	NS	NS	m[2]	5 "C"	7¾ x 4½ x 2¼ 3	Remote-control mike Vinyl carrying case *Ac adapter* *Headset* *Foot switch* *Close-talking mike* *Phone pickup* *Extra cartridges* *"Car mount" and 1,000-kHz osc for auto radio use*
Panasonic RQ-102  **$59.95**	1⅞ 3¾ (flutter & wow NS)	3	2M	100–4,000 @ 1⅞ 100–7,000 @ 3¾	yes[3]	ac 35kHz	NS	m[2]	6 "C"	9⅝ x 3 x 8½ 4½[5]	Remote-control mike Reel of tape Patch cord *Voice-control mike*
Panasonic RQ-105  **$49.95**	1⅞ 3¾ (flutter & wow NS)	3	2M	100–4,000 @ 1⅞ 100–7,000 @ 3¾	yes[4]	ac 35kHz	NS	m[2]	4 "C"	10¼ x 2½ x 7¾ 4½	Remote-control mike Reel of tape *Voice-control mike*
Panasonic RQ-116  **$129.95**	1⅞ 3¾ (flutter & wow NS)	3	4M	100–4,000 @ 1⅞ 100–7,000 @ 3¾	yes[4]	ac	NS	m[2]	12 "AA"	7¾ x 7¼ x 2½ 4⅛	Voice-control mike Monitoring via internal speaker *Foot switch* *"Home adapter"—ac power supply plus 4-in. spkr* *Ac adapter* *Phone pickup*
Panasonic RQ-152  **$99.95**	1⅞ 3¾ (flutter & wow NS)	5	2M	100–4,000 @ 1⅞ 100–7,000 @ 3¾	yes[3]	ac 35kHz	NS	m[2]	6 "D"	11⅜ x 3⅓ x 10¼ 7½	Remote-control mike Reel of tape Patch cord Earphone Monitoring via internal spkr. *Voice-control mike*
PHONO-TRIX 88-B  **$149.95**	1⅞ (below 1%)	2½	2M	100–6,000	yes[4]	ac	dc	no	3 "C" 3 "AA"	1⅞ x 4¼ x 7½ 2¾	One-piece cast zinc-alloy body *Leather carrying case* *Auxiliary high-volume amp/spkr (for PA)* *Lapel, fountain-pen, throat & tie-clip mikes* *Phone pickup* *Ac adapter*
ROBERTS 1510 $79.95	1⅞ 3¾ (flutter & wow NS)	3¼	2M	NS	NS	ac	NS	m[2]	NS	NS	This model currently being redesigned; new design expected Spring 1966. Specs here not final
ROBERTS 6000S  **$359.95**	15/16 1⅞ 3¾ 7½ (flutter & wow 0.18% @ 7½)	5	see note 10	40–20,000 @ 7½ 30–5,000 @ 15/16 note 11	yes[12]	ac 65kHz	ac	yes[13]	rechg. 6-v	4 x 9⅜ x 10 11⅛[5]	Three separate heads "Cross-field" head design 4-watt mono, 8-watt stereo output Digital tape counter *Extra spkr. for stereo* *Carrying case*

Make, Model, Price	Speeds; (Flutter, wow %)	Max. Reel Size	Tracks; Mono or Stereo	Freq. Resp.	AC Operation	Bias Type	Erase Type	Level Ind.	Batteries	Size & Weight (in.; lb.)	Features; Included Accessories *Optional Accessories in italics*
SONY 800  **Less than $199.50**	1⅞ 3¾ 7½ (flutter & wow 0.25%, 0.2%, 0.15%)	5	2M	50–6,000 @ 1⅞ 50–9,000 @ 3¾ 50–12,000 @ 7½	yes[3]	ac	NS	m[2]	8 "D"	12¼ x 10½ x 4¼ 13	Automatic record volume control Remote-control mike Digital tape counter *Variable-speed & pause control for transcribing dictation*
SONY 900  **$67.50**	1⅞ 3¾ (flutter & wow 0.35%, 0.25%)	3¼	2M	90–5,000 @ 1⅞ 90–9,500 @ 3¾	yes[3]	NS	NS	none[6]	4 "D"	8¾ x 8¾ x 3¾ 5½	Automatic record volume control Remote-control mike *Voice-control mike*
TANDBERG 11  **Price NS[15]**	1⅝ 1⅞ 3¾ 7½ (flutter & wow 0.4, 0.3, 0.2, 0.1%)	7	2M[11]	30–16,000 @ 7½ 40–3,000 @ 1⅝	yes[4]	ac	ac	m[2]	10 "D"	13 x 10 x 4 7½	Remote-start/stop from mike (mike not included) "Joystick" tape motion control *Tape-reversing pilot-tone module*
TELEFUNKEN  **MAGNETOPHON 300, $149.95;**	3¾ (0.3%)	5	see note 16	40–14,000	yes[4]	NS	NS	m	5 "D"	10¾ x 3 x 10⅞ 6¾	2-watt audio output *Storage battery & charger* *Ac adapter* *Windproof outdoor mike* *Monitor phones* *Carrying case or strap*
UHER 4000-L  **$440**	1⅝ 1⅞ 3¾ 7½ (flutter & wow 0.15% @ 7½)	5	2M	50–22,000 @ 7½ 70–5,000 @ 1⅝	yes[4]	ac	ac	m[2]		10½ x 8½ x 3¼ 7[5]	Digital tape counter All-metal case Rechargeable battery Leather carrying case Ac supply *Hand- & foot-operated remote controls* *Slide-projector sync* *Voice-control* *Transistor mixer*
V-M 760  **$129.95**	1⅞ 3¾ (flutter & wow NS)	3¼	2M	200–6,000 @ 3¾	yes[17]	ac	ac	m[2]	rechg.	10⅝ x 6 x 2¾ 5	Die-cast aluminum case Remote-control mike Ac cord Reel of tape *Foot switch* *Auto battery cord* *Phone pickup*
WESTINGHOUSE  **32R1—$60**	1⅞ 3¾	3⅜	2M	NS	yes[4]	NS	NS	m	4 "D"	3 x 10⅝ x 9½ 6	Reel of tape

RECORDER ROUNDUP NOTES

1. Has jack for ac adapter (not supplied)
2. Level meter doubles as battery indicator
3. Ac-line power supply built in
4. With optional ac power pack
5. Less batteries
6. Automatic level control
7. 8 "C" cells or 12-volt storage battery
8. Built-in ac-line supply rejuvenates batteries
9. Uses special 2-oz., 4 x 2½ x ½-in. cartridge of ⅛-in. wide tape, 300 ft. long; cartridge snaps in and out
10. Model 6000S, 4-track stereo; 6000M, 4-track mono; 6000F, single-track (full-track) mono
11. ±2 db and ±4 db respectively. Other speeds: 3¾, 40–12,000 ±2 db; 1⅞, 30–10,000 ±3 db
12. Model 6000S with ac adapter; 6000M optional accessory adapter
13. 2 meters; on playback, left meter indicates battery condition
14. Full-track heads optional
15. Expected to become available in Spring 1966
16. Magnetophon 300, 2-track mono; 301, 4-track mono
17. Built-in ac supply recharges batteries

Add Sound to Your Home Movies

Simple sync box needs no connections to tape recorder! Use on any projector with "universal" motor

By ROBERT R. SHEPARD

HERE IS A DEVICE WHICH WILL SYNCHRONIZE A HOME movie projector to a tape-recorded sound track with split-second timing. It's simple, uses few parts and requires absolutely no modifications or connections to the recorder. You can even make the sound in stereo if you like. Accuracy is good enough to let you dub in speech to synchronize with lip movements on the screen if you're careful.

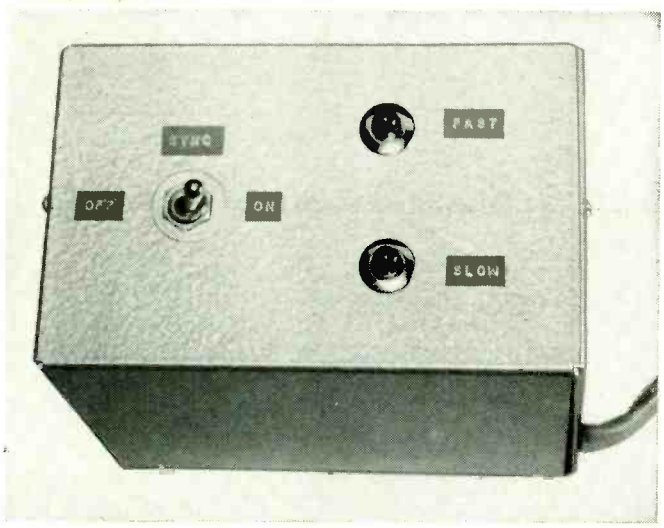
There is one special requirement: your tape recorder *must* have a synchronous drive motor. Most better-quality machines have one because it provides a perfectly constant tape speed. If you are in doubt about yours, check the operating manual or catalog listings, or write the manufacturer.

The idea behind the synchronizer is simple. Since the tape speed is constant, then if you also hold the film speed constant, the two will always remain in synchronization. But most home movie projectors have brush type motors which are notorious for inconsistent speed. You could replace the projector's motor with a synchronous unit, but that isn't very practical. Instead, the synchronizer accomplishes the same result by sensing the projector's speed, comparing it to a constant reference speed and automatically correcting any difference.

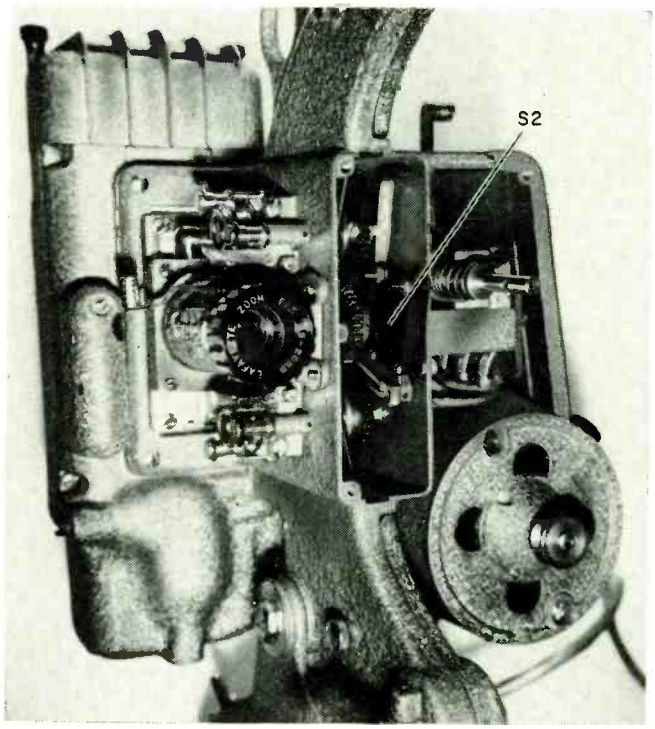
How it works

The diagram shows the synchronizer's circuit and how it is connected to a typical projector. The dark lines indicate wiring added to the projector.

Relay RY switches resistor R2 in and out of the projector's speed-control circuit at about a 1-second rate. Under normal operating conditions the projector runs slightly below the desired speed when R2 is not connected. When R2 is switched in, it shunts the speed control, lowers its effective resistance and causes the projector to run slightly fast. Therefore the projector continuously hunts above and below the desired speed. The time spent at each speed is controlled so that the average speed is perfectly constant.



Single, neat 4 x 5 x 6-inch aluminum box contains entire synchronizer. Connecting cable should have grommet.



How author added microswitch to his projector. Screw through gear acts as cam to actuate switch lever.

Snap switches S2 and S3 do the controlling. The projector closes S2 once during each revolution of the sprocket. Likewise, synchronous motor M switches S3 at the desired constant reference speed. When S2 closes it activates relay RY which disconnects R2 and slows the projector. The relay locks on through contact 2. A few tenths of a second later, motor M opens S3, which releases the relay and speeds up the projector. This cycle is repeated continuously; the relative timing between the switchings of S2 and S3 determines the times spent at each speed.

When the average projector speed is correct, the fast and slow times are equal. If for some reason the average speed is too fast, S2 closes sooner than normal and starts the slow part of the cycle earlier. This lengthens the slow portion and correspondingly shortens the fast portion of the cycle. The average speed is therefore soon reduced to the correct value. Just the opposite takes place if the projector is running too slow.

The two neon pilot lights were added, one indicating fast speed and the other slow, to help in adjusting the speed control. D, R1 and C1 power the relay (a plate circuit type) with dc. R3 limits the relay coil current to a convenient

value. Capacitor C2 suppresses line spikes, especially from the projector motor, which can cause trouble.

While almost any type relay will work, I used a hermetically sealed, mercury-wetted contact type for reliability and quiet operation. It is available as surplus for $5.95 from Burstein-Applebee Co. If you use a different relay, you may have to change the value of R3 for proper operation.

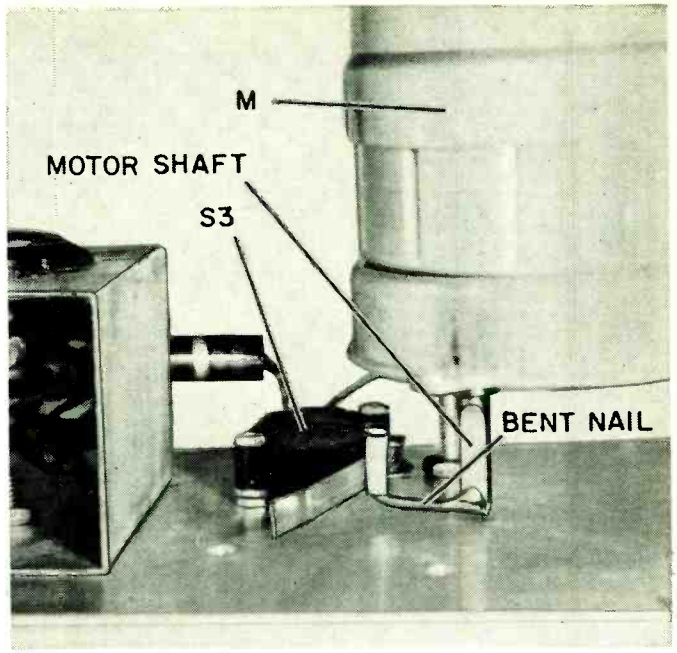
Motor M is a Hurst type CA unit available from Allied Radio Corp. It is single-speed and comes with capacitor C3. *If you substitute, make certain the motor you use is synchronous.* Otherwise the accuracy of the synchronizer will suffer greatly.

Modifying the projector

The first step is installing snap switch S2. Take the projector apart enough to expose the drive gears. On mine, a vintage 1946 model, I had to remove only one cover plate. Next, locate some rotating part which can be modified to activate the switch once each revolution. Turn on the projector, adjust it to normal speed and count the number of revolutions the part makes in 1 minute. The counting will be easier if you put a mark on the part so each revolution will be more distinct. Select a speed for motor M as close to this number as possible. The Hurst motors come with standard speeds of 40, 48, 50, 60, 64, 80, 100, 120, 150 and 160 rpm. The speed of mine was 80 rpm.

Don't exceed 160 rpm, because operation above this value becomes rather critical. However, slower speeds will work, so check the Allied catalog if necessary. Make sure that the projector will run properly with the part rotating at the selected speed and that the speed control has at least 10% range above and below the selected speed. If not, try a different speed.

I mounted the switch to the inside of the projector case with 4-40 screws. To activate the switch I drilled a small hole in the side of one of the drive gears and secured a 4-40 x ½-inch screw in it. As the gear turns, the screw moves the leaf of the switch enough to insure good switching. Slip a piece of plastic sleeving over the screw to reduce wear. Since each projector is different you may have to do a little figuring to find the best way of installing the switch in yours. Make sure the switch won't be damaged when the projector is run in reverse.

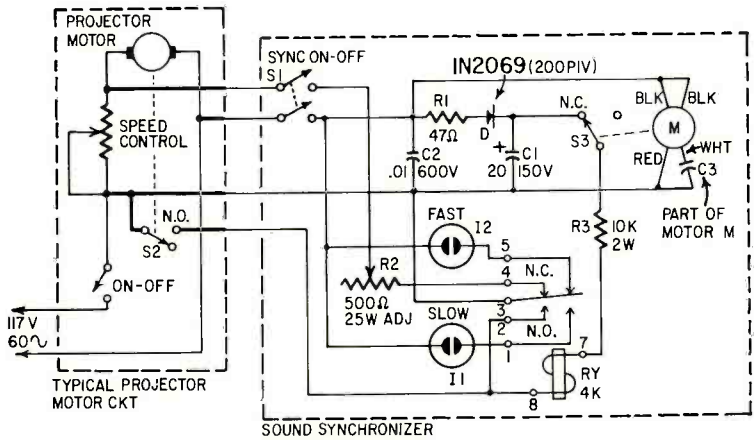


Bent nail soldered to synchronous motor shaft actuates microswitch S3 once per revolution.

Add the remaining wiring to the projector as shown by the dark lines in the diagram and bring it out through a four-conductor cable to the synchronizer unit. Install a connector in the cable so that the two may be disconnected when the projector alone is being used. The female end should be on the projector side to avoid shock hazard.

Construction details

The synchronizer unit was built into a 4 x 5 x 6-inch aluminum Minibox. Mount motor M so that it activates S3 once during each revolution. First put a right-angle bend in a small finishing nail and solder it near the end of the motor

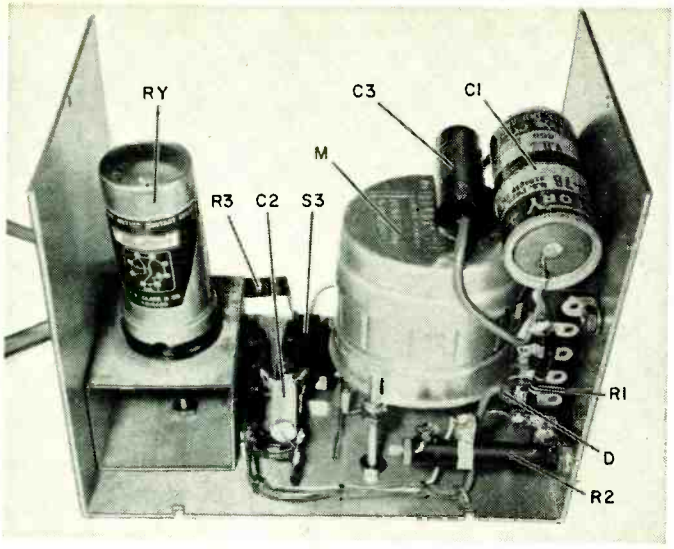


Schematic of Synchronizer and its connections to projector. Neon lamps I1 and I2 should include dropping resistors for 117-volt ac operation; if you use "bare" lamps such as NE-2 or NE-51, use 220,000-ohm resistors in series.

PARTS LIST

C1—20-μf, 150-volt electrolytic
C2—.01-μf, 600-volt paper
C3—Supplied with M
D—200-piv diode (1N2069 or equivalent)
R1—47 ohms, ½ watt
R2—500 ohms, 25 watts, wirewound, with adjustable slider
R3—10,000 ohms, 2 watts
RY—dpdt relay, Clare HG 1077 (Burstein-Applebee part No. 18C912**, Universal Relay Corp. cat. No. R3184*** or equivalent—see text)
S1—dpst switch
S2, S3—spdt snap-action switches (Acro model 2CMD1-2AXX-A24* or equivalent)
I1, I2—117-volt neon pilots with built-in resistors (Drake HR117 or equivalent)
M—Synchronous motor, Hurst CA series. See text for speed selection*
Cabinet—4 x 5 x 6-inch aluminum two-piece box
3-ft length four-conductor cable, connectors, miscellaneous hardware

*Available from Allied Radio Corp., 100 N. Western Ave., Chicago, Ill. 60680
**Available from Burstein-Applebee Co., 1012-14 McGee St., Kansas City, Mo. 64106.
***Universal Relay Corp., 42 White St., New York, N. Y. 10013



Where the parts go in the box.

shaft so that it describes a circle of about 1¼-inch diameter as the shaft turns (see photo). Mount the motor on 6-32 x 1½-inch screws so that its shaft just clears the bottom of the Minibox. Then mount the snap switch with 4-40 x ⅝-inch screws with two nuts between it and the bottom as spacers. Position S3 carefully so that the nail moves its leaf far enough to give reliable switching as the motor turns.

The relay plugs into a standard 8-pin octal socket. I mounted the socket in the side of a small metal box open on each end and secured the box to the inside of the Minibox. Mount switch S1 and the two neon indicators in the lid of the Minibox and connect them to the main circuit with leads long enough to allow removal of the lid. I salvaged a short piece of six-conductor cable from the junkbox to make the connection. Keep resistor R2 away from any heat-sensitive components because it gets rather warm. The construction details are not critical.

Adjustment

After construction adjust the slider on R2 to the middle of its range and set the projector speed control to minimum speed. Turn on the projector and synchronizer and watch the neon lights. If they blink on and off alternately, so far so good, even if there is no set pattern. You should also notice the projector speed up whenever the FAST light blinks on.

Next adjust the projector speed control so that the FAST and SLOW lights are on for about equal times. This is the key adjustment. The synchronizer should have a tendency to lock in as you approach the proper setting. When locked in, the lights blink back and forth in a regular pattern although one may be on longer than the other. This is the main reason for the lights.

If the FAST light is on more, the projector speed control should be set for a higher speed. If the SLOW light is on more, try a lower speed setting. However, the unit should remain locked in over about 20% of the range of the speed control. This is controlled by adjusting R2 so that there is about 20% difference between the fast and slow speeds when the unit is locked in.

If your unit won't lock in, take the projector apart to expose the snap switch you've installed. Compare its switching rate with that of S3 in the synchronizer unit. If you cannot make them equal within the range of the speed control, you've selected the wrong speed for motor M. You can reduce the lowest speed on the projector somewhat by adding a power resistor in series with the speed control, but be careful you don't slow the motor down so much that it doesn't cool the lamp properly. If this won't do it, you'll have to change synchronous motors.

Using the synchronizer

Adding sound to a film with the synchronizer is easy and fun. First start the projector and tape together and record the sound track to match the action on the screen. Then whenever you want to show the film with sound merely start both together again at exactly the same spot as before and they will remain in perfect synchronization.

To insure proper starting positions I splice leaders on both the film and tape. I then place the start of the film at the bottom of the film gate and the start of the tape at the playback head before each showing. Any other scheme that accomplishes the same purpose should work as well. Just remember that the synchronizer *must* always be used when you record or play any sound track. Check the adjustment of the projector speed control occasionally by seeing that the FAST and SLOW lights are on for about equal times.

If you have trouble getting the sound just the way you want it while watching the film, try recording only a verbal description of the action. You can then go through without the projector and make the actual sound track bit by bit to match the description. If you have a stereo recorder, you won't even have to erase the description as you go. Merely record the sound track on the other channel.

While you can add sound to almost any length movie, it's best to splice your short films into one longer one which tells some sort of story. A few titles at the beginning will help greatly, especially if accompanied by some well-chosen music. Don't spare the scissors when it comes to poor or uninteresting footage. Sound will enhance a good movie far more than it will a bad one.

I've made two 40-minute sound tracks so far as well as several shorter ones. By carefully choosing the music to fit the action of the film, I find that dialogue is mostly unnecessary. While my favorite sources of music are movie soundtrack albums, I've also used mood music and Broadway show recordings and even dipped into the classics on occasion. The only real requirement is that the result be interesting and entertaining. END

TINY FLOOD MAKES NOISE ARC

A high-band police repeater system, in the 150-mc region, was constructed so that the incoming signal was brought into the receiver through an antenna diplexer, broken down to audio, fed into a transmitter and back out through the other side of the diplexer to the same antenna for rebroadcast. The transmitter was keyed by a relay in the receiver squelch circuit.

The system worked fine for a few days, but began to act up in the repeater mode one night after a snowstorm.

On a strong signal, it would sound good for a split second, then fade down into the noise, and the transmitter would key off. Then the signal would return to normal, and the whole process repeated itself in a slow but regular oscillation of the transmitter keying circuit.

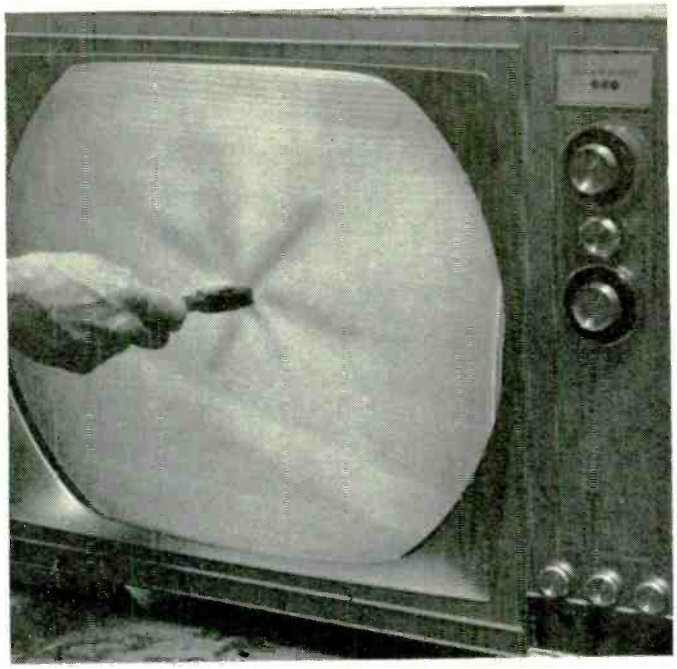
Like the desk sergeant said: "Wha hoppen?"

Moisture had got into the coax fitting at the bottom of the antenna. When the transmitter was on, an arc began at the wet spot, increasing in intensity with time. Although the energy from the transmitter was about 3 mc higher than the receiver frequency, the rf noise generated by the arc covered a frequency range more than sufficient to put a strong noise signal into the receiver.

Since the squelch circuit in most FM receivers operates on the noise the receiver picks up when there is no signal, this artificially generated noise closed the squelch, turned off the transmitter, doused the arc, let the signal through again to open the squelch and turn the transmitter back on, in a self-sustaining oscillation of sorts.

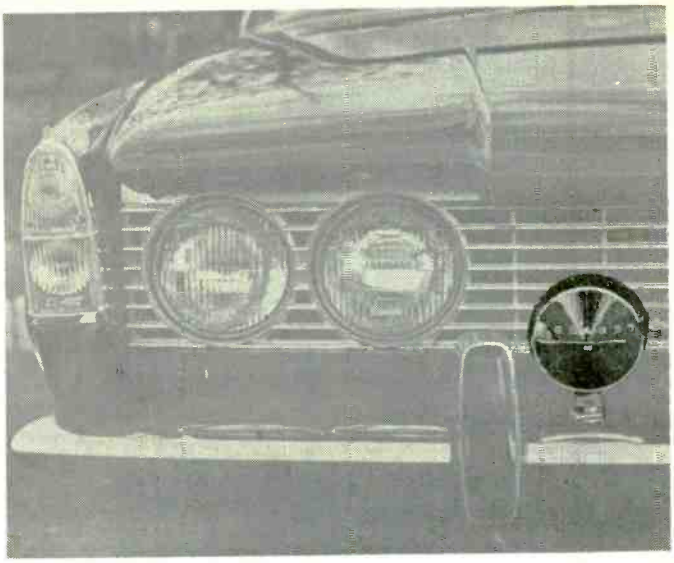
The moral of this little story is—keep your power dry, men!—*Eugene Austin*

WHAT'S NEW

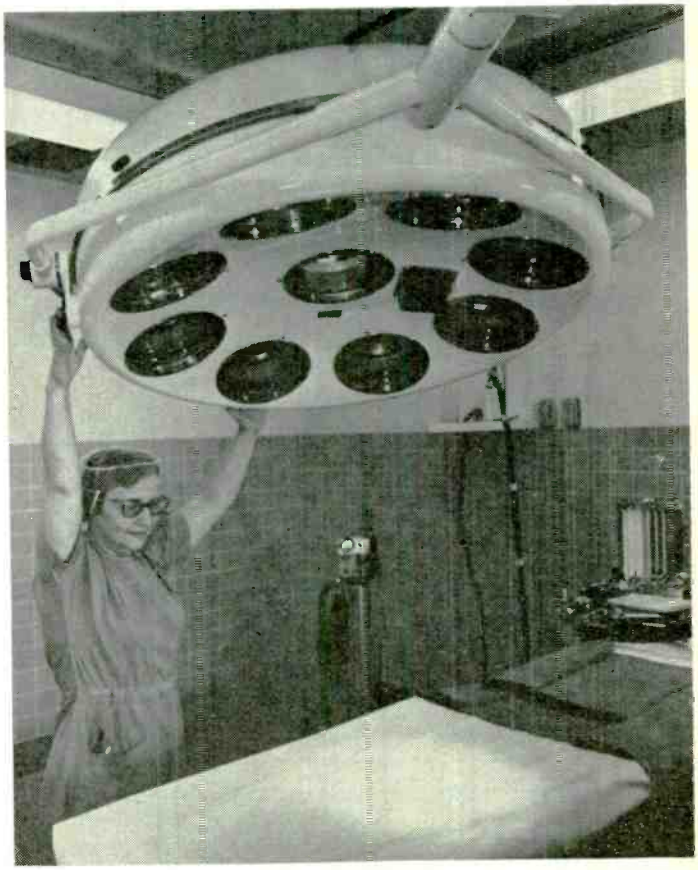


MAGIC-WAND DEGAUSSER is pocket-size tool for set owner or servicer. To use, magnet wheel is spun and brought near color TV screen areas where there are permanent patches of color. After moving it rapidly back and forth, withdraw it while wheel is still spinning. Pulsating magnetic field generated by spinning alternating poles degausses picture tube. Device (patent pending) was developed by Zenith.

LIBRARY KEEPS ITS BOOKS, thanks to new Packard-Bell closed-circuit-TV installation. Five automatic all-transistor cameras with wide-angle lenses scan reading rooms, audio-visual racks and hallways in the Beverly Hills, Calif., public library. Five 17-inch monitors near librarians' desks allow them to watch almost every part of the building. Library officials say system has cut horseplay in study areas, and reduced thievery and damage of phonograph records.



DRIVER, IT'S COLD OUTSIDE, warns new Icelert, standard equipment on all British Rover 2000 cars sold in North America. Using a transistor in a chromed housing on the front bumper as the sensor, the Icelert begins flashing an amber light on the dashboard at 36°F. The flash rate increases as the outside temperature falls toward freezing, until at 32°F the light glows steadily. System is sold separately for about $30 and can fit other cars, 6 or 12 volts, negative or positive ground.



KEEPING AN EYE ON THE OPERATION is the job of a closed-circuit television camera installed in this bank of surgical lights at Hollywood (Calif.) Hospital. High-resolution, 800-line Sylvania camera lets medical staff and nurses follow surgery at remote locations outside the operating room. Surgeon can converse with observers via intercom. If he moves the light, operator at remote point adjusts camera appropriately.

VICTOR BROCINER
ASSISTANT TO
THE PRESIDENT
H. H. SCOTT, INC.,
MAYNARD, MASS.

High-quality amplifiers keep getting better and better. No one seriously questions that lower distortion and lower noise are real improvements. But there is an honest difference of opinion about one kind of "improvement": should amplifier frequency response be extended indefinitely in both directions beyond the commonly assumed limits of human hearing, or should it be rolled off just outside those limits?

Here, two men responsible for setting the courses of engineering development for their inter-

THE WIDER THE BAND,

No:

By VICTOR BROCINER

TO OBTAIN HIGH-FIDELITY REPRODUCTION, IT IS NECESSARY to reproduce the audible range of frequencies but it is neither necessary nor desirable to design an amplifier to cover a much wider band.

It is generally accepted that the design of a component of a system is determined by the over-all performance required of the entire system; but there seems to be a tendency to make an exception in hi-fi. Isolating one aspect of a problem this way is likely to lead to erroneous conclusions. It has done so for the advocates of a frequency range well below and far above the limits of human hearing.

Let us avoid this pitfall by considering the elements of the hi-fi system: from program source to reproducing system, to room acoustics, to the ear. The widest frequency range claimed for recorded material is about 16 to 25,000 Hz. Broadcasts are more restricted in range. This, then, is the widest range of frequencies that can conceivably be fed to the reproducing system in the form of program material. For the moment, the rash assumption will be made that the amplifier and speaker can handle this range of frequencies. The acoustics of the room will certainly introduce variations in frequency response, but will not be a primary limiting factor as far as range is concerned.

The last link—the range of human hearing—*is* a limiting factor. 16 Hz is just about the lower limit of hearing sensitivity. The high-frequency limit is around 20,000 Hz, for young people, and considerably lower in older persons. Hence, a reproducing system covering 16 to 20,000 Hz will satisfy the requirements of the program material for frequency range as limited by hearing sensitivity alone. It does not necessarily imply that the quality of reproduction will be perfect. *Phase shift* must also be considered, since music consists of complex waveforms, not pure sine waves.

A repetitive complex waveform can be shown to consist of a fundamental sine wave whose frequency is equal to the repetition rate, and harmonics (overtones) of frequencies that are integral multiples of the fundamental frequency. If one or more of the harmonics is shifted in phase, the resultant complex waveform is altered in shape. The information presented to the ear is now different than before. But can the ear detect the difference? Current theory is that the ear acts like a continuously scanning wave analyzer and responds to the amplitude of the harmonics regardless of their phase relations. In other words, we tend to hear harmonic structure rather than waveform.

There are exceptions. For example, a large number of tones can be combined in such a way that they sound like a rushing noise. Reversing the phase of a few of the components changes the sound to a rapidly repeated click (in a dead room). Similarly, reversing the phase of one of the speakers in a two-way system using a direct-radiator woofer and a horn tweeter affects the quality of signals having a short "attack" time, like the sound of tap dancing. In both cases the phase shift is abrupt, large (180°), and in the middle of the frequency range. Phase shifts in well-designed amplifiers are gradual, occur at the ends of the frequency range, and are quite small within the range of rated frequency response. Such phase shifts do not produce a degradation of the audible signal. Thus, although the ear is sensitive to certain kinds of phase shift, these are not to be found in present-day amplifiers. This answers the argument that a very wide band is required in order to eliminate phase shift *within* the audible range.

Transient response is a characteristic that is almost invariably invoked to support the need for ultra-wide frequency range. A transient can be thought of in terms of the repetitive complex waveform referred to earlier. If the transient is not repeated, the equivalent frequency group becomes a continuous spectrum of frequencies. The equivalence works in both directions; a group or spectrum of sine waves in fixed phase relations can be resolved into a transient.

To analyze the behavior of an amplifier to which a transient is applied, we can mathematically resolve the signal into a group or spectrum of frequencies, determine what the amplifier does to the amplitude and phase of each element of this composite signal, then re-transform the output into its transient form and see what has happened to its shape. This implies that *the frequency response and phase characteristic of an amplifier determines its response to transients.* It means that if we prove something in terms of bandwidth and phase, we do not have to deal with it all over again as a transient. (We have assumed that the amplifier is linear.)

It has been claimed that human hearing, or, at any rate, sensitivity, actually extends to higher frequencies than was previously believed; also that extremely low frequencies make a contribution to realism, presumably through the sense of feeling. These factors are claimed to support the need for ultra-wide band reproduction. The trouble with this reasoning is that most of the sub- and ultrasonic frequencies never reach the *input* of the amplifier, and those that do never come out of the loudspeaker. The lowest frequency anyone claims to have recorded is 16 Hz. Radio transmitters do not go below 50 Hz; their upper limit is 15 kHz. The best tape recorders are good to 20 kHz; this is at least as good as the best phonograph pickups, even though some recordings are claimed to go higher. Conclusion: The maximum range of frequencies in the input is 16–20,000 Hz. Of this, the lowest

continued on page 94

nationally respected companies present their cases. At left, Victor Brociner of H. H. Scott, Inc., says that unlimited bandwidth is "neither necessary nor desirable." Below, Robert E. Furst of Harman-Kardon, Inc., says "this viewpoint is now open to serious question."

We invite you to hear both sides and come to your own conclusions. Your comments are welcome, and Radio-Electronics will print some of the better letters we get.

ROBERT E. FURST
VICE PRESIDENT,
ENGINEERING
HARMAN-KARDON, INC.
PLAINVIEW, N. Y.

THE HIGHER THE FI?

Yes:

By ROBERT E. FURST

THE GENERAL CRITERIA FOR AUDIO AMPLIFIER DESIGN HAVE changed little over the past 50 years. The theories of human hearing experimentally established in early years with the most rudimentary test equipment are still adhered to strenuously today. As a result, the good textbook says that human hearing is limited from 20 to 20,000 Hz and is unable to detect phase shifts in the harmonic structures of musical tones.

This viewpoint is now open to serious question. The human hearing that can detect the subtlest inflection in a number of different languages has also learned to perceive in intricate detail the multiplicity of sounds produced by the modern symphony orchestra. The ear's capabilities are far too complex to be described by a simple set of rules. Little work has been done to gain a more thorough understanding of them.

Even if the ear cannot hear below 20 Hz, it is not the only organ of the body that responds to sound phenomena. The human skin functions as a diaphragm and responds to subsonic tones. We know that the perception of sound pressure is indispensable to the enjoyment of good music. The fundamentals of tympani, a contrabassoon or a 32-foot organ pedal note are *felt* rather than heard. Many good recordings contain these fundamentals and a good music system should have wide bandwidth to reproduce them.

A similar case may be made for the ability of the brain to perceive sound phenomena above 20,000 Hz. The mathematical analysis of the attack and decay time of a simple 1-kHz tone burst indicates an energy distribution over an extremely wide frequency spectrum (essentially from zero to infinity). Approximately 25% of the energy falls outside the audible range. Clearly this is not heard as a group of discrete pitches, yet the use of wide-band amplification equipment lends a sensation of ambience to this type of tone burst that is not present in a frequency-limited amplifier.

There is a third reason why the modern high-fidelity amplifier must have wide bandwidth. It is impossible to limit the high- or low-frequency response without at the same time introducing phase distortion in the entire remaining audible spectrum. We have learned by many years of listening to good music that the ear is acutely responsive to phase distortion in reproduced music. For instance, when a recorded duet of an oboe and a clarinet was reproduced on a phase-linear system, the two instruments were clearly separated and recognizable. Seemingly, the ear has learned to associate with each instrument those harmonics that pertain to that instrument.

When 15° phase distortion at 10,000 Hz was introduced into the system, the two instruments started to blend. Although the music was clearly audible, the individual characteristics became blurred and indistinguishable.

Freedom from phase distortion is also important in the bass region. Good phase linearity will improve the definition of bass instruments. The differences between a cello and a bass viol become dramatically apparent, for example.

Stereo has become important in modern high fidelity. It takes two ears to hear stereo. The phase displacement of the music impinging upon the (separated) ears creates a sense of sound direction in the brain. Unless phase linearity, or, at the very least, precisely equal phase distortion, is observed in the reproducing chain, stereo perception will suffer severely.

It must also be said that phase distortion is a cumulative phenomenon. Phase distortion in the amplifier will add cumulatively to the phase distortion in either the loudspeaker or program source. Therefore, introducing a link with good phase linearity into the chain will bring about a corresponding improvement in the final result. I am sure that the day will come when the entire chain will be phase-linear. When this occurs, we shall have made a great stride toward the faithful reproduction of the original music.

Opponents of the wide-band approach point out that high-fidelity equipment produces disturbances of its own that fall outside the classic 20–20,000-Hz spectrum. These disturbances include turntable rumble, tone-arm resonances, stylus resonances, ultrasonic noise, and multiplex carriers in FM stereo. They claim that it is important to limit the spectrum to avoid the effects these disturbances have on tone quality. We have found by experience that this point of view is fallacious.

Let us agree that high-quality turntables and tone arms must be used for the reproduction of high-fidelity music, with minimum turntable rumble and a damped tone-arm resonance. Let us also agree that amplifiers capable of reproducing 20 Hz at full power are not capable of eliminating all signals from 19 Hz on down. Narrow-band amplifier responses below 20 Hz are usually attenuated at the rate of no more than 12 db per octave. A 50-watt amplifier capable of producing 20 Hz at full power would still be able to reproduce approximately 5 watts at 10 Hz. Unwanted noise in that region is still being amplified. However, it falls into a nonlinear region and will readily intermodulate with the remaining music, causing audible distortion.

Conversely, a wide-band amplifier, used with a high-quality record-playing system, amplifies the rumble and the tone arm resonance with minimal distortion. No intermodulation with the program source results. Since the rumble content is relatively low, it will neither be audible nor will it

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In TV Service, Patience is a Virtue!

But it certainly isn't the way to make money

By FRANK SALERNO

I'VE KNOWN BENNY B. A LONG TIME. In fact, he gave me one of my very first TV assignments back in 1950, when I was still going to service school. TV receiver kit-building was the big thing then, and I had just finished putting together a 12-inch Transvision kit for myself when Ben asked if I would do one up for him. I picked a 30-tube Techmaster kit that was designed exactly along the lines of the already famous RCA 630TS chassis. Ben built the cabinet, I built the set and we were on our way.

Things went along pretty normally. Except for a service call here and there, the set worked fine for the next six years. About that time, Ben moved to a new home and decided he would like a larger-screen TV set. He wanted to finish his basement with knotty-pine paneling, and wondered if we could enlarge his TV picture area and maybe build the set into a wall.

"Good idea," I told him, and immediately got busy rewiring the set to accommodate a 20CP4. When everything was done, Ben's basement was the envy of the neighborhood. Everyone was deliriously happy.

Then came the black year, 1963. Ben's wife called to say that the TV set wasn't working too well and asked me to take a look at it. I ran over to the house and turned the set on, but it didn't look bad at all. I sat for a while, drinking in some daytime TV fare, and finally left with that great parting line we love to use—"If it acts up again, let me know."

She let me know. The following week I was back, still finding nothing wrong. Ben's wife tried to describe the trouble she was having with the set but, as usual, none of it sounded like anything I ever hope to see. I bundled up the chassis and yoke assembly and took them away with me.

In the shop, I hooked everything up to the shop tube. I covered the chassis with an old sheet and watched it cook. During four days of testing I found several minor faults, but none that even approached the descriptions Ben's wife had offered me. I put in a new 6BG6-G to correct slight horizontal shrinkage, a new 6J5 to eliminate a vertical jitter, a 6K6-GT for improved contrast, a 6J6 to reduce tuner drift, and replaced several darkened resistors that were pretty close to value but looked a little the worse for wear.

All this was necessary, but it left me unsatisfied. According to Ben and his missus, once that set started to act up, it really went haywire. I saw no such thing. At any rate, I delivered and installed the chassis and again used that great parting line.

I would have been surprised if Ben hadn't called me that same night. He didn't surprise me—he called.

"Same trouble, Frank."

"Oh, no!"

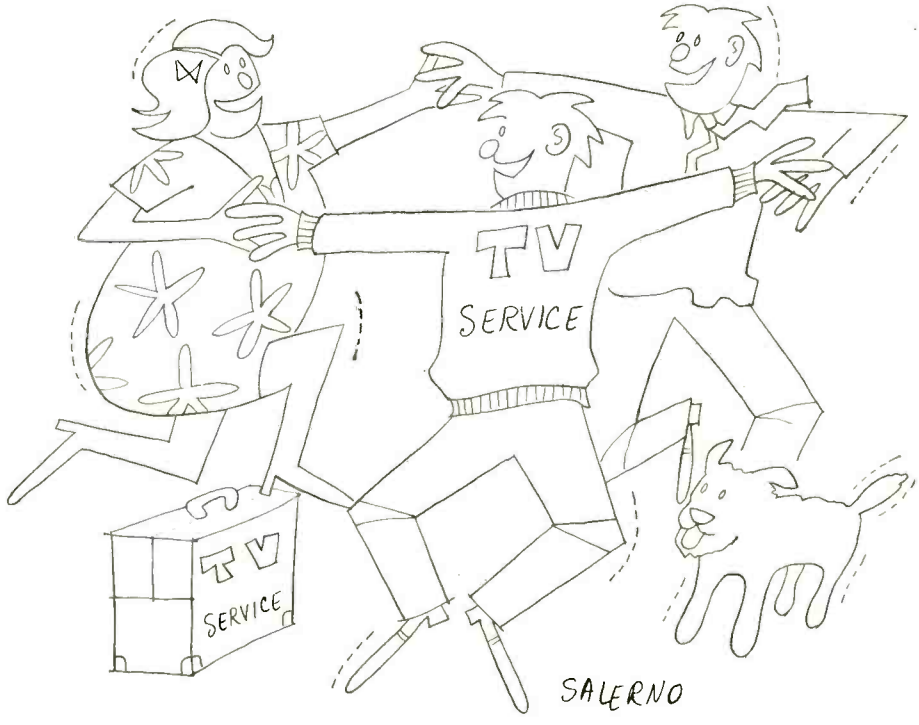
"Yep!"

"Okay, Ben, what can I say? I'll drop by tomorrow."

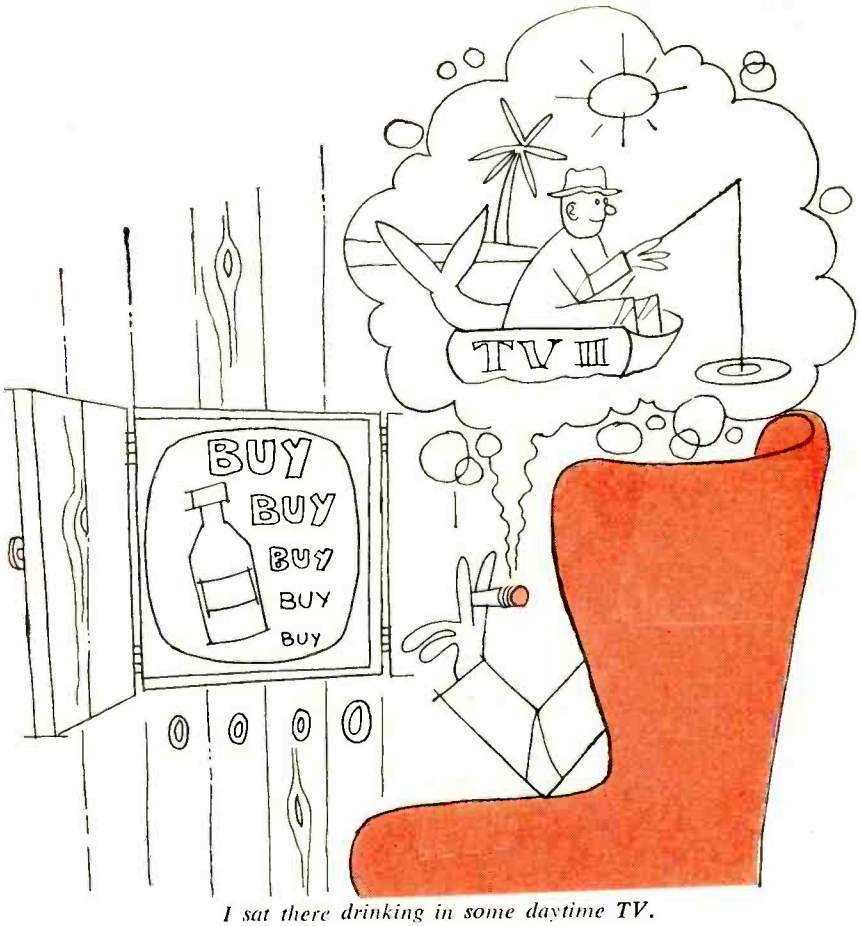
The next day I was at Ben's house bright and early. I had arranged with them that the set should be turned on a couple of hours before I got there, so it would be well heated up. Same old story! I squirmed through a half-hour of morning TV. The picture was beautiful. I exited once more with that gracious, reliable line.

For 4 whole weeks, I didn't hear a word from Ben. "Could it be?" I wondered. "It must be. The set has probably settled down. Oh, happy day."

I finally mustered up the courage to give Ben a call that seemed to prove the old service axiom—"Old troubles don't fade away—they just get worse." Ben complained that the set was now completely undependable. As soon as it



When everything was done . . . . everyone was deliriously happy.



I sat there drinking in some daytime TV.

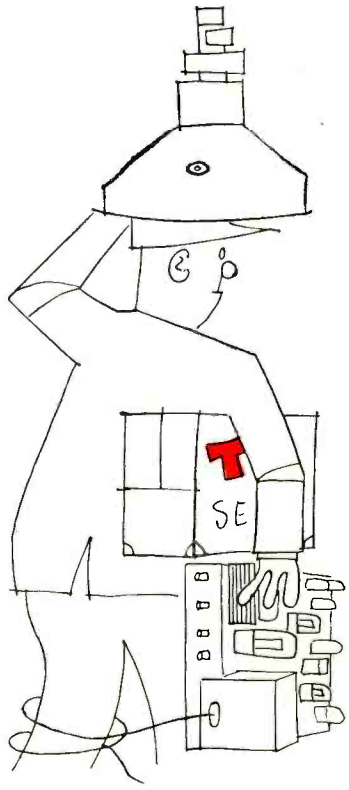
warmed up a half hour or so, he said, you couldn't bear to watch it.

The next morning I showed up again, about an hour after the set was turned on. As I walked into the room I was stunned. There it was—the picture was completely uncontrollable. It was sliding and rolling, and the hold controls were no help. Without turning the set off, I changed all the sync tubes and even went through the video and i.f. strips. There was no helping this baby, so for the second time I bustled it all off to the shop. This time I threw in the picture tube just for luck.

I reassembled the whole business on the bench and again started the process of watchful waiting. It seems we spend a third of our lives, watching and waiting. But they say all things come to him who waits, so . . . we stick it out. I waited three days before that picture would go out of sync again, and then I was almost sorry it did.

I checked through from the sync takeoff point to the sync output, and I couldn't find a single resistor or capacitor that wasn't 100% on the button. To make matters more difficult, the trouble was not consistent. On one channel, the picture would bob and weave and on another it would be steady. Even on the programs that were poor, the sync loss seemed to depend on the picture content. One camera shot would run away and the next camera shot might lock in. Perplexing, to be sure.

Nevertheless, through all my testing and checking, one clue started to stand out. It seemed that, whenever the sync did become unreliable, I needed only to advance the brightness control to maximum, and the sync would take hold. Even my scope helped to prove this. Clipped onto the sync output, the scope pattern became highly contaminated with video information when the picture lost stability. But, as the brightness was turned up, the sync output took on a crisp, clean look. This was the point at which the picture took hold.



This time I dragged everything away.

It didn't take long to pin down the culprit after that. I clipped onto the sync output and waited until I got the dirtiest pattern I could possibly find, and then quickly pulled off the picture-tube socket. The sync pulses stood up as clean as a whistle. When the socket was reconnected, the pulses became dwarfed and dirty.

I pursued this further with the voltmeter, and found the picture-tube grid was conducting slightly. By changing the brightness control level of the tube I was varying the amount of grid conduction. The sync takeoff, effectively in the grid circuit of the picture tube, was being distorted by the grid emission!

And thus was virtuous, uncomplaining patience once again rewarded! END

NEED TELEPHONE DIALS FOR BUSY-BOX?

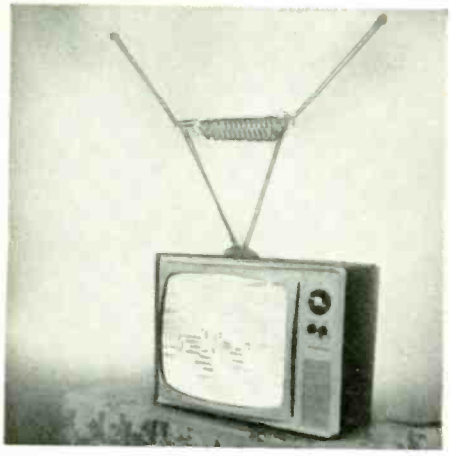
Some readers have complained that they are not able to obtain the telephone dial needed to complete the "Busy-Box" (December, page 44). Just before we went to press each of the firms mentioned in the parts list confirmed that they had a good supply of dial assemblies. We fell into the trap that always exists when specifying surplus equipment or components. That is, a surplus dealer may have hundreds of an item on hand one day and then sell his entire stock to another dealer or manufacturer the next day.

If you need a telephone dial to complete the project, you can order them for $3.95 each by writing to Mr. W. L. Jennings, Telephone Equipment Co., 144 Hickory Street, Montrose, Mich. or to Mr. John Boguski, Telephone Engineering Co., Lincoln Building, Simpson, Penna.

Mr. Bob Mullican, of Burstein-Applebee, says that the music box specified is still in stock. If your order was returned unfilled, it was an error. Place your order again and address it to his attention.—*Editor*

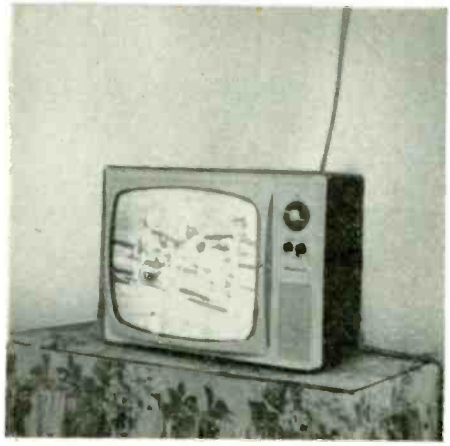
Radio-Electronics Is Your Magazine!

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



Poor antenna in poor location picks up signal and lots of interference.

Outdoor antenna is in the clear, picks up more signal than interference.



Same set, same place, but connected to outdoor antenna. Fine picture now.

HOW TO KILL INTERFERENCE

Once you've found the cause of interference on radio or TV, what do you do about it?

By THOMAS R. HASKETT

EARLIER, WE SPOKE OF TRACKING DOWN interference.* But what do you do when you find it? Or what if you can't track it down? Let's attack these problems in three steps—what the user can do to his receiver, what the technician can do to it, and what can be done to the interference source.

For the set owner

The first photo at the top of this page shows a TV with herringbone interference. It really doesn't matter what's causing the interference, except that it's *not* coming in on the power line—a battery-operated portable proved that. The key point is that the TV antenna is a pair of rabbit ears, inside the house, where the signal level is low. When the rooftop antenna of photo 2 is tried, the clean picture of photo 3 is the result. Put the antenna where it gets the most signal pickup, and you eliminate much interference. This applies to every type of receiver—AM, FM, TV, SW, etc. Simply putting the antenna on the roof may not do; you may have to stick a mast up there, or probe from one end of the house to the other until you find a good signal. But in many cases this will clean up the picture.

Another rule for the user: Keep lead-in away from ac lines, and from any wire or metallic object. Photo 4 (next page) shows the worst possible case—the twin-lead is parallel to and only a few inches from unshielded house wiring run through the rafters. The result is much ac hum and noise in the receiver.

For the technician

Where the antenna is in the clear and the lead-in well routed, yet interference persists, the technician can treat the receiver. Don't overlook the possibility of set-generated noise, such as Barkhausen oscillations—horizontal oscillator radiation picked up by the tuner. The first step in receiver interference is usually grounding—since by tying the receiver chassis to earth you bleed off much unwanted noise.

A short, direct, low-resistance connection to ground is what you want; the easiest way is to locate a cold-water pipe where it enters the building foundation, as shown in photo 5. Note that the ground wire and strap go to the *earth* side of the meter and valve. Don't connect it to the other side, for there's much resistance in pipe joints.

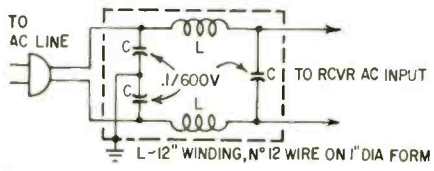


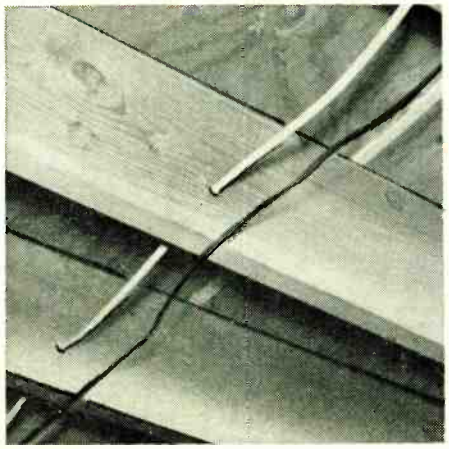
Fig. 1—If simpler remedies are to no avail, this low-pass filter for the power line will probably help. Note that "12-inch winding" means a winding 12 inches long, not a wire 12 inches long.

It's sometimes more desirable to sink a steel ground spike in the earth, away from electric and telephone grounds, but in most cases this won't be necessary. Try to avoid using the power company's ground, for this often causes more noise than it eliminates. Whatever the ground, try a piece of solid insulated wire—at least No. 10—bolted to the chassis and thence to ground.

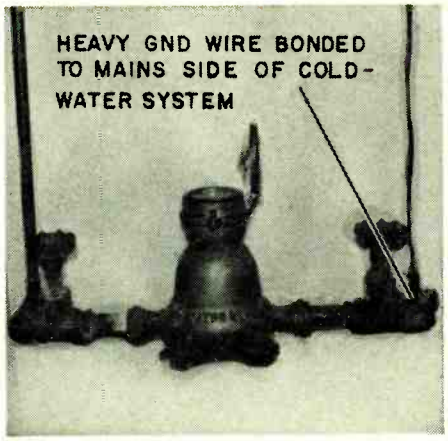
Caution: Don't try a direct ground on a transformerless set. Because one side of the ac line is connected to chassis, grounding must be through a capacitor, such as a .01-μf 600-volt paper. Even so, in some cases, a receiver will work better without the ground than with it, so try it both ways.

If your interference tracking has proved that the power line is bringing the noise into the receiver, a line filter is the specific remedy. Two commercial filters are Sprague's Filterol and C-D's Quietone. Each is available in several models, differing in the degree of attenuation and the current rating. If you like, you can build one, according to Fig. 1. Whether you buy or build, be sure the wire in the chokes can carry the current drawn by the receiver. In almost every case, the filter must be connected to earth to be effective, and you may want to try it at both the chassis end and the plug end of the line cord, to see which is most effective.

*"How to Track Interference", RADIO-ELECTRONICS, December 1965, p. 32



But if you run lead-in from outdoor antenna like this, watch out!



Receiver chassis, noise-producing sources, filters, need good ground.

If the noise leaks around the filter, you will have to use a shielded line cord, such as Belden 8422 or Alpha 1746. You can usually find room inside the chassis to mount the filter direct, but if it's to be installed at the wall receptacle, you'll have to mount it inside a box.

If the power line is clean and the interference is coming in through space, the antenna is picking it up along with the signal. Solution? A high-pass filter in FM or TV lead-in. Details are given in Fig. 2. Again, the circuit works best in an "earthed" metal box. Representative commercial models are the Regency HP-45 and the Drake TV-300-HP. For an AM receiver, use an antenna trap, shown in Fig. 3.

In rare cases, you may get direct rf pickup by circuit wiring within a receiver. One way of circumventing this is shown in Fig. 4—taking rf out of the audio. Note that the grid bypass must be small to avoid affecting audio frequencies. In even rarer cases, you may have to wrap foil shielding around a chassis, making sure it is well grounded.

Source remedies

It's surprising the number of interference sources you can find right at home. One prize-winner is the common **fluorescent light.** If you turn it off and the noise goes away, try grounding its metal frame. If that doesn't help, put a .01-μf, 600-volt capacitor across the line as it enters the fixture. If *this* doesn't work, use a line filter as described before. One more thing: Check the ballast. If it's a 15% low-power-factor type, replace it with a 90% high-power-factor type. The 15% type always gets noisy.

After fluorescents, **electric motors** seem to be the most prevalent noise sources. The usual remedy is simply to clean and readjust the brushes, and check for a missing ground. You can try the ubiquitous .01–600 across the line, but you'll get better results with a line filter. If there are shields, make certain they ground effectively and don't vibrate and make poor contact.

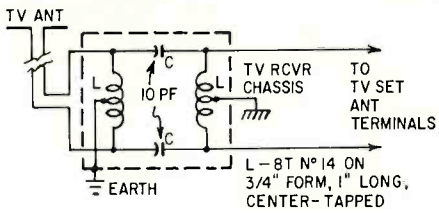


Fig. 2—High-pass filter for use between TV antenna and set will suppress interference below about 40 mc.

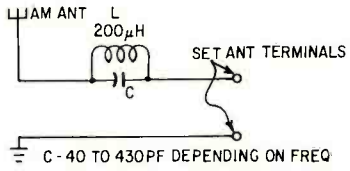


Fig. 3—Parallel-resonant trap in series with external antenna for AM or short waves block interfering signal. Capacitor C should be mica or ceramic, or a padder or trimmer of approximately the right capacitance, which can be adjusted to null the interfering signal.

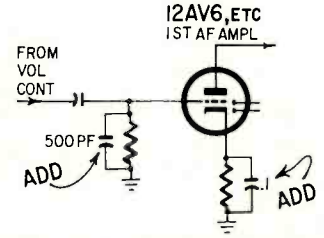


Fig. 4 — Bypass capacitors in first audio stage of many radios and amplifiers will cut interference picked up by chassis wiring. Not all such stages will have cathode resistor as shown here.

A lot of other appliances can cause you trouble: **air conditioners, oil burners, blinker lights, neon signs, thermostats, electric ranges, hair dryers, etc. In each case, follow the same steps: ground, filter, and shield.** Check existing grounds, shields, and possible internal filters and decoupling networks. Make sure there is good metal-to-metal contact wherever it's necessary, as in grounds and shields; intermittents here cause noise. If shielded ac line isn't already used (with a line filter), you might install one.

While we're on the subject of the ac line, why don't you unplug *all* appliances in the house, turn off *all* lights, then go around plugging in a *single* brand-new bulb (to draw current without causing noise). If you still get noise, it's possible you have loose or faulty fittings, joints, taps, splices, etc., in the power line itself. These should be tightened—and that goes for any loose conduit or electrical box fittings you find, too. You might even locate a forgotten appliance—like the old thermostat I found once that had nothing to control, but was still arcing away.

All these source remedies concern interference transmitted chiefly by the power line. Interference from transmitters, via free-space radiation, is a little harder to pin down. Sometimes it's hard to determine which transmitter and which frequency, but if you read the preceding article (December 1965, p. 32), you should have a good idea of how to get there.

Let's assume you have tried a high-pass filter at the antenna terminals, and it didn't help. Probably the interfering signal is being radiated at or near the frequency of the station you're trying to receive. Find the transmitter, talk to the operator, and the two of you can investigate the situation. If it's a diathermy machine, radiation or induction heater, arc welder, or similar noncommunication device, it is probably just a matter of improper grounding, filtering or shielding. Sometimes spurious harmonics are generated by cross-modulation in poor construction joints in buildings, such as metal downspouts. This usually happens only in a strong rf field—several thousand watts or so. The remedy is to bond the poor contact joint securely.

If a communications or broadcast transmitter, or even amateur or CB, is causing the interference, it *may* be their fault. In almost every case, if you approach the operator politely, he will cooperate in checking the rig out. Often they are not at fault, and if no amount of trapping will work, you can—as a last resort—shift the receiver i.f. slightly to miss the interference.

Occasionally another receiver will

cause interference. Remember that almost all present-day receivers are superhets, with local oscillators that radiate. Although such radiation in all new receivers is held to low limits by FCC edict, exceptional circumstances occur, and there are quite a few older receivers not covered by this rule.

Local-oscillator interference in AM is usually an unmodulated whine or beat note heard along with the desired signal. It cannot be tuned out but disappears when the other receiver is tuned to another station. In FM and TV the symptom is the same as an interfering harmonic—it blanks out the sound or causes herringbone in the picture. A special case is TV horizontal oscillator radiation into AM. It sounds like a buzzsaw and covers the whole band. (Matter of fact, it even gets up as far as the amateur 75-meter band!)

The general cure here is to reposition one or both receivers, and/or ground, filter, and shield. It is generally fruitless to try to deal with horizontal-oscillator radiation at the AM receiver; it's much better to install line and lead-in filters in the TV set, grounding them, if necessary. It has been necessary to shield the whole TV with a metal-foil lining for the cabinet, and ground the foil.

Hardly any interference problem is insoluble. The catch is that the tough ones take time—and money. If the customer wants to spend the cash, you can clean up everything. In most cases, however, money *is* an object, and you must be prepared to do battle with only a few weapons.

Look at it this way: The ideal receiver is a black box, sealed from annoying external influences. But wait—we have to let the *signal* in. OK, but *just* the signal: nothing else. Oh yes, we have to get some ac, don't we? Except for battery sets, that's right. But let's let in *only* 60-cycle sine wave. When you let in *only the signal and the ac*, keeping everything else out, you are rid of the interference. END

Cold-Start Circuits for Transistor Ignition Systems

By VERN E. BAKER

COLD STARTS WITH TRANSISTOR IGNITION systems should be faster than with stock flame throwers. Yet many tuneup men will tell you that some drivers have trouble when the temperature gets below 30.

Most cars now have a resistor in series with the coil primary in normal run position. This resistor is bypassed, when the key is on START, by a wire (z) from the ignition switch or the starter solenoid (Fig. 1).

Suppose the temperature is down to zero. When the starter is engaged, the battery voltage drops to about 9. But because the resistor is bypassed, the coil primary still passes enough current to fire the plugs.

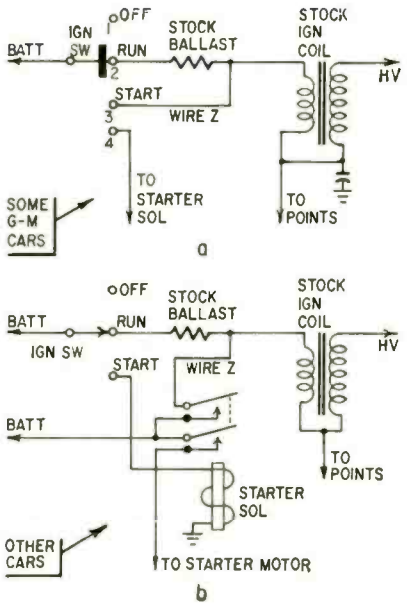


Fig. 1

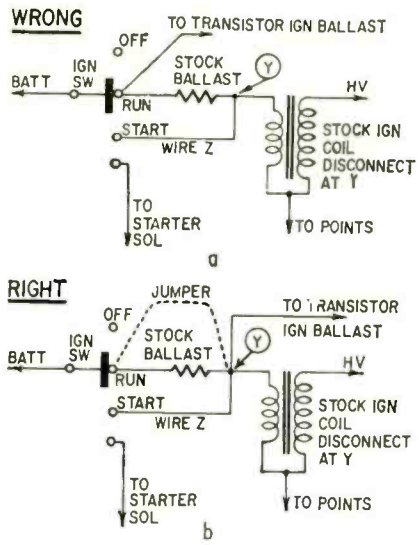


Fig. 2

Most transistor systems have no provision for maintaining 9 amps or so through the coil primary for cold-weather starts. About 6 amps is borderline for a hot spark.

Don't junk it

But don't junk the transistor system you built or bought. *It will work*, and save you money on tuneups and gas. Mistakes are made most often in connecting the ballast to the ignition switch. The error happens most on cars with the switch wired as in Fig. 1-a. General Motors cars are wired this way. The resistance wire is usually in the wiring harness. If the ballast is wired direct to the RUN terminal of the switch as in Fig. 2-a, and the stock coil disconnected at Y, the car would start if pushed. It could start just as you released the key. But it won't be likely to start in the START position. Many systems have been junked because of this easy-to-make error.

Connect the transistor ballast with a No. 14 wire at point Y, and run a jumper around the stock coil resistor as in Fig. 2-b. Remove or disconnect the stock coil. Check the coil circuit with your dealer if in doubt.

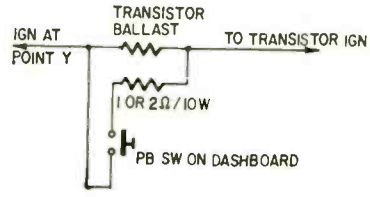


Fig. 3

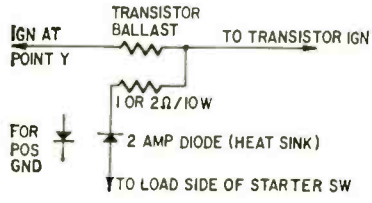


Fig. 4

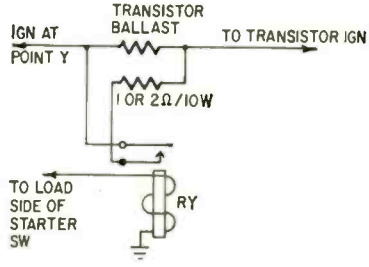


Fig. 5

An ammeter in series with the transistor ignition coil should read at least 8.5 amps with the motor running. Reduce the value of the ballast until about 9 amps is drawn.

Figs. 3, 4 and 5 show sure-fire methods for cold-weather starts. A 1- or 2-ohm resistor is paralleled with the ballast on start only. Omit the resistor for 6-volt cars. END

Variable Speed for Your Tapes and Records

Continuously variable speed for recorders and turntables opens the door to many exciting experiments in sound recording

By FRANK J. DiELSI

Author gets set to roll a tape as he adjusts capstan speed. Chassis of original version is bigger than needed (it was rack-mounted). A smaller chassis may be more convenient for you.

THIS VARIABLE-FREQUENCY SPEED CONTROL will drive a turntable or tape machine with 60 watts of stable frequency from 50 to 100 Hz. It will vary the speed of any 60-Hz synchronous, shaded-pole or capacitor motor over a range of approximately 83% to 166% of normal. Musicians can get absolute pitch from their recordings. The range is wide enough to produce many novel sound effects with tape and disc recordings, including variable echo produced by using the time delay between the record and playback heads on a continuous loop of tape. It is also useful for playing tapes originally recorded on an off-speed machine.

Trying to change the speed of a synchronous motor by varying the voltage won't work. The speed of a capacitor or shaded-pole motor, used in the lower-cost machines, *can* be changed by adjusting the voltage, but the speed will be very unstable. This unit uses *variable frequency*, not variable voltage, for stable control of motor speed.

Circuit

The diagram shows the complete circuit of the variable-speed drive. V1 is an oscillator with two feedback loops. The negative feedback from the cathode of V1-b to the grid of V1-a is through the bridged-T network C1, C2, R3, R5 and ganged frequency control R4. The null of this network determines the oscillator frequency. The positive feedback is through the voltage divider consisting of the lamp I1 and waveform control R2. The nonlinear resistance of I1 acts as an automatic amplitude control.

Instead of an expensive hi-fi output transformer capable of delivering up to 75 watts at 50 Hz, a lower-cost multitapped bias power transformer is used. The high-voltage winding is connected as the primary, and the 117-volt winding is the secondary. The taps shown in the schematic will deliver 108 volts at 50 Hz and 123 volts at 100 Hz with a 0.5-amp motor load. This voltage change is desirable because it tends to compensate for the rising reactance of the motor as the frequency increases. Panel-mounted pilot light I2 indicates output and is a stabilizing load.

Substituting a pair of 6550's for the 7027-A tubes, and resetting the output taps and BIAS control R17, increases the output to approximately 75 watts.

Voltage regulator tubes V4 and V5 are wired so that the power supply circuit is opened if the tubes are removed. Bias supply rectifier D5 is connected to the power transformer with low-dissipation voltage divider C10 and R15. BIAS control R17 is set at −43 volts for the 7027-A output tubes.

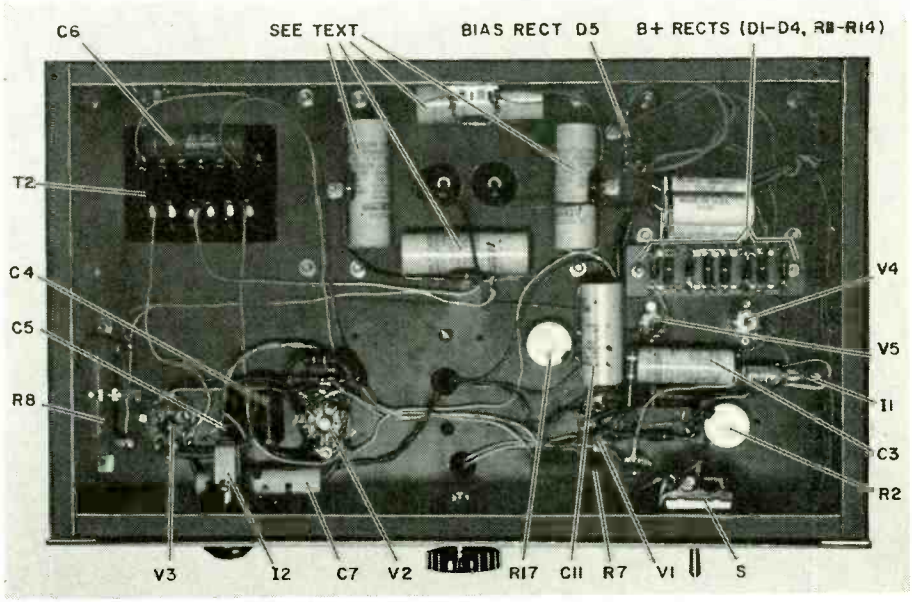
Construction

The unit shown in the photographs was built for standard rack mounting on a 17 x 10 x 3-inch chassis. It differs a little from the parts list because I used some components that were already on hand. Layout is not critical and the size of the unit can be reduced considerably without any difficulty.

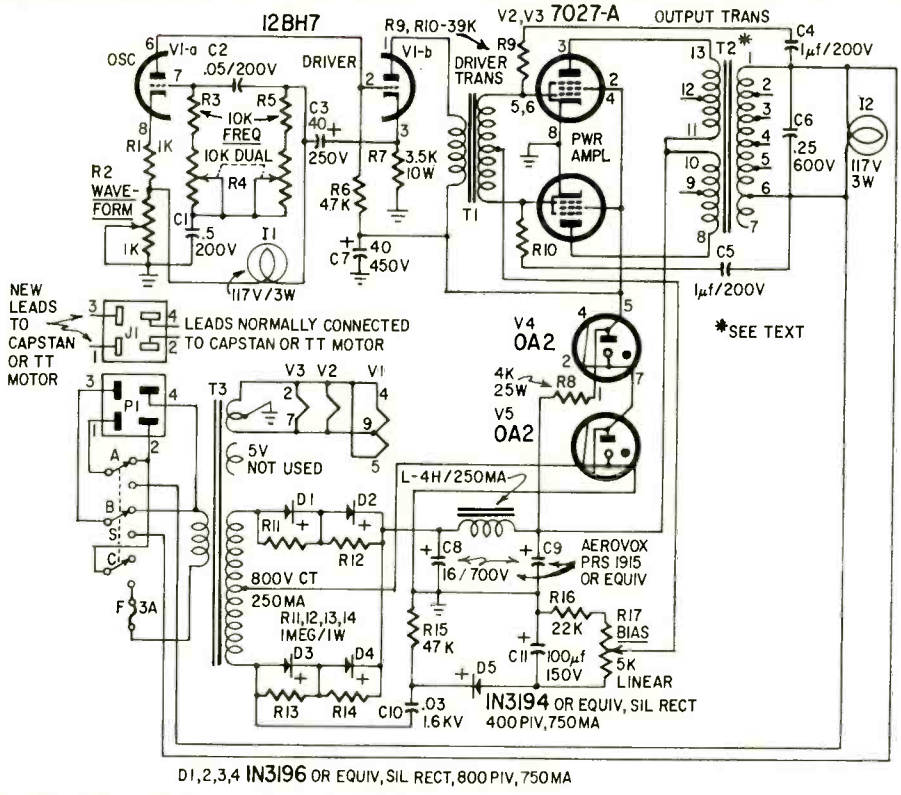
To connect the unit to a tape machine, disconnect the power leads *to the capstan motor* only and extend them to pins 4 and 2 of socket J1. The two motor leads are connected to pins 3 and 1 on J1. When power switch S1 is shut off, sections S1-a and S1-b complete the normal circuit from 2 to 1 and 4 to 3 on P1. A dummy cable clamp socket with internal jumpers can be used if the drive unit is removed entirely for use with another machine.

Adjustment

With cable connector J1 plugged into chassis connector P1, turn on the



Most of the under-chassis components are marked here.



Circuit of the variable-speed supply. With 6550 tubes and correct bias adjustment, supply can put out 75 watts between 50 and 100 cycles. With 7027-A tubes shown, output is about 60 watts.

R1—1,000 ohms
R2—pot, 1,000 ohms
R3, R5—10,000 ohms, 5%
R4—ganged dual pot, 10,000 ohms (Ohmite type CCU or equivalent)
R6—47,000 ohms, 2 watt
R7—3,500 ohms, 10 watt
R8—4,000 ohms, 25 watt
R9, R10—39,000 ohms
R11, R12, R13, R14—1 megohm, 1 watt
R15—47,000 ohms
R16—22,000 ohms
R17—pot, 5,000 ohms, linear
C1—0.5 μf, 200 volts
C2—.05 μf, 200 volts
C3—40 μf, 250 volts, electrolytic
C4, C5—1 μf, 200 volts
C6—0.25 μf, 600 volts
C7—40 μf, 450 volts electrolytic
C8, C9—16 μf, 700 volts, electrolytic (Aerovox PRS 1915 or equivalent)
C10—.03 μf, 1,600 volts (Aerovox VBC 33 or equivalent)
C11—100 μf, 150 volts, electrolytic
T1—driver trans., 1.2 : 1 turns ratio (Thordarson 15D85, Stancor A4752 or equivalent—see text)
T2—output trans, UTC S52 or equivalent—see text (This transformer is not listed in most mail-order catalogs but it is available from all UTC distributors.)
T3—power trans., 800 vct, 250 ma; 6.3 v, 5 a (Stancor PC8413 or equivalent)
L—choke, 4 hy, 250 ma (Stancor C1412 or equivalent)
S—3 pdt toggle switch (Arrow Hart 82615 or equivalent)
F—3-amp fuse
D1, D2, D3, D4—silicon rectifiers, 800 piv, 750 ma (RCA 1N3196 or equivalent)
D5—silicon rectifier, 400 piv, 750 ma (RCA 1N3194 or equivalent)
J1—cable-clamp socket (Cinch Jones S304CCT)
P1—recessed chassis-mount plug (Cinch Jones P304RP)
I1, I2—lamp, 117 volts, 3 watts (G-E type S3)
V1—12BH7
V2, V3—7027-A tube
V4, V5—0A2 tube

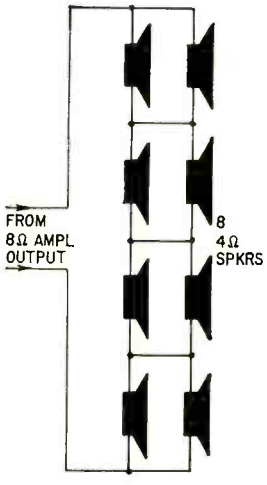
tape machine or turntable. Then turn on S1 and, after a 1-minute warmup, adjust waveform control R2 until clipping of the sine wave just begins to show on a scope connected to the plate of V1-b. Now connect the scope across output indicator I2 and select the taps for maximum output without excessive clipping. The output taps may vary for different motors. If the output tubes oscillate with R9 and R10 connected, reverse the plate leads to the output transformer.

Do not change the values of the bridged-T network to get lower frequencies because most 60-Hz motors will draw excessive current and overheat when driven with a source much below 50 Hz

END

WHAT'S YOUR EQ?

Conducted by E. D. CLARK

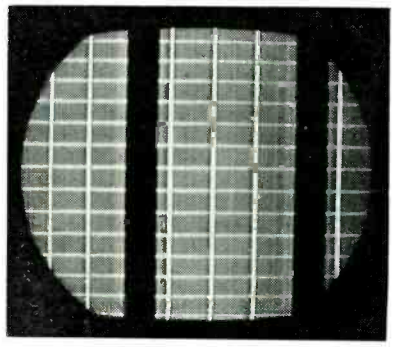


Connections

The diagram shows a recent hi-fi annual answer to a reader's query about how to connect eight 4-ohm speakers so they could be driven properly from the 8-ohm output of an amplifier. What's wrong with it?—*P. E. Sutheim*

What Is It?

This is a color TV set showing a crosshatch pattern. It is? Who ever saw



one looking like that? This pattern is firmly locked—no wiggle or jitter. What causes it? The set? The generator? Can you figure it out?—*Jack Darr*

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

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

Answers to this month's puzzles are on page 99.

50 Years Ago

In Gernsback Publications
In February, 1916
Electrical Experimenter

Construction and Use of a Decremeter
Reception of Long Damped and Undamped Waves
500-Watt Military Radio Pack Set
How to Build a Photophone

Build A Stereo Headphone Amplifier

Neat little "Transistor Twelve" costs no more than $30 to build. Battery-powered, completely hum-free; works with any cartridge, any phones

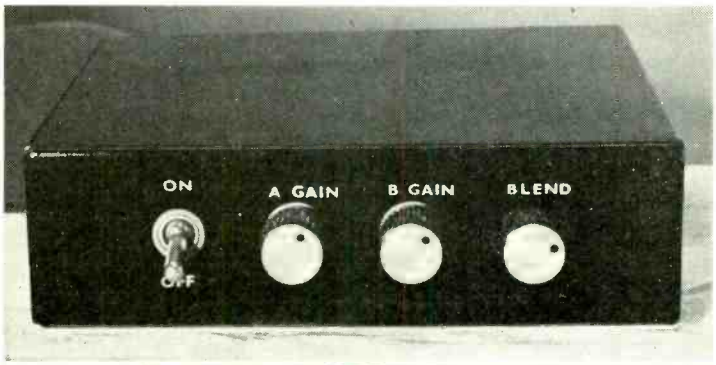
By STEVEN RISKIND and NICHOLAS J. YASILLO

HEADPHONE STEREO IS MORE THAN JUST a way to keep your family happy when you want to listen to loud music late at night. Through phones, each ear hears the signal from one channel only. The acoustics of your listening room do not mix the stereo signals before they reach your ears. You are transported directly to the recording location, and with a good recording you will be able to pick out the location of each instrument. Stereo through headphones doesn't suffer from the dryness or the "orchestra-inside-your-head" effect that makes monophonic listening through phones less than ideal. [Since stereo recordings (as contrasted with *binaural* ones) are made with wide mike spacing and intended to be played through speakers, the effect through headphones is a little exaggerated and is not everybody's cup of tea. But it is pretty exciting.—*Editor*]

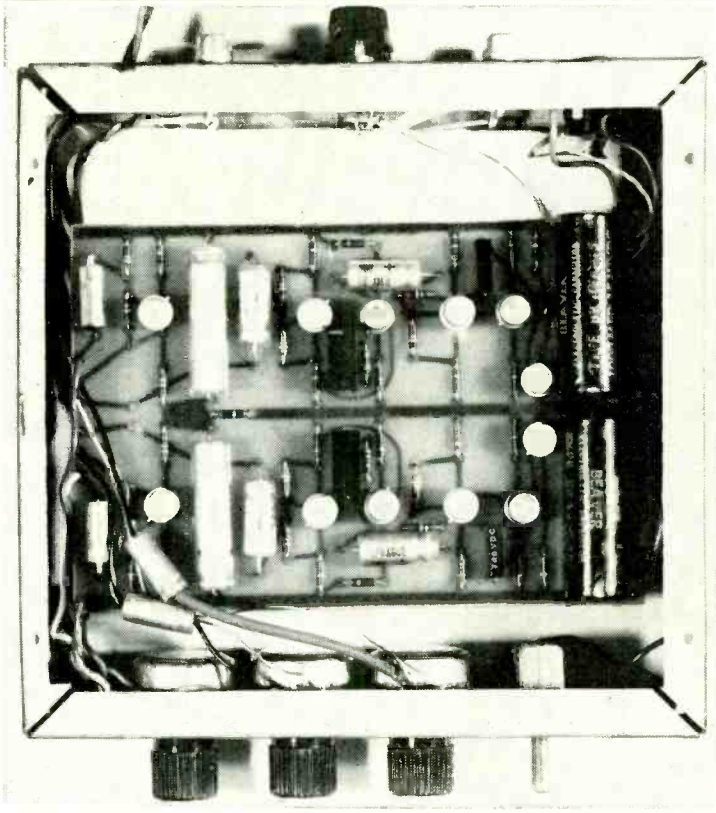
Stereo headphones can deliver the performance of a speaker system many times their cost. Because they require very little driving power, it is possible to design inexpensive, flea-power equipment for them.

A simple approach

The Transistor Twelve is a preamplifier that drives low-impedance stereo headphones from a magnetic phono cartridge. Its power supply is a pair of humless dry cells. It has gain and blend controls and can feed a stereo power amplifier. After several years of headphone listening, we are convinced that tone controls will not be missed on this type of preamp.



Neat cabinet is just a 7 x 7 x 2-inch chassis, carefully sprayed black and labeled with dry-transfer letters.



Circuit board fits into cabinet with room to spare. Note plastic sponge block under board; a similar piece over the board makes a tight "sandwich" when the bottom cover is fastened, and is a perfect shock mounting for the circuit board. Controls (top of photo) for amplifier outputs were omitted in final design.

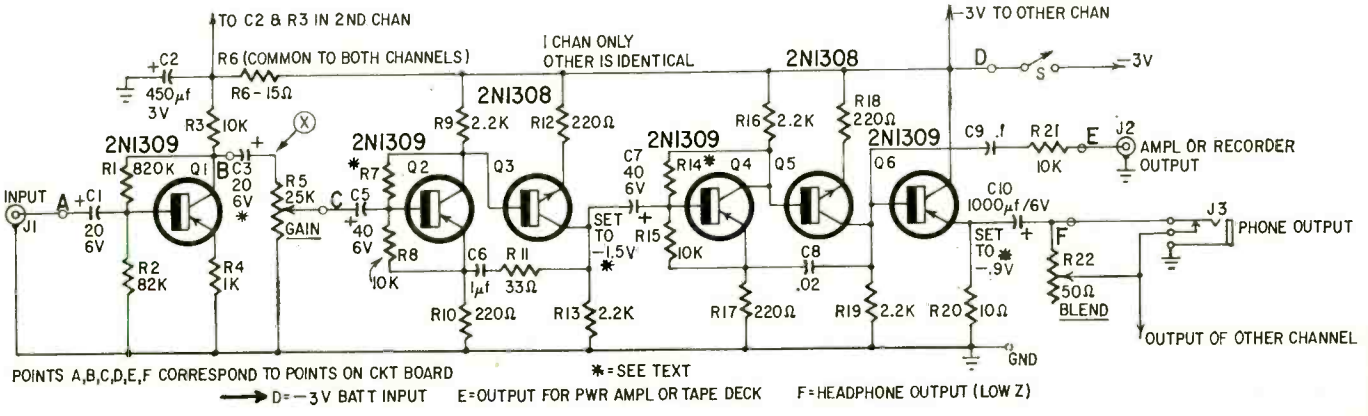


Fig. 1—Schematic of one channel of the Transistor Twelve. Transistors are stable, inexpensive germanium units (about a buck apiece). If you like, connect FM tuner through .002 μf shunted by 330,000 ohms, then through .01 μf to point X in diagram.

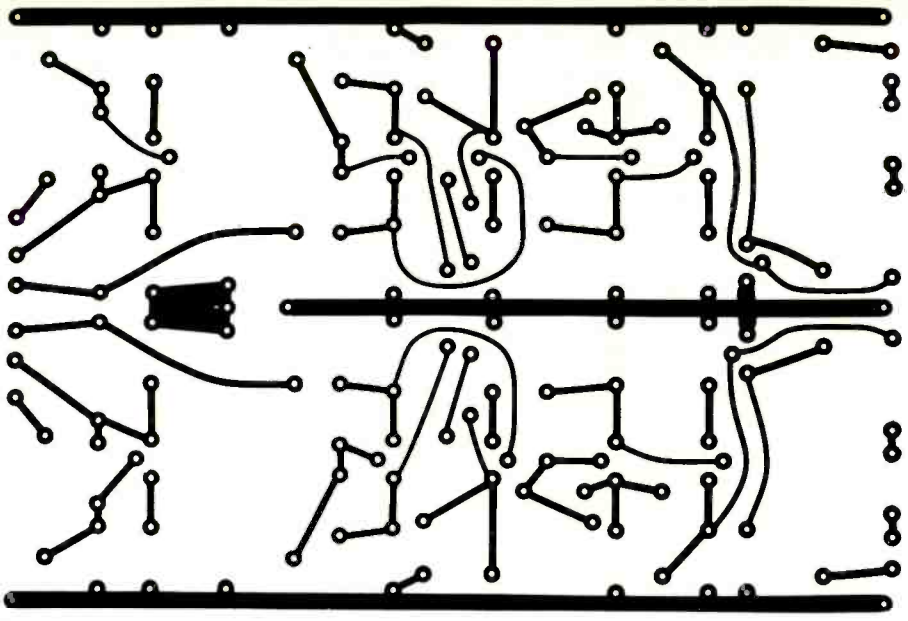


Fig. 2—Exact reproduction of circuit board pattern used in original Transistor Twelve. A negative of this, blown up to exactly 4 x 6 inches and used to expose a photosensitive copper-clad circuit board, will make a perfect duplicate of authors' board.

For a stereo amplifier, you will need two of every part listed except those marked *, of which you need only one.

C1, C3—20 μf, electrolytic (Cornell-Dubilier Electromite)
C2—450 μf, electrolytic (Cornell-Dubilier Electromite)
C4—omitted
C5, C7—40 μf, electrolytic (Cornell-Dubilier Electromite)
C6—1 μf, Mylar or metallized paper
C8—.02 μf, Mylar or metallized paper
C9—0.1 μf, Mylar or metallized paper
C10—1,000 μf, electrolytic (Cornell-Dubilier Blue Beaver 1000-6)
Electrolytic capacitors can have any voltage rating from 3 up; brand names are given only to indicate what was used in original. Other makes may differ in size and not fit circuit board pattern.
R1—820,000 ohms
R2—82,000 ohms
R3, R8, R15, R21—10,000 ohms
R4—1,000 ohms
R5—pot, 25,000 ohms, audio taper
R6—15 ohms*
R7, R14—see text
R9, R13, R16, R19—2,200 ohms
R10, R12, R17, R18—220 ohms
R11—33 ohms
R20—10 ohms
R22—pot, 50 ohms, linear*
All resistors ¼ or ½ watt, 10%
J1, J2—phono jacks
J3—2-circuit (stereo) phone jacks*
Q1, Q2, Q4, Q6—2N1309 (RCA, TI)
Q3, Q5—2N1308 (RCA, TI)
S—spst toggle switch*
Chassis, 7 x 7 x 2 in., with bottom plate*
Two No. 6 dry cells (1.5 volt)—pair in series for both channels*
Circuit board or terminal strips
Hardware

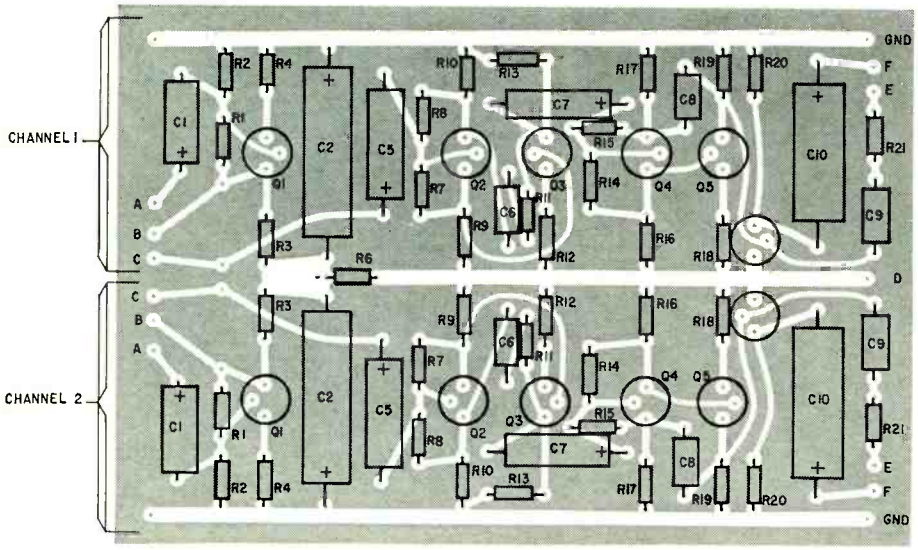


Fig. 3—Layout of parts on circuit board. This drawing is to scale as is the pattern of Fig. 2 (but component sizes, especially capacitors, may differ from this). C3 is not on board; it's connected from point B to the high side of R5 (gain).

A = CARTRIDGE INPUT
B = TO GAIN CONTROL
C = FROM GAIN CONTROL
D = —3V (BATTERY)
E = TO POWER AMP OR TAPE RECORDER
F = HEADPHONE OUTPUT

Each channel of the Twelve consists of an input gain stage followed by two amplifying blocks and an emitter follower. Transistor Q1 is the input stage. Capacitor C2 decouples it. Following the input stage is the gain control, placed here to reduce hiss from the input transistor. If the gain control were placed at the input, the first stage would always be running wide open into the succeeding stages.

Transistors Q2 and Q3 comprise the first of the two amplifying blocks. Q2 is dc-coupled to Q3, and R7 and R8 set the bias for the pair of transistors. C6 and R11 make a feedback loop around the stage, which lowers the distortion and stabilizes the gain in the amplifying block. The feedback loop also provides RIAA record compensation. Actually, C6 and R11 provide bass boost from 20 to 1,000 Hz. C8, the feedback capacitor in the second amplifying block, provides the treble cut above 1,000 Hz. To insure accurate compensation, the feedback capacitors should be high-quality components, the same in each channel.

The second amplifying block is identical to the first except for the feedback circuit. The output of this second block can drive an external power amplifier. It also drives the base of Q6 a p-n-p transistor, wired as an emitter follower. The emitter follower's output impedance is low enough to drive the stereo headphones. C10 blocks the dc on the emitter of Q6 so that only ac can appear across the coils in the phones. Because C10 is a 1,000-μf capacitor, the Transistor Twelve's response is less than 3 db down at 25 Hz.

Tests with a signal generator and oscilloscope show that the Transistor Twelve can provide a maximum clean signal of about 0.8 volt. This and the efficiency of the headphones (how much sound they make for a given input) determine the maximum undistorted level you will hear. We like our music loud, and we've found that there is plenty of clean sound with Koss SP-3 or PRO-4, Jensen HS-1, or Sharpe HA-8 or HA-10 headphones. Any other low-impedance stereo headphones will work if they are as efficient as the ones mentioned. The efficiency of other phones can easily be tested in any hi-fi showroom.

The Transistor Twelve can be used with all magnetic phono cartridges that produce more than 2 mv for a recording velocity of 5 cm/sec. Any of the stereo cartridges in widespread use today has sufficient output.

If you are going to use the Transistor Twelve to drive a stereo power amplifier, the amplifier must be sensitive enough to be driven to full output by 0.8 volt. (By unplugging the headphones, the Transistor Twelve will be unloaded and the undistorted output will rise a lit-

tle. Also see the note on biasing for another way of increasing the maximum voltage swing.)

You can use the Transistor Twelve to add stereo phones to your monophonic hi-fi system by paralleling its amplifier outputs and connecting them to the input of your power amp or to a preamp's high-level unequalized input.

Construction of the Twelve

The Transistor Twelve Circuit board shown in the photographs was laid out with tape resist and etched. You can duplicate the layout with tape, or, if you have photographic equipment, make a full-size negative of the layout. This negative can then be contact-printed onto a photosensitized circuit board, which is then developed and etched.

The circuit could just as easily be wired up on a perforated phenolic board or even conventionally, point-to-point. The 4 x 6-inch circuit board leaves plenty of room to wire controls and connectors on the front and back of the chassis. There is no need to use shielded cable anywhere inside the chassis. Keep input jacks and wiring away from output circuitry.

Before operating the unit, set the dc biases in the four amplifying blocks to optimum levels. This allows the Transistor Twelve to produce the largest clean signal possible and deliver the most power to the headphones.

The voltage on the collector of Q3 in each channel should be adjusted to read 1.5 volt on a vtvm or 20,000-ohm/volt vom. This is done by varying the value of R7, which should fall in the range of 180,000 to 330,000 ohms. The second amplifying block should produce approximately 0.9 volt on the emitter of Q6. To adjust, vary the value of R14, which should fall in the same range as R7. Set these voltages accurately, or you may have high distortion. This procedure will take care of transistor variations, so you do not have to select 2N1308's and 1309's. *We strongly recommend that you not change transistor types.*

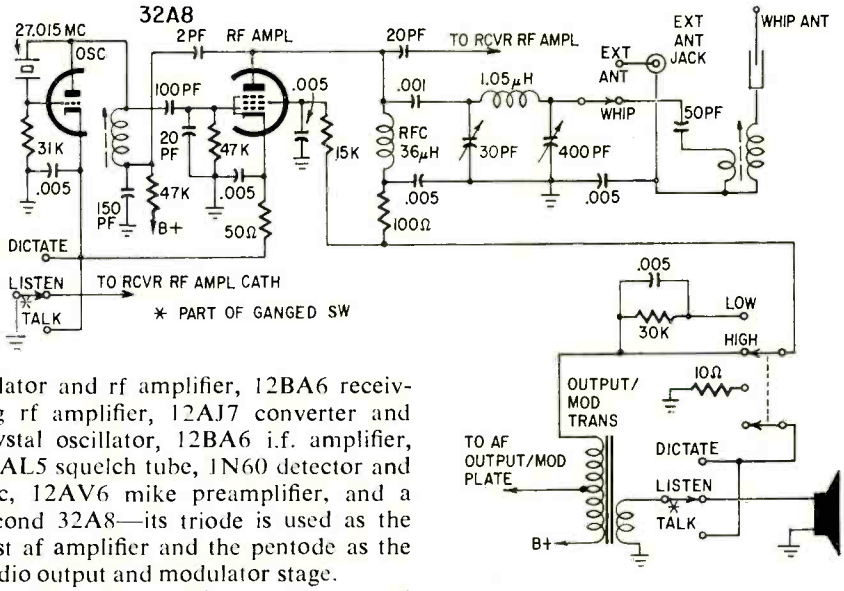
NOTE: The collector bias on the first amplifying block is set at half the supply voltage to give maximum output voltage swing. This would be ideal for the second amplifying block, but there, current drain must be considered. With 0.9 volt on the emitter of Q6 in each channel, the Transistor Twelve will draw about 130 ma, a reasonable drain. Raising the bias to 1.5 volts will nearly treble the power consumption. If you want a larger output from the Transistor Twelve, build a well-filtered power supply for the unit and also put small heat sinks on Q6 in each channel. Such modifications are not necessary for headphone listening and for using the Transistor Twelve with most power amplifiers.

The cabinet was made from a 7 x 7 x 2-inch aluminum chassis with a bottom plate. The chassis was given two coats of Krylon metal primer, two coats of flat black paint, and a coat of clear Krylon. It was then lettered and given two more clear coats.

The dry cells that power the Transistor Twelve should last 6 months if the unit is used 2 hours a day. The cells could be replaced with a very well filtered 3–4-volt dc supply, but unless the unit is used many hours each day, such a supply will equal the cost of many years' batteries. Battery operation has the advantage of entirely hum-free performance. The low supply voltage and the choice of transistors make hiss nearly inaudible. END

Wireless Intercom Is CB Transceiver

Line-powered 3-watt CB base-station transceiver converts to 100-mw unit for use as intercom and for short-range communications



FOR THE LAST YEAR OR SO, CIRCUITS IN intercoms and CB transceivers have been relatively static with few new circuits worthy of note. Now, Radio Shack has brought out its SELECTaCOM, a combination *wireless* intercom and CB base-station transceiver. As an intercom, it functions as a 100-milliwatt transceiver operating into a built-in whip antenna. It has all the conveniences of a wired-wireless (carrier-current) intercom without restricting communications to units on the same side of the power distribution transformer.

Connect an external CB antenna, flip the HIGH-LOW power switch to HIGH and the SELECTaCOM is ready for service as a class-D transceiver operating under Part 95 of the FCC Rules. It resembles a standard intercom with the usual TALK, LISTEN, DICTATE switch and volume control on the front panel.

The CB intercom is a seven-tube ac-dc unit with a 32A8 transmitting oscillator and rf amplifier, 12BA6 receiving rf amplifier, 12AJ7 converter and crystal oscillator, 12BA6 i.f. amplifier, 12AL5 squelch tube, 1N60 detector and avc, 12AV6 mike preamplifier, and a second 32A8—its triode is used as the first af amplifier and the pentode as the audio output and modulator stage.

The units are shipped with channel 5 transmitting and receiving crystals and with the power and antenna switches in the LOW and WHIP positions, respectively. These switches and the external antenna jack are covered with a strip of tape. A printed sticker warns that the tape may be removed *only* after obtaining a class-D CB license.

[The FCC recently circulated a letter emphasizing that a transmitter capable of more than 100-mw input does not meet the requirements of Part 15 of the Rules and must *not* be operated without a license.

The commission points out that reduced power lessens interference and power-reduction switches in CB transmitters are permissible and encouraged. —*Editor*]

The diagram shows the transmitter's rf circuitry and the power input switch. Heising modulation is used. When the switch is in the HIGH position, plate and screen voltages and currents of the rf amplifier are normal for 3 watts input. Throwing the switch to LOW inserts a 30,000-ohm resistor in series with the B-plus lead to the final amplifier. The resistor reduces the plate and screen voltages and limits the input to under 100 mw. A 10-ohm resistor loads the modulation transformer and reduces the audio voltage to prevent overmodulation.—*Robert F. Scott*

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EQUIPMENT REPORT

Sony-Matic TC-900 Battery Tape Recorder

Circle 23 on reader's service card

THE SONY-MATIC TC-900 PORTABLE TAPE recorder looks different from most other portables in its price range in a very important way: it has no record-level meter, and no record-level control.

These omissions are no oversight. The Sony-Matic uses an automatic volume control (avc) to compensate for variations in the level of the input signal. In such applications as recording telephone calls—where the voice at the phone nearer the recorder is invariably much louder than the voice from the farther phone—the avc prevents underrecording of the softer voice while preventing overload distortion of the louder.

The avc has its peculiarities and side effects, of course. When recording in noisy surroundings, it automatically raises the recorded level of the ambient background noise whenever no one is speaking; and it compresses musical dynamics to the point where the music (though still listenable) is suited primarily for background listening.

Music recorded or played on this machine would be suitable only for background in any case, for the frequency response of the recorder is limited, dropping gently at about 4 KHz (at 3¾ ips, its higher speed), and falling rather precipitously thereafter. Speed regularity is fairly good, and a recorded sine-wave form observed on an oscilloscope looked quite presentably clean at lower settings of the output gain control.

Distortion at higher output levels is rather high, but this may be somewhat reduced by opening the case lid (which reduces bass resonance), listening through good headphones instead of through the unit's own speaker, or playing the tape back on another machine.

Like most inexpensive recorders, this one records rather better than it plays back. Most natural-sounding response was obtained with the tone control turned to the 3 o'clock position or higher (nearly full treble).

The Sony 900 is convenient to use. It is equipped for ac operation without external adapters, just the cord provided with the machine. Threading is as simple as it can get. The plastic window in the case lid gives a good view of the reels inside, but the amount of tape left on these reels would be easier to judge if the surface below them were lighter in color. The plastic window is not calibrated to indicate the amount of tape remaining on the 3¼-inch reels, nor is there any tape counter.

The earphone monitor jack is "live" during record as well as playback, a desirable feature that is often omitted.

The batteries provided are rated at 20 hours of life in this recorder. They are standard D size, and easy to replace. A

continued on page 69

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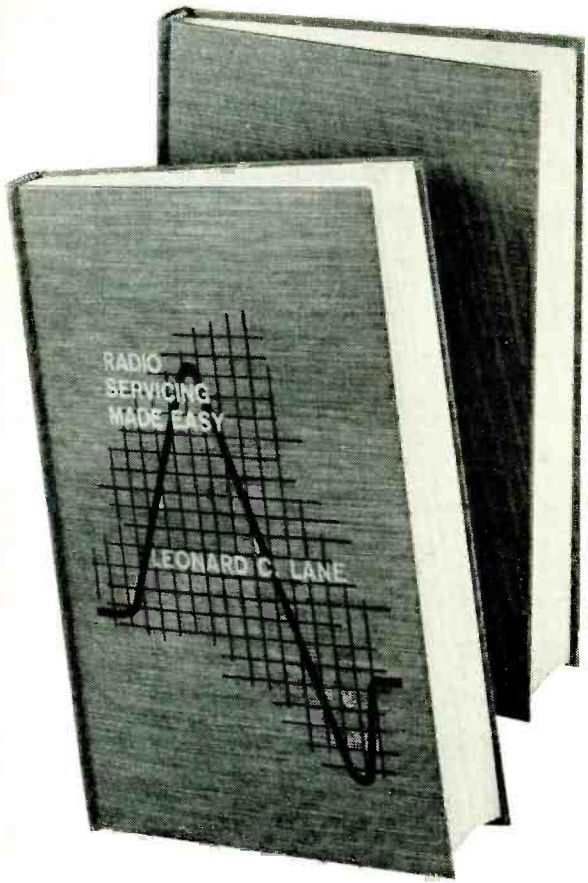

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EQUIPMENT REPORT continued

cloth tape is supplied for cleaning the heads.—*Ivan B. Berger*

MANUFACTURER'S SPECIFICATIONS

Speeds: 3¾, 1⅞ ips
Tracks: two
Max. reel size: 3 in.
Bias frequency: 30 KHz
Power output: 1 watt
Supply: 6 volts (4 D-cells or built-in line-operated supply)
Size: 8¾ x 8¾ x 3¾ in.
Weight: approx. 4½ lb less batteries
Price: $67.50

Knight-Kit KG-415 Four-Track Stereo Tape Recorder

Circle 24 on reader's service card

USED TO BE, IF YOU WANTED A "PROFESsional" recorder, you went out and bought a professional recorder—for $500 to $2.000. Otherwise, well, there was a nice line of recorders priced between $100 and $300 you could choose from. Recently, the gap has been filling in. There are now recorders at almost any price you care to name.

The word "professional" is getting fuzzier month by month. What I mean by it in this case is: a recorder that compares favorably with machines used by people in the field who know their work, take it seriously and try to make money at it. Specifically, this means a frequency response of 50 to 15,000 Hz within 2 db, or better, at 7½ ips, noise level more than 40 db below average recording level; flutter and wow less than 0.2% at 7½ ips; separate record and play heads, a valid and reliable record-level indicator (either an "eye" tube or a meter), a high-frequency, low-distortion bias and erase oscillator, and a fair amount of ruggedness.

Now when all these features and more can be had in a kit for $250, that's worth a report. Allied Radio Corp.'s Knight-Kit division has combined them all in the KG-415, a four-track stereo job with all-transistor circuitry and an excellent two-speed, two-motor Viking transport—with three separate heads and *no pressure pads*. (Pressure pads. the easy way to insure tape-to-head con-

tact, are supposed to wear the heads five times faster than the tension method of holding tape against the heads.)

The whole KG-415, electronics and transport, is an impressive piece of hardware. Examples: The KG-415 can mix mike and "line" (high-level) inputs in each channel. It offers you a choice of monitoring (through phones or an external amplifier) either the source itself or the program as just recorded on the tape. A flick of a switch will give you either tape-delay echo or sound-on-sound. With the recording-level meters and a built-in 1-KHz test oscillator you can set up bias and recording levels in minutes for different kinds of tape. The VU meters can be switched to recording (source) or playback.

The transport is designed with the tape editor in mind—there's a hinged flip-up head cover so you can see the tape as it passes over each head, and a CUE position on the transport function knob that puts the tape on the heads but disengages the drive, allowing you to move the tape by hand to find the exact spot for cutting.

For those who tremble about assembling a tape recorder, let me say that *the transport is completely assembled and adjusted*—all you do is fasten it in place at the correct moment. You do *not* have to get tangled in belts and watch tiny springs fly across the room to be swallowed by the cat. But there's still a solid week's absorbing spare-time work building the electronics.

The instructions are masterful and practically flawless, complete with frequent reminders to knock off for a rest before your eyes cross. Most of the point-to-point wiring is exactly that: wiring, with comparatively few resistors, capacitors and such. Except for the power supply, equalization and the 1-KHz test oscillator, almost all the electronics is on six etched circuit boards, which come packed in plastic bags with separate instructions and all parts.

Four of the boards are identical: two recording and two playback amplifiers. The equalization is separate, not on the boards, so they are completely interchangeable—a useful feature if one of them conks out. Especially fine is the fact that they aren't *wired* into the chassis; they *plug* into special connector strips mounted on it.

One of the remaining boards is the monitor amplifier for the earphones. The sixth board is the bias and erase oscillator—a push-pull silicon-transistor circuit that gives a very clean 80-KHz sine wave.

The circuit boards are coated on the foil side with a blue plastic film everywhere except where a lead poking through a hole from the other side is to be soldered to the foil. This effectively prevents solder from flowing between the close-spaced conductors and causing shorts.

Sour notes? A few, but nothing serious. The gain on the mike channels is a bit low, making it necessary to open the mike level controls all the way for many recordings. (That might be fixed easily by increasing the value of the feedback resistors in the mike preamp circuits.) The microphone input impedance is a rather impractical 3,000 ohms, which matches neither low-impedance mikes (usually 250 ohms, balanced) nor high-impedance mikes (usually about 50,000 ohms). This problem is shared by many transistor recorders, and sooner or later there will probably be a fair choice of microphones with a "compromise" impedance (there are some already). For the time being, either use high-impedance dynamic mikes and suffer along with the loss of signal level, or use low-impedance mikes with outboard stepup transformers (not easily obtained with 3,000-ohm secondaries, but there are transformers that can be used). Of course, you could use an external preamp.

But neither of these criticisms detracts from the overall worth of the KG-415. At $250, it is a superb value

for a serious amateur recordist.—*Peter E. Sutheim*

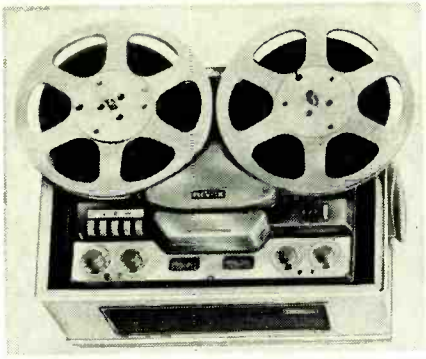
MANUFACTURER'S SPECIFICATIONS

Tape speeds: 7½, 3¾ ips
Wow & flutter: less than 0.2% rms at 7½ ips
Frequency response: 50 to 18,000 Hz ±2 db at 7½ ips; 50 to 15,000 Hz ±2 db at 3¾ ips
Harmonic distortion: less than 1.5% at 0 VU
Bias frequency: 80 KHz
Signal-to-noise ratio: better than 50 db for signal recorded at 0 VU
Dimensions: 14½ x 14 x 9⅝ in.
Weight: 26 lb
Price: $249.95 kit

ReVox G-36
Stereo Tape Recorder

Circle 25 on reader's service card

ALTHOUGH THE NAME REVOX MAY BE new to many, those of us who follow the European audio publications have known of this fine Swiss machine for years. We have, in fact, wondered why some enterprising importer was not distributing the machines here. Well, Elpa, distributor of Ortophon, Thorens and EdiTall, has leaped into the breach.



This ReVox is a three-motor, three-head, quarter-track (four-track) stereo recorder. It is large (it has to be to accommodate all that's in it), it is heavy, and it is solid. Before any tests or auditions, I was impressed by the feel of it. Perhaps the most accurate word to describe the recorder is *massive*.

Inside and out this is a well-made machine. The drive motor (a Pabst hysteresis-synchronous, inside-out), the capstan wheel, flywheel and heads are on heavy castings rigidly linked together. The electronics, all-tube, are of neatly laid out and conservatively designed. Recording equalization is entirely via passive R-C networks; there are no tuned circuits. Playback is equalized with negative feedback around the gain stages.

Only one speaker/amplifier is built into the unit. Output is around 6 watts; the speaker is satisfactory. There is a speaker-out socket on the rear.

Five piano-type keys are electrically linked to all tape motion. One of the keys is the record interlock. It cannot be depressed and held down accidentally. On the far right is the three-digit counter, button-resettable.

The ReVox, alone of machines in the $500-or-less category, fits 10½-inch reels. These require higher hold-back and spooling tension than smaller reels to assure good head contact and a smooth rewind. At the point of the head cover is a knurled knob. *In* is for the large reel. *Out*, which exposes a shaft that prevents large reels from fitting, adjusts motor tensions for standard small reels.

Tests showed excellent record/play response at both speeds. The two channels are within 2 db of each other throughout. While 7½-ips response extends well beyond 20 KHz, interference tones apparently generated by beating between input and bias frequency are generated above 18 KHz. Still, this is outstanding performance.

Flutter measurements at the high speed exactly met the published specification of .05%. Very low indeed. At the slow speed, flutter measured somewhat higher than specified but was still only 0.12%, excellent by any standard.

There are three input pairs to the unit. Two are for high-level, one is for microphone. They cannot be intermixed (though each channel is individually set). All connections are on the rear apron. The microphone inputs use RCA phono jacks, which is not standard for mikes. [Elpa has asked the manufacturer to change them to phone jacks.—*Editor*]

The outputs are fixed-gain, in parallel pairs. Connections to a standard control amplifier with a tape-monitoring facility allow A-B comparisons during recording. (This can also be done through the built-in speaker with a top-side control.)

Since there are separate play and record heads and electronics, special effects such as echo are easy. All they call for is careful re-insertion of the playback signal into the record amplifier. Sound-on-sound is easy also; there are controls that feed channel 1 into channel 2 or 2 into 1.

A tape cutoff switch shuts off power when there is no tape and activates the solenoid-operated brakes. This also happens if power should fail, so there is little likelihood of accidental tape breakage.

I like this machine. The utter cleanness of the recorded sound, indistinguishable from the input sound at 7½ ips is impressive. So is the sound of well recorded commercial tapes.

It seems that $500 can buy an awful lot. This ReVox G-36 is a good buy.—*Leonard Silke*

MANUFACTURER'S SPECIFICATIONS

Tape speeds: 7½, 3¾ ips
Speed accuracy: 0.3%
Wow & flutter: 0.1% or less at 7½ ips
Frequency response: 40 to 18,000 Hz at 7½ ips; 40 to 12,000 Hz at 3¾ ips (+2, —3 db)
Overall weighted signal-to-noise ratio: 55 db at 7½ ips for half-track operation
Bias oscillator: push-pull, 70 KHz
Power: 117 volts, 60 Hz, 120 watts
Case size: 18½ x 12¼ x 11½ in.
Weight: approx. 45 lb
Price: $500

END

WHATSIT

What has 18 tubes, costs about $5 and can save you twice that much every day? A Whatsit. What *is* it? An old TV chassis that's still in working condition. Not good enough to repair and sell, but great for *servicing*. Jack Darr shows how to take this junk heap, fix it up with connectors and cables, and turn it into a valuable piece of test equipment.

READ IT

There's something about communicating over a light beam that has thrilled thousands ever since it was first thought of. It's an exciting way to spend spare hours in the yard or basement. Read how it's done. Simple plans make it easy to use an amplifier and parts you have on hand.

TRY IT

Silicon controlled rectifiers are now available "over the counter" at voltages up to 400, and for currents from a few milliamperes to 50 amperes. They have recently been used in a wide variety of low and medium power hand-tool speed controls, lamp dimmers, etc. The higher-power (10 amps and up) SCRs are ideal for controlling theatrical and photographic lights, replacing heavy and costly faders, saturable reactors and variable transformers. They have the added advantage that the control can be some distance from the power circuits, and can be electrically isolated from it quite simply. Find out more about high-power SCR controls and try some simple circuits.

Precise 111M Tube & Transistor Tester

Circle 26 on reader's service card

THE VERSATILE MODEL 111M TUBE AND Transistor Tester, a product of Precise Electronics & Development Corp. (Mineola, N. Y.), can test a vacuum tube at least five ways.

Besides the usual emission and transconductance tests you can set up a tube with self-bias—through an externally connected resistor. Since many tubes are operated with self-bias, it is best to test them that way.

To this you can add a "life" test—reducing the filament voltage to simulate tube aging by reducing the cathode emissivity.

The unique test, for an instrument in this price range, is curve tracing. Most circuits are designed with the tube's family of characteristic curves in mind. When a circuit defect occurs, the curve is never given a thought.

To view the characteristic curve of a tube, the tester must be set up for a self-bias test. A resistor is connected in series with the cathode of the tube (Fig. 1). Connections are made through tip jacks on the panel and by setting a couple of selector switches to tap into the wires that go to the cathode and plate pins of the tube under test. (Since B-plus voltages are involved, it is best to make a test jig to hold the resistor and tie points for leads to the scope and tube-tester pin jacks.)

Changing the value of the self-bias resistor, the setting of the PLATE SHUNT switch and the GRID BIAS control will change the characteristic curve traced on the scope.

Of course, the more common tube tests can be performed on the Precise 111M. Internal shorts are indicated by a neon lamp—it lights when one tube pin (selected by a rotary switch) is shorted to another. All internal connections and filament pins are indicated on the roll chart.

Very sensitive noise tests can be made. Sparking and intermittent shorts will often show up in the usual short test, but oxide flakes and other high-

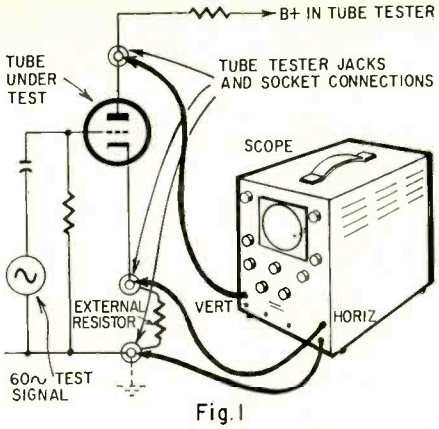


Fig. 1

resistance intermittents may not. So you connect the antenna and ground leads of an operating radio receiver to the NOISE and GROUND jacks of the tube tester. (The basic circuit is shown in Fig. 2.) With the radio tuned to a quiet spot between stations, gently tap the suspected vacuum tube. Repeat the regular short-test procedure—tapping gently as you switch from position to position. Noises in the radio indicate a bad tube.

The 111M tests ballast tubes, TV picture tubes and pilot lamps. And

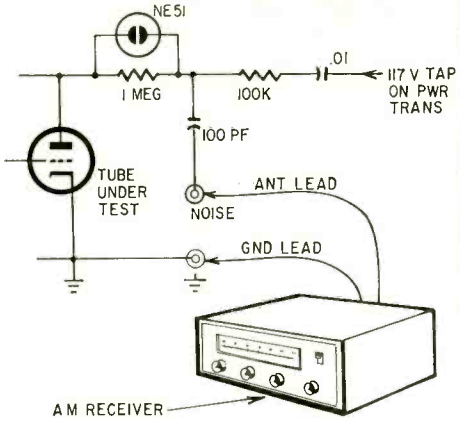


Fig. 2

transistors, diodes—even tetrode transistors.

For critical push-pull stages in hi-fi and industrial systems, the tester will help you balance tubes—for both transconductance and emission.

I chose the tubes in a 10-year old custom-630 TV chassis as the guinea pigs for my model 111M tests. Many of the tubes were the original ones. Most passed the emission test, but quite a few showed up as unsatisfactory during the conductance tests. New replacement tubes were tested before they were installed and showed considerably higher readings.

The double tests are ideal for preventive maintenance, and probably many of the "tough dogs" will be solved by more comprehensive tube testing.—*Elmer C. Carlson*

Price: 111MK, kit, $115.95; 111MW, wired, $199.95

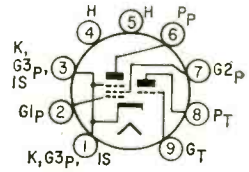
END

NEW SEMI-CONDUCTORS AND TUBES

NOW: HALF-FRAME GRIDS

You've heard of frame grid construction? Two new pentode-triode tubes for vhf TV front-end use *half*-frame grids in the pentode sections.

The Westinghouse tubes, called **6HJ7** and **6HD7,** are 9-pin miniatures in which triode and pentode sections share a common cathode. The sharing requires the use of half grids to keep the two sections electrically separate. The 6HD7 uses conventional half grids, but the 6HJ7's pentode section has a new half-frame grid, which gives it some 4 to 5 db more gain over the pentode in the 6HD7. Otherwise, both tubes are essentially the same.



6HD7, 6HJ7

Another innovation in the two new designs is a vibration damper, which rests on the common cathode and virtually eliminates low-frequency microphonics, a characteristic of earlier triode pentode tubes.

The triode section is said to cause negligible frequency variation (when used as a vhf local oscillator) with changes in supply voltage. This feature is particularly important for color television, where local-oscillator instability

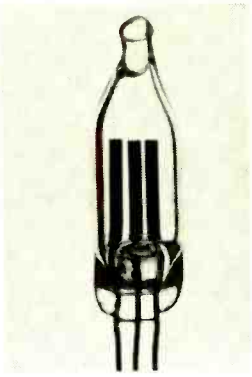
can produce shifts in hue.

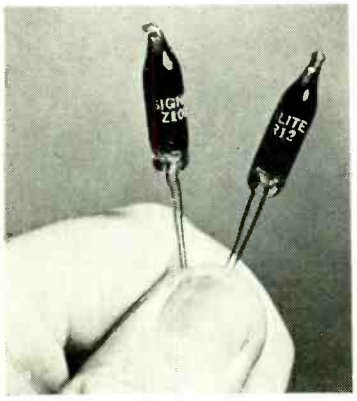
The 6HD7 pentode section (ordinary grid) has a transconductance of 8,000 μmhos; the 6HJ7 pentode section (frame grid), 13,000. The triode sections of both tubes have transconductance of 8,000 μmhos. Both sections of both tubes are designed for use with low B-plus voltages (100–150 volts).

Shielding in the pentode section results in a grid-to-plate capacitance of only .007 pf. The pentode is also shielded from the triode section.

HAIL THE DURABLE NEON

If you read Tom Jaski's "Why Glow Lamps Glow" in the February RADIO-ELECTRONICS, you know that neon lamps, unlike some other gas-and-glass components, are in little danger of being replaced—in the near future, anyway. One company in particular is actively exploiting the unique characteristics of neon lamps, and has made a science out of stabilizing the little things and rendering their performance more predictable. (Many experimenters have discovered that off-the-shelf, dime-apiece neons have too wide a tolerance to be useful for much more than pilot lights.)





Signalite, Inc., 1933 Heck Ave., Neptune, N. J., has just introduced a subminiature neon trigger tube for critical circuitry. It is a three-element device labeled TRQ250, intended for use in timers, ring counters, shift registers, memory cells, X–Y matrices, computer readouts, machine control and other related applications.

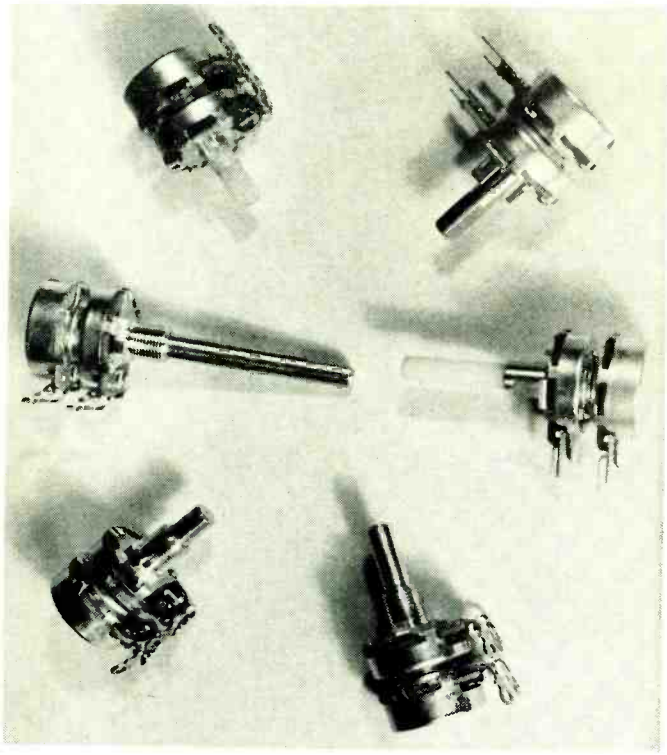
The tube is ionized (turned on) by a signal of 106 ±4 volts dc between trigger electrode and cathode. Its maintaining voltage, between anode and cathode, is 100 ±2 volts dc (in other words, within 2%), which is sustained until the circuit is interrupted. Operating current range is 1 to 6 ma; maintaining voltage is measured at 2 ma. Turn-on current is 1 μa maximum. Life expectancy for continuous operation is greater than 25,000 hours. Its standoff voltage (below which the tube will not ionize spontaneously, without being triggered) is 190 to 210 volts dc. The TRQ250 is less than ¼ inch in diameter, and 1 1/16 inches long. It is designed to be used with transistor circuitry.

Another Signalite component, possibly of more immediate interest to experimenters, is the Z100R12, a 100-volt reference tube (same size as the TRQ-250, above) *accurate to 1%!* It costs $3.50 in one-apiece quantities. (A 2% version, the Z100R12-1, costs $1.75.) The tube seems a natural as a calibration source, perhaps with a divider string of 1% resistors to give accurate voltages of 1, 10 and 100 volts dc. END

Attenuation in both sections of stereo loudness and tone controls must stay within a few db. How is it done? Where can you get close-tracking controls for replacement or home-brew?

STEREO CONTROLS AND YOU

By JAMES A. FRED



A STEREO LOUDNESS OR VOLUME CONTROL IS USUALLY A TANdem control—two potentiometers operated by one shaft. What makes it unique is that both sections must match each other in attenuation at almost every point along the control's rotation.

Set manufacturers have decided that, for their purposes, the threshold of audibility is a sound level of −60 db, and therefore they specify most stereo controls to match between front and rear sections from 0 to −60 db. For our discussion, we will consider the reference level 0 db as 10 volts rms, 60 cycles.

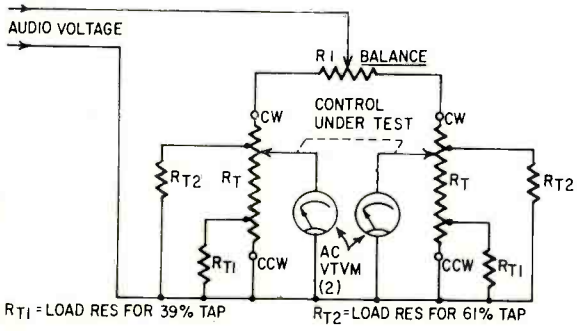


Fig. 1—Basic control-tracking test circuit used (in semi-automated form) by many manufacturers.

Most stereo manufacturers do not depend on the control maker's tests alone. Depending on the selling price of the stereo set, you will find varying degrees of testing. Inexpensive portable stereo record players have the poorest controls. The production line may use only a sampling plan for incoming inspection. A top-quality hi-fi component manufacturer would probably use a 100% inspection plan.

To use the circuit of Fig. 1, the technician chooses for each loudness-compensation tap a load that simulates the circuit in which the control will be used. The tap load for a control with one tap per section is 7.5% of the section's total resistance. If the control has two taps per section, the 39% (of mechanical rotation) tap will be loaded with a resistor equal to 5% of the section's total resistance. The 61% tap will be loaded with a resistor equal to 15% of the section's total resistance. (These are designated R_{T1} and R_{T2} in Fig. 1.) A 10-volt rms audio signal is applied to the clockwise end of the control through R1, a potentiometer of about 1-megohm resistance used to give a balanced reading on the vtvm's to start. As the control shaft is rotated, the vtvm's will indicate voltage picked off the control element by the contact arm. By using vtvm's calibrated in db, you can subtract one reading from the other and come out with the *tracking error.*

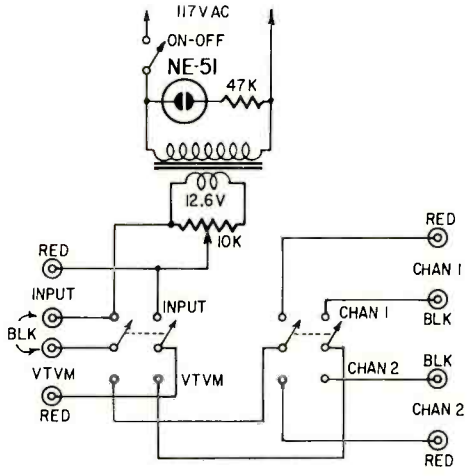
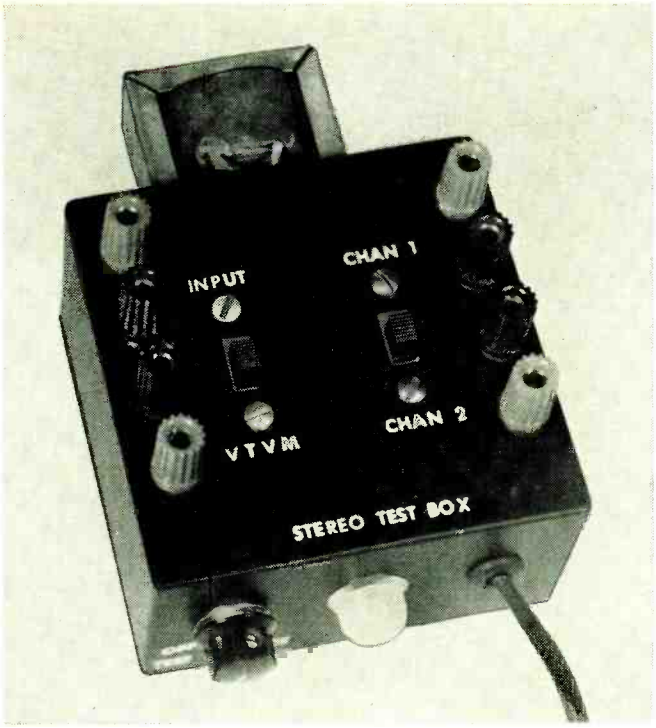


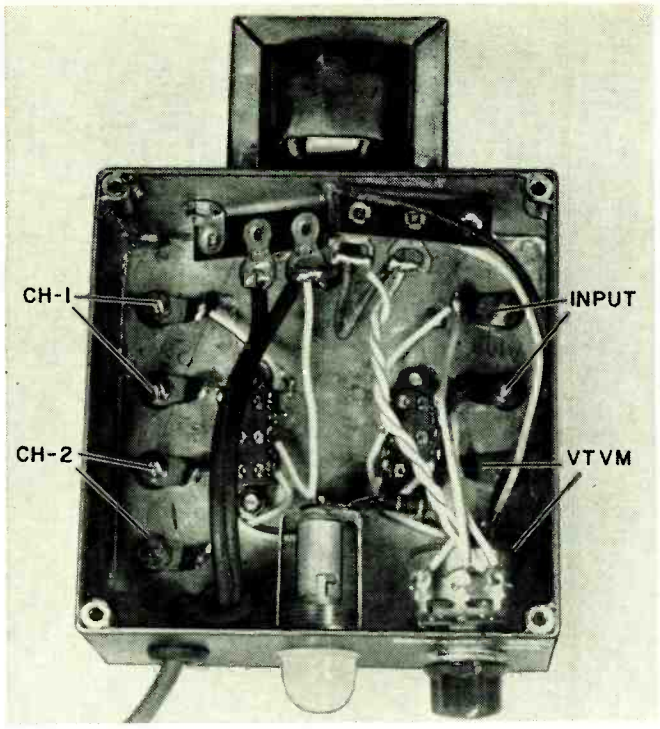
Fig. 2—Stereo-Test Box—simplified version of Fig. 1 circuit for home use. Needs only one vtvm. 12.6-volt transformer can be of any current rating—the smallest will do.

Control manufacturers use specifications on stereo control tracking recommended by the EIA (Electronic Industries Association). These specifications are listed in the table of "Classes of Tracking for Stereo Controls." High-fidelity manufacturers may use any one of these classes, depending on the quality of their stereo equipment.

A much simplified version of the test equipment usually used in a manufacturing plant is shown in Fig. 2. This stereo test box furnishes a variable ac voltage, a switching arrange-



Stereo Test Box with self-contained 60-cycle signal source is handy for checking stereo controls or complete systems for tracking. Voltage control pot and pilot are on chassis skirt.



Wiring details of Stereo Test Box. If you plan to use the circuit only a few times, perhaps a "haywire" temporary hookup would be better.

ment and binding posts for the control and vtvm. The switching allows you to get along with only one vtvm. You will need an external balance control of about 1 megohm.

To use the box to check stereo controls, measure the resistance of the control you are going to test. Figure the tap loads if the control has taps. Then, connect the control and box as shown in Fig. 3. Turn the control under test to the tap, or, if there are two taps, to the higher tap. Set the switches to INPUT and CHANNEL 1. Adjust the control on the test box (Fig. 2) until the vtvm reads 10 volts rms. Switch to VTVM and take the channel 1 reading. Switch to CHANNEL 2 and take a reading. Adjust the balance control until the readings are the same.

Turn the control under test fully clockwise. Read first channel 1, then channel 2. Record the difference between the two readings. Turn the control counterclockwise and take readings every 10% of rotation. Remember to take the readings on the db scale of the meter and change ranges so that your readings fall in the upper third of the meter scales. When you finish, you will know how well the control tracks.

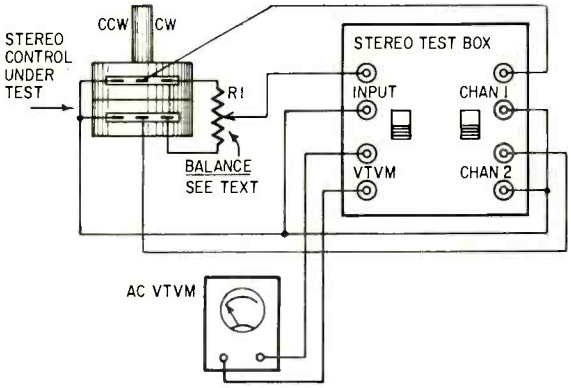


Fig. 3 —How to connect a stereo control and initial-balance control to test box.

You can also use the stereo test box to check a stereo amplifier. To do this, connect as shown in Fig. 4. Feed enough audio voltage into the stereo set inputs to give reasonable vtvm readings at the lowest audible volume setting.

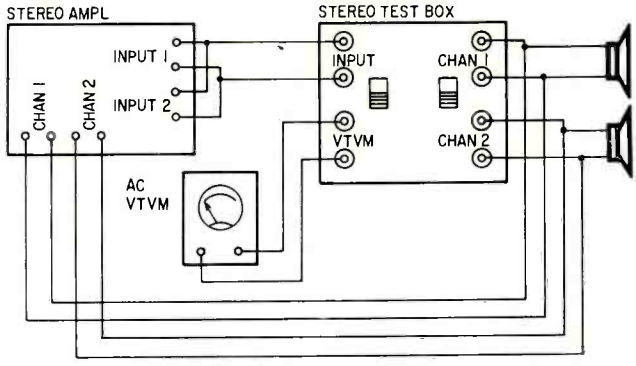


Fig. 4—How to connect a stereo amplifier and speakers to the test box.

As you advance the loudness control, take readings alternately on channel 1 and 2 as you did before. Compare the readings to get the db difference between the two channels.

How can you buy closer-tracking controls if you need them? I wrote to the Distributor divisions of Centralab, IRC, Clarostat and Mallory to see if they had special stereo controls that were matched to any specifications. As of mid-1965, none of these companies would guarantee the tracking of their controls. Several furnish snap-together control sections with a tolerance of ±20%. Chances are that with a random selection of parts you would never get a very good stereo control. The best thing to do would be either to buy an original equipment replacement part or to sort through several controls until you get one that matches to your satisfaction. Several of these companies plan to bring out matched controls sometime in the future. END

Make a High-Power PA Load

Neat, compact dummy load speeds checks on large PA systems

By WILLIAM F. KERNIN

THE TOTE-A-LOAD WAS DEVELOPED TO handle a particular problem: measuring outputs of audio amplifiers—especially big ones.

The industrial service technician has the same responsibility as the TV service tech on a house call—to present a neat and efficient-looking appearance in his work and equipment. He must choose his test equipment wisely for maximum utility in a minimum of space. (Ask any technician who has lugged a scope, full-size audio oscillator, vtvm and tools around for a while.)

To measure the power output of an audio amplifier in industry, a resistance load of ample wattage can be connected to the output of the amplifier and an audio signal around 1 KHz fed to the input. The ac voltage developed across the load resistor is measured with an audio-frequency vtvm. From the equation $P = E^2/R$, the power developed by the amplifier can be calculated easily.

The Hi-Fi boys may shudder at this. But for industrial repairs, this procedure is fast and efficient. And in industry, time is money.

The Tote-A-Load is a composite load resistor in a neat package. You can switch for 16 ohms at 150 watts or 8 ohms at 75 watts maximum power dissipation.

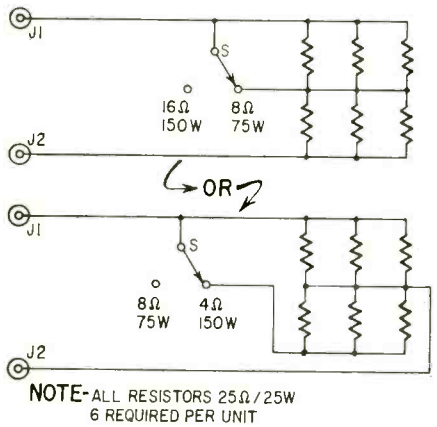


Fig. 1—Two alternate forms of the dummy load box: 8 ohms, 75 watts and 16 ohms, 150 watts; or 8 ohms, 75 watts and 4 ohms, 150 watts. Take your choice, or build two.

To reduce the number of instruments needed, an accurately calibrated vom of 20,000 ohms/volt—our service workhorse—is substituted for the vtvm.

Fig. 1 shows the wiring of the unit and the parts needed. The load is made up of six 25-ohm 25-watt wirewound resistors. Switch S selects six resistors for the 16-ohm, 150-watt rating or three resistors for the 8-ohm 75-watt rating. If you prefer, the switch can be wired to select 8 ohms at 75 watts or 4 ohms at 150 watts, as shown in the diagram. The double banana-jack–binding-post terminals are the input connections.

The actual values work out to 16.7 and 8.3 ohms. But considering the accuracy of the wirewound resistors and the type of service for which the unit is designed, that's close enough.

The unit is small and compact—about 6½ inches long by 3 inches wide by 1½ inches high. No. 10 bare wire is used for all connections, making the resistor assembly rigid. The bus wire at the back of the unit secures the assembly to the chassis by a ground lug bent around the bus, soldered to it and bolted to the chassis. See the photographs for details.

The main chassis is made from 1/16 inch aluminum sheet—or whatever you have on hand. Layout is shown in Fig. 2. Drill the holes first and then bend the chassis.

Mount the switch and input terminals. Wire up the resistors as a unit, install them in the chassis and secure the rear end of the assembly to the chassis with the ground lug. The front end is secured by the connections to the switch and one terminal.

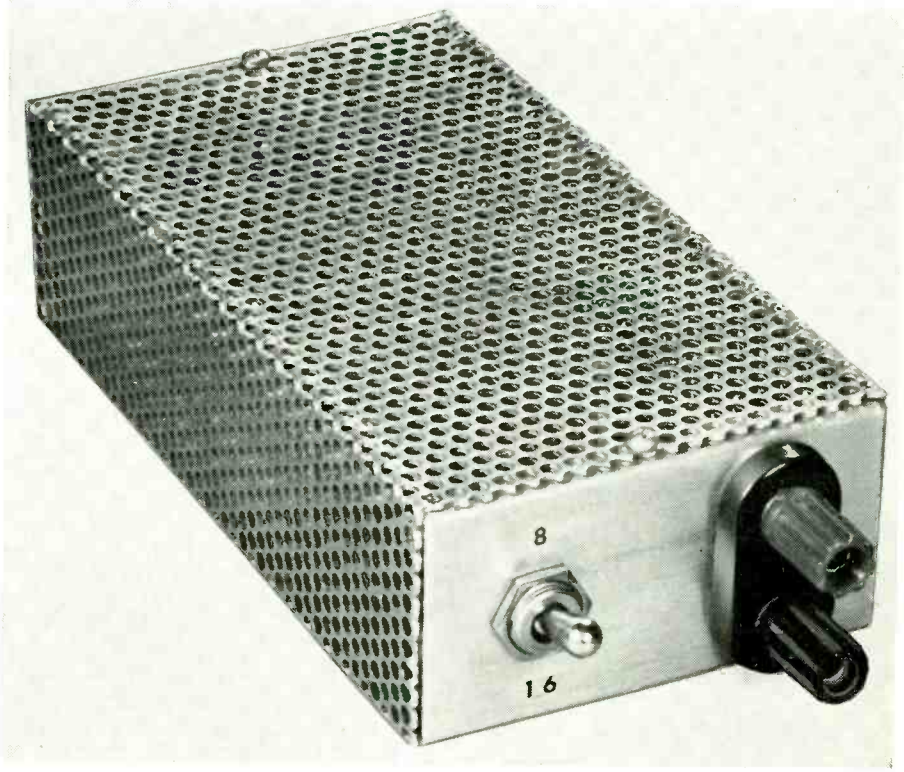
Six 25-ohm 25-watt wirewound power resistors
S—spdt switch
J1, J2—Dual 5-way binding post (GC 33-276 or equivalent)
No. 10 bare wire, 1/16 inch aluminum sheet, perforated aluminum sheet, solder ground lug, hardware

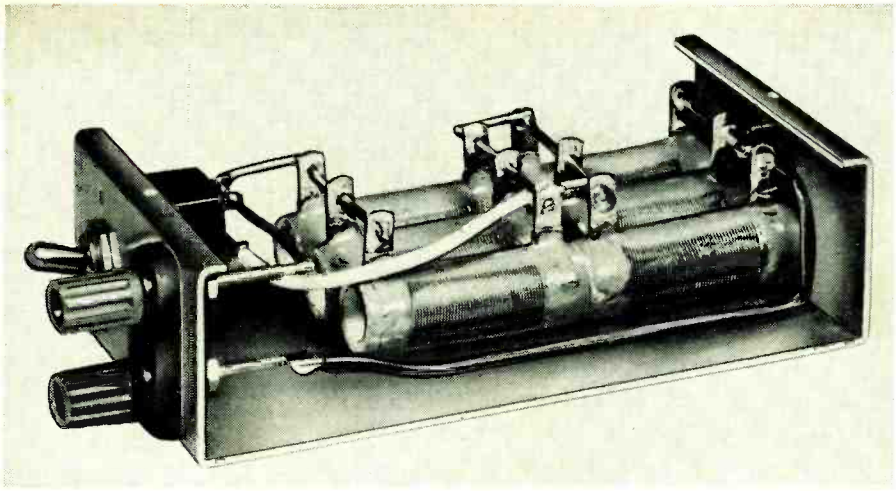
For the cover, I used perforated aluminum sheet for ventilation and looks. Polish the cover and chassis with steel wool, apply appropriate decals and spray on a couple of light coats of clear Krylon.

Using the load

To use the load, run wires from the load terminals to the output of the amplifier under test. Connect an audio vtvm across the load terminals and throw S to either 8 or 16 ohms, as the amplifier requires. Apply a 1-KHz sine wave of sufficient amplitude to the amplifier input and read the output voltage. Figure power by squaring the voltage and dividing that figure by the load you used (8 or 16 ohms).

Now to calibrate the vom. Connect it across the load terminals in parallel with the vtvm. Set the vom to the appropriate ac range. Vary the 1-KHz input signal to produce desired output voltage steps as indicated on the vtvm. For ex-





Connections of No. 10 wire make Tote-A-Load sturdy and reliable. One end of resistor string is common to metal chassis.

ample, for the 50-volt range, 5-volt steps would be about right. Note the reading on the vom as compared to the vtvm.

Suppose the input voltage is adjusted so that the vtvm reads 10 volts rms. The vom reads 9.8 volts rms. Thus, this vom reading corresponds to 10 volts true reading.

Any discrepancy between the vtvm and the vom can usually be attributed to the frequency response of the vom. Calibration of a model 260 Simpson vom used with this setup against an audio vtvm offered no problem. Three of these instruments had a frequency response up to 10 KHz on the three ac ranges—2.5, 10 and 50 volts—within the specified accuracy of the meter.

As long as the ac scales are calibrated at 1 KHz against a vtvm with good audio-frequency response, the vom can be used accurately with the Tote-A-Load, provided 1 KHz is used for the input frequency.

When you'd use it

Let's run through a typical test. The plant PA system is out. First, check for tubes being lit and B-plus being up to snuff. Look OK? Turn off the power, disconnect the speaker distribution system and hook up the Tote-A-Load and vom. Since there is normally 100 watts perking through here, use the 50-volt ac scale with the 16-ohm load. Hook up a suitable 1-KHz oscillator to the microphone input and turn on the amplifier power.

With the amplifier gain control wide open, the oscillator amplitude is varied but the vom needle barely budges. Skip over to the phase inverter grid with the oscillator. Plenty of power coming out now. The vom reads about 25 volts—around 40 watts of power. So now inject the audio signal into successive stages, back toward the input. Oh-oh! The output signal just went. This stage must be kaput. A little more probing around and you've found your trouble.

The speakers had to be disconnected—can't have 1 KHz wailing through the plant. And a lot of time was saved by using a dummy load and the handy signal-injection troubleshooting method.

A bit of advice. A 50-watt soldering iron puts out a lot of heat and you wouldn't pick it up by the hot end. The same for the load. So, when you service at high power levels, it is best to apply power to the load intermittently—say a few minutes at a time. Also, put a piece of asbestos under the case of the Tote-A-Load to prevent it from scarring any surface it's on. I usually carry an asbestos pad in my tool box to lay the soldering iron on while I work.

The Tote-A-Load system has been used in setting up power amplifiers and running performance checks on them. It can be used for periodic checks on production equipment using power amplifiers. With a battery-powered 1-KHz transistor sine-wave oscillator with a calibrated amplitude control, no ac power would be required for the test gear. This may seem a small matter, but you can waste lots of time just looking for a suitable ac outlet to power a vtvm and oscillator, especially on a production line.

Many other uses for the system suggest themselves—servicing church sound systems, intercoms, hospital paging units, military base and hangar paging systems, and so on. Whenever you need a substitute load in place of the original speakers, drivers, transducers, vibrators, what have you—the Tote-A-Load and vom can usually solve the problem nicely. END

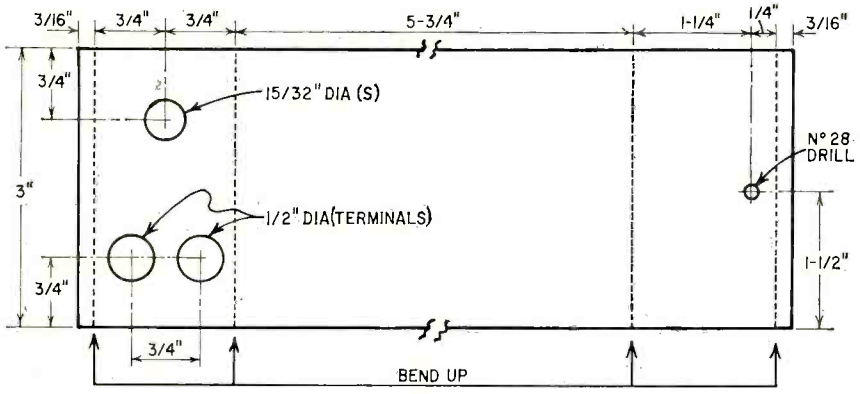


Fig. 2—Chassis layout and dimensions. Aluminum sheet 1/16 inch thick is good to use. Make a cover to fit if you wish. Different terminals may require different mounting holes.

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Hz = Hertz = cycles per second; KHz = kilocycles; MHz = megacycles

4-SPEED STEREO AUTOMATIC/MANUAL TURNTABLE, the *Princess Deluxe, model RCD-4.* 11-in. turntable and anti-static mat; 4-pole balanced motor resiliently mounted; built-in stylus brush; built-in muting switch; built-in 45-rpm centerpiece and removable spindle; automatic tone-arm locking. 10-record intermix play on automatic.—**RFS Industries, Inc.**

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70-WATT FM-AM—FM STEREO RECEIVER, *Knight KN-376,* uses 44 semiconductors. Amplifier: 70 watts IHF, 35 watts per channel, 140 watts peak, 20 watts per channel continuous sine wave power; response 20–20,000 Hz; 1% harmonic distortion at full power; less than 1% intermodulation distortion at normal listening level; ±½ db, 30–20,000-Hz

power bandwidth; input sensitivity, magnetic phono 4 mv, tape head 4.5 mv, aux 2, 0.5 v, aux 1, 1 v; hum and noise —75 db on aux, tuner, —60 db on phono, tape head; output impedance 4, 8, or 16 ohms; low-Z headphone jack matches 4- to 25-ohm headsets. Tuner: IHF FM sensitivity 3 μv (2 μv for 30 db quieting); i.f. bandwidth 300 kHz; FM distortion 0.5% at 100% modulation; 3-db capture ratio; AM suppression 48 db; stereo separation 30 db; AM sensitivity 5 μv for 20 db S/N. 17¾ x 13⅜ x 6 in.—**Allied Radio Corp.**

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CAR STEREO TAPE PLAYER, *model C-502,* chrome finish. Plays up to 2 hours at 3¾ ips. 4-track dual-head playback method; capstan drive; 12 transistors. Response 100–10,000 Hz. Harmonic distortion less than 5%. Channel separation: better than 35 db. Speaker impedance 4 to 8 ohms per channel. Power: 10–16 vdc, 1 amp, for positive or negative ground. Complete tape library available. 9½ x 3½ x 9¾ in., 13 lb.—**Craig Panorama, Inc.**

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160-WATT ALL-SILICON AMP/PREAMP, the *S-9000a.* Power output: 160 watts IHF music power, both channels, 8 ohms; 120 watts continuous sine wave, both channels, 8 ohms. Power bandwidth 12–25,000 Hz at 0.5% harmonic distortion. Harmonic distortion 0.25% at rated output; .57% at 10 watts or below. Intermodulation distortion 0.25% at rated output, 0.10% at 10 watts or below. Damping factor 40. Hum and noise: phono —70 db, tuner —80 db. Sensitivity: tape head 0.6

mv; phono 1.8 mv; tuner 0.25 v. Baxandall tone circuits. 3 pairs high-level inputs; 2 pairs low. Outputs: 4-, 8-, or 16-ohm speakers, stereo recorder, stereo headphones. Power consumption: 30–150 watts. 23 silicon transistors, 4 silicon rectifiers. 14 x 12½ x 4 in., 24 lb.—**Sherwood Electronic Laboratories, Inc.**

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FM TUNER IN RACK PANEL. The *model 481* is designed for background music and commercial sound installations. Range 88 to 108 MHz, sensitivity less than 2 μv. 300-KHz bandwidth; response 20–

20,000 Hz ±1 db. Afc circuit, output jack for multiplex adapter. Power consumption 21 watts. Low-silhouette cabinet 9½ x 7 x 2 15/16 in. or standard 3½ x 19-in. rack panel. Escutcheon is removable from panel.—**Trutone Electronics, Inc.**

Circle 50 on reader's service card

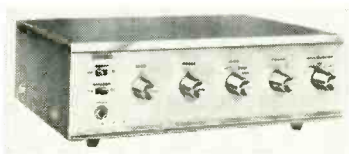
DYNAMIC STEREO HEADPHONES, *B-HM-16.* Sensitivity: 108 db at 1,000 Hz. Response 40–15,000 Hz. Impedance 16/16 ohm.—**Permoflux Corp.**

Circle 51 on reader's service card

BOOK-SIZE CORDLESS TAPE RECORDER, the *Charger,* operates for 4 hours on built-in rechargeable nickel cadmium power cell, plugs into ac outlet to re-

charge. Response: 200–6,000 Hz at 3¾ ips. 40 db signal-to-noise. Erase —40 db. Track separation: 50 db. Power output 800 mw peak music power. Capstan-driven.—**V-M Corp.**

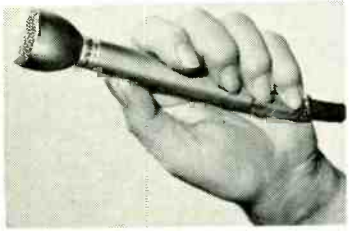
Circle 52 on reader's service card



40-WATT SOLID-STATE STEREO AMPLIFIER, *model LA-340A.* 5 pairs of stereo inputs accommodate tuner, phono

with magnetic or ceramic cartridges, tape recorder and auxiliary sources. Response ±1 db, 30–20,000 Hz; 1% harmonic distortion; hum and noise —70 db (tuner), —56 db (aux). Outputs 4–16 ohms impedance, 2 high-impedance for tape recording; equalizations NAB and RIAA. For 117 volts, 50/60 Hz. 11¾ x 3¾ x 10½ in. Gold extruded-aluminum front panel.—**Lafayette Radio Electronics Corp.**

Circle 53 on reader's service card



BROADCAST MICROPHONE FOR HOME TAPE RECORDING, the *E-V 635A*, weighs 6 oz, is big around as a dime. Internal shock absorber; 4-stage filter against "pops" and wind noise. Response 60–15,000 Hz; output —55 db. Available in low Z only.—**Electro-Voice, Inc.**

Circle 54 on reader's service card

SOLID-STATE STERECORDER, *model 660*, has automatic tape-reversing action triggered by 10 seconds of silence. Develops 50 watts per channel. Power: 115 v, 60 Hz; 150 v, 50 Hz optional. 7½

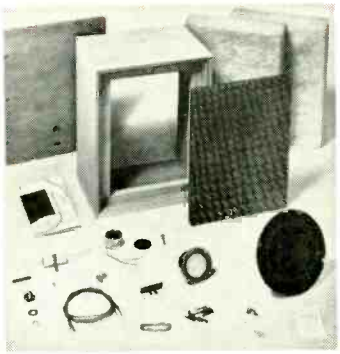
and 3¾ ips. Response: 30–18,000 Hz, 50–15,000 Hz ±2 db. Signal-to-noise ratio 50 db or better. Flutter/wow less than .06% at 7½ ips; less than .10% at 3¾. Bias frequency 100 KHz. 2 VU meters. 17 x 17 x 10¾ in., 55 lb.—**Sony Superscope.**

Circle 55 on reader's service card

35-WATT FM/AM RECEIVER, PAGING AMPLIFIER, the *MusiCall model BC-350*, for stores, restaurants, factories. Priority paging silences system when desired. Can be used with phono table, tape recorder, tape deck. Audio output of push-pull amplifier circuit rated at 35 watts at sine-wave input; 1.5% distortion. Paging volume preadjusted at time of installation for constant-level output.—**Fanon Electronic Industries, Inc.**

Circle 56 on reader's service card

COMPACT SPEAKER-SYSTEM KIT, *model RM-1K*. 6-in. linear high-compliance acoustic suspension woofer; 2½-in. high-frequency wide-dispersion tweeter with calibrated level control to adjust highs. Response is 45 to 20,000 Hz. Power



handling 40 watts average—80 watts peak (minimum input of 10 watts required). Impedance 8 ohms; crossover frequency 5,000 Hz. 14½ x 10½ x 7¼ in., 12 lb. Unfinished birch veneer; ½-in. nonresonant panels.—**Sonotone Corp.**

Circle 57 on reader's service card

60-WATT AM/FM MULTIPLEX STEREO RECEIVER, *model TK-60*. Music power 60 watts (IHF standard at 4 ohms); 50 watts (IHF standard at 8

ohms); response 20 Hz—70 KHz ± 1 db. 4-gang tuning capacitor. 5 i.f. stages with 3 noise limiters and wide-band ratio detector.—**Kenwood Electronics, Inc.**

Circle 58 on reader's service card

100-WATT SOLID-STATE FM STEREO RECEIVER, the *Stratophonic SR-900B*. At full 100 watts bandwidth is 5–100,000 Hz. D'Arsonval tuning meter. Automatic FM stereo indicator light.—**Harman-Kardon, Inc.**

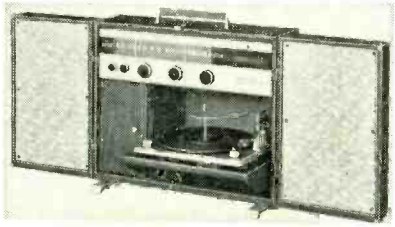
Circle 59 on reader's service card

4-TRACK STEREO TAPE DECK KIT, the *Knight-Kit Superba KG-415*, with Viking tape transport, capstan motor. Overall record/play frequency response: ±2 db, 50–18,000 Hz at 7½ ips; ±2 db, 50–14,000 Hz at 3¾. Flutter/wow less than 0.2% rms at 7½ ips. Signal-to-noise

ratio: 50 db or better. Harmonic distortion less than 1.5% at 0 VU. Fast-forward time: 1,200 ft in 60 sec. Rewind time 1,200 ft in 90 sec. 17 transistors, 6 diodes. Input impedance: mike 3,000 ohms; line 50K ohms. Input sensitivity: mike 1.5 mv for 0 VU; line 100 mv for 0 VU. Output impedance: playback 250 ohms; monitor/playback 250 ohms; source 1,000 ohms. Monitor output; modular amp drives low-Z stereo headphones. Bias/erase 80 kc. 1-kc test oscillator. 14½ x 14 x 8 in., 30 lb. **—Allied Radio Corp.**

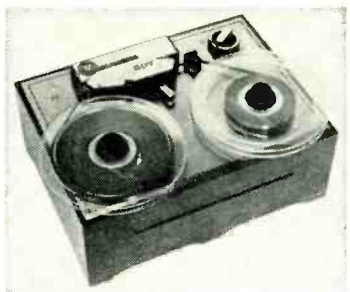
Circle 60 on reader's service card

PORTABLE TABLETOP STEREO, the *Stereo Duet,* combines AM–FM–stereo–FM radio and stereo phonograph. 4-speed record changer. Micro-Touch 2G tone arm with ceramic cartridge. Stylus



cleaning brush. Diamond and manufactured-sapphire styli. Swing-out, removable speaker units, 8-in. woofer and 3½-in. tweeter in each. Dual-channel amplifier. Dial lights, 45-rpm adapter.**—Zenith Sales Corp.**

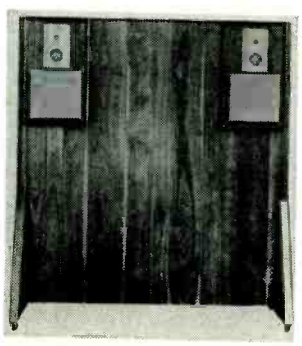
Circle 61 on reader's service card



TAPE TURNTABLE, *model 807,* is a tape playback unit without electronics. Connects to tape head or magnetic phono inputs of music-system amplifiers. Response: 30–18,000 Hz at 7½ ips; 30–12,000 Hz at 3¾. Capstan and reel motors: 4-pole, 115-volt, 50/60-Hz. Flutter and wow less than 0.2% rms at 7½ ips. 1,200-ft reel fast-forward time: 60 sec; rewind time 90 sec. 6½ x 13½ x 10 in. without reels, 15½ lb.**—Viking of Minneapolis.**

Circle 62 on reader's service card

CUSTOM SPEAKER INSTALLATION, the *Wall of Sound,* consists of 12-



in. woofer, high-frequency and mid-range speakers in one package in acoustical lens assembly. Crossover network built in. Walnut mounting frame included in unit. **—Empire Scientific Corp.**

Circle 63 on reader's service card

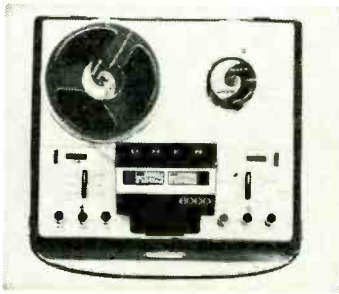
SMALL PHOTOMULTIPLIERS, the *XP1110* (formerly 152AVP), available in S-1, S-13, S-20 and S-11 photocathodes. Hemispherical dynodes mounted between rugged ceramic bars, supported by rigid leads. Measures 0.75 in. at broadest diameter, 4 in. long.**—Amperex Electronic Corp.**

Circle 64 on reader's service card

SOLDERING IRON KIT, the *Marksman SP-23K,* includes 23-watt iron

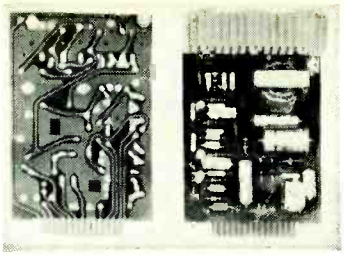
(pencil style), 3 soldering tips, 5 ft of 60/40 rosin-core solder, soldering-aid tool, instructions.**—Weller Electric Corp.**

Circle 65 on reader's service card



4-TRACK STEREO TAPE RECORDER. the *Uher 8000E* (revision of 8000), all solid-state. 4 speeds, reel size up to 7 in. Response: 50–20,000 Hz ±3 db at 7½ ips; 50–16,000 Hz ±3 db at 3¾ ips; 50–8,000 Hz ±3 db at 1⅞ ips; 50–4,000 Hz ±3 db at 15/16 ips. Channel separation 50 db. Wow and flutter ±0.15% at 7½ ips (audible frequency only). Output power 2 watts each channel. Power 117 v, 60 Hz ac, 30 watts. 14 x 3 x 7 in.**—Martel Electronics**

Circle 66 on reader's service card



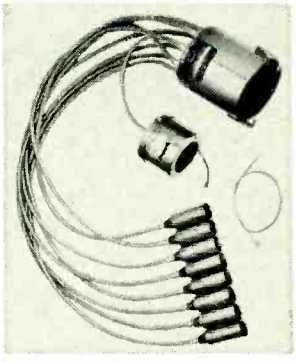
AUDIO AMPLIFIER, *model 200.* Designed for use with audio–visual sound/projector. Output 5 watts max. Response: 50–15,000 Hz ±1 db. 5% distortion at full output. Input sensitivity 100 μv full output. Input impedance 150 ohms standard; 400, 1,000 and high as optional. Supply: 12–24 vac; 12–30 vdc. Power consumption: 0.5 watt, no signal; 8.2 watts, full signal. −40°F to +160°F ambient operational temperature. Relay power (coil): 6 vac standard, other voltages 6–30 vdc, 6–36 vac available.—**Arkay International, Inc.**

Circle 67 on reader's service card

UNIDIRECTIONAL MICROPHONE, *model 580 Unidyne A.* Available in high- (*580SA*) and low- (*580SB*) impedance units. *580SA* available in matched pairs for stereo recording. Both mikes matched to within 2 db frequency

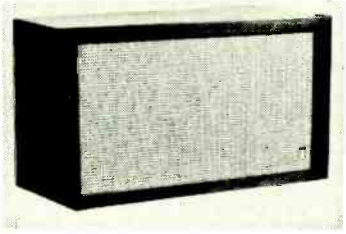
response. Plugs attached to fit most tape recorders. Adjustable stand adapter permits microphones to be tilted through arc of 90°, vertical to horizontal. Output of *580SA* is −59 db (0 db = 1 volt per microbar); *580SB* −58 db (0 db = 1 mw per 10 μbars). Cardioid pickup pattern.—**Shure Bros. Inc.**

Circle 68 on reader's service card



IGNITION SHIELDING SYSTEM, *Signal Savers,* suppresses rf interference generated by internal combustion engines. Features: distributor cap shield for arc-over protection; feedthrough capacitor to ignition hot-lead switch eliminates conducted interference; abrasion and corrosion-protected plug shields; ignition cable certified to −65°F to +250°F; Warranty; approved by military.—**Hallet Mfg. Co.**

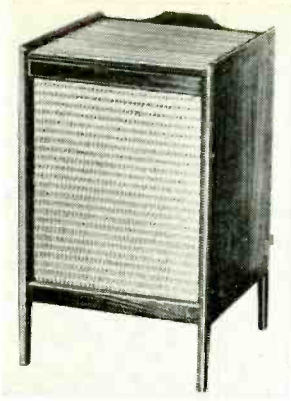
Circle 69 on reader's service card



8-OHM TWEETER, installed in Jensen's TF-3 bookshelf speaker system, (system now called TF-3A) improves power output above 10,000 cycles by 3 db. System rated at 25 watts.—**Jensen Mfg. Div.—Muter Co.**

Circle 70 on reader's service card

3-WAY SPEAKER SYSTEM KIT, *model AS-15,* has 4 speakers: one 12-in. high-compliance, low-resonance woofer with 1½-in. voice coil and ceramic ring magnet (free-air resonance 25 Hz); two 2-in. direct-radiator dome-type mid-range speakers with 6¾-in. frames and 4½-in. ceramic ring magnets; one 1-in. direct-radiator dome-type ultra-high-frequency tweeter, 4¾-in. frame, 2¼-in. ceramic ring magnet. 40–20,000-Hz response; high- and middle-frequency attenuators; 3-way



L-C and R-C crossover networks at 1,000 and 10,000 Hz. Walnut finish, floor model cabinet: 18½ x 19 x 32⅜ in.—**Heath Co.**

Circle 71 on reader's service card

BATTERY-OPERATED TAPE RECORDER, *model 350,* automatically reverses tape, will record for 6 hours at 1⅞ ips. Uses 5-in. reels. 9 transistors, 1 diode. 3 x 6-in. 8-ohm speaker; stop/start remote dynamic type mike. 4-pole dc motor, with special platinum-coated governor. Power: 6 D-batteries or optional ac. Battery life over 10 hours. 11½ x 11 ½ x in., 10 lb.—**Concord Electronics Corp.**

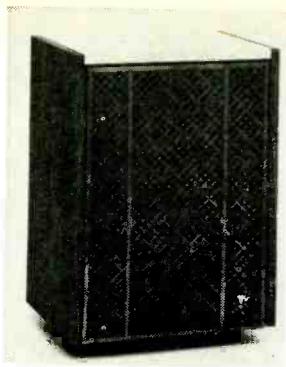
Circle 72 on reader's service card

TWO NEW SPEAKERS, *12U10* (12-in.) and *15U10* (15-in.) are adaptable to full-range use or as woofers. They

handle up to 100 watts music power. Each has 3½-lb Alnico V magnet, 3-in. diameter voice coil, built-in heat sink, rear air vent. —**Oxford Transducer Co.**

Circle 73 on reader's service card

MODERATE-SIZE SPEAKER, the *Lancer 101,* has hand-carved fretwork grille and Adriatic marble top. Components include 14-inch long-throw linear efficiency woofer and massive horn-loaded



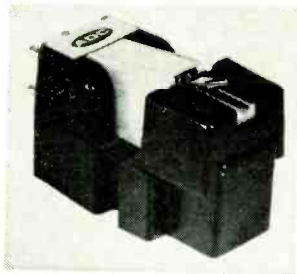
high-frequency assembly with 14-element acoustic lens.—**James B. Lansing Sound, Inc.**

Circle 74 on reader's service card

WEATHERPROOF OUTDOOR SOUND COLUMNS, the *Argonaut,* 8 speakers with wide side-to-side sound pattern. Sound level doesn't have to be high to cover audiences of 1,000 or more. Tested by Inland Testing Labs, warranted for 3 years.—**Argos Products Co.**

Circle 75 on reader's service card

CARTRIDGE, *ADC 10/E,* has minute moving system performing below critical point of record groove yield. Induced magnet type; sensitivity 4 mv at 5.5 cms/sec recorded velocity. Channel separation 30 db, 50–10,000 Hz. Response 10–20,000 Hz ±2 db. Elliptical stylus:



contact radius .0003 in.; lateral .0007 in. Vertical tracking angle 15°. Tracking force range ½ to 1 gram. IM distortion less than ½%—400 and 4,000 Hz at 14.3 cm/sec velocity. Compliance 35 × 10^{-6} cm/dyne.—**Audio Dynamics Corp.**

Circle 76 on reader's service card

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

LINE RADIATOR, *LR4SA.* 40 watts program power-handling capacity; extruded-aluminum case, black metal front grille; generates sound pressure of 116 db at 4 ft on axis with 40 watts input. 160° horizontal and 30° vertical dispersion pattern.—**Electro-Voice, Inc.,** Buchanan, Mich. 49107 END

NEW LITERATURE

All booklets, catalogs, charts, data sheets and other literature listed here are free for the asking with a Reader's Service number. Turn to the Reader's Service Card facing page 80 and circle the number of items you want. Then detach and mail the card. No postage required!

ZENER & REFERENCE DIODE SELECTION GUIDE, designed for desk, wall or 3-ring binders, covers more than 4,000 industrial and Mil-type Zener and temperature-compensated reference diodes.—**Motorola Semiconductor Products Inc.**

Circle 77 on reader's service card

TAPE, PHONO, AUDIO ACCESSORY CATALOG, *659C,* hundreds of items including recording heads, patch cords, adapters, audio connectors. New items are TK-9 Tape Editing Workshop and PK-10 Phono and Record Care Kit.—**Robins Industries Corp.**

Circle 78 on reader's service card

INSTRUCTION BROCHURE, "How to Build the AR Component Shelf", 4 pages. The shelf hooks over a single strip that can be attached simply to any wall that has studs.—**Acoustic Research, Inc.**

Circle 79 on reader's service card

SPEAKER SYSTEM CATALOG, enclosures, amplifiers, energizers, foldout pamphlet, photos, price list.—**James B. Lansing Sound, Inc.**

Circle 80 on reader's service card

1966 TAPE RECORDER CATALOG, 20 pages, photographs with op-art backgrounds, specs of 14 recorders, 13 mikes, 3 types of tape, accessories. Among new features is automatic-reverse recorder.—**Sony/Superscope**

Circle 81 on reader's service card

1966 GUIDE TO CUSTOM STEREO, 20-page brochure has photographs, descriptions and specs of complete line of components, kits and speakers.—**H. H. Scott, Inc.**

Circle 82 on reader's service card

PA AMPLIFIER CATALOG, 2 pages, gives specs, photos, on ME-10, ME-25, ME-40 compact public-address amplifiers.—**Harmon-Kardon**

Circle 83 on reader's service card

GERMANIUM TUNNEL-DIODE BROCHURE, *SM 2934,* describes, with characteristics and structural diagrams, solid-structure tunnel diodes, 20 mils square, that can be assembled directly into thin-film integrated circuits.—**Sylvania Electric Co.**

Circle 84 on reader's service card

ANTENNA BROCHURE, 4 pages, of log-periodic antennas, photos, prices. Includes reprint of newspaper piece on University of Illinois Foundation, where these antenna designs were developed.—**JFD Electronics Corp.**

Circle 85 on reader's service card

WINTER CATALOG, *No. 662,* 108 pages. Latest in CB, stereo, high-fidelity, amateur equipment, tape recorders, test equipment, automotive accessories, photographic equipment, new closed-circuit TV systems, portable radios, etc. Illustrated.—**Lafayette Radio Electronics Corp.**

Circle 86 on reader's service card

CATALOG, *1500,* describes TACO line of antennas designed for use in 2,500-MHz band assigned to ETV; photos, specs, curves.—**Jerrold Electronics Corp.**

Circle 87 on reader's service card

BULLETIN, *No. 49, Standards for Industry.* 4-page, punched list of formulas and conversions: typical test setups, return-loss VSWR chart, dbmv-microvolt chart (0 dbmv equals 1,000 μv across 75 ohms), transformation formulas.—**Blonder-Tongue**

Circle 88 on reader's service card

VARIABLE TRANSFORMER CATALOG, *P1065G,* 76 pages of characteristics, outline dimensions, connections, charts, illustrations or Powerstat line of manual and motorized 50/60-Hz variable transformers.—**Superior Electric Co.**

Circle 89 on reader's service card

THERMISTOR LITERATURE. *EM14, Thermistor Probes,* 8 pages, punched; diagrams of standard thermistor probe assemblies. Bulletin L-1, *Thermistors, Their Characteristics and Uses,* 4 pages.—**Fenwal Electronics, Inc.**

Circle 90 on reader's service card

MINIATURE ELECTROLYTIC CAPACITORS, 4-page catalog, specs, dimensional drawings and curves of axial lead and printed-circuit lead electrolytic capacitors.—**Centralab**

Circle 91 on reader's service card

SHORT-FORM COAXIAL SWITCH CATALOG, *No. CS-5.* Illustrations and technical information on 23 series of switches, with section on modular Dynaform switch series. 16 pages.—**Amphenol RF Div.**

Circle 92 on reader's service card

FERROXCUBE ENGINEER, *Vol. 7, No. 3,* subtitled "How Square the Loop . . . How Wide the Shmoo?". Lead article discusses "user-oriented" high-speed digital computer which uses Ferroxcube memory stack.—**Ferroxcube Corp. of America**

Circle 93 on reader's service card

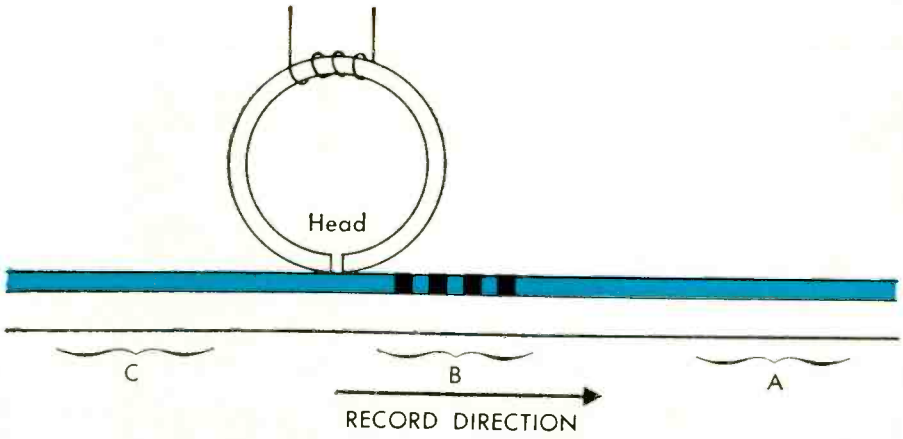


Fig. 1—Recording process leaves magnetized regions along tape. They behave like any other magnets and can affect adjacent layers of tape on a reel.

LONG LIFE FOR YOUR TAPES

By RAYMOND C. SMITH*

TO THE PROFESSIONAL TAPE DUPLICATOR, magnetic printing—the transfer of a recorded signal from a layer of magnetic tape in a roll to its adjacent layers—can be a bothersome problem.

On home recording equipment, print is usually lost in the noise level of the system. However, on professional equipment, print becomes more noticeable because of the greater dynamic range of the system. Engineers who duplicate tapes can minimize magnetic printing by storing master tapes on the takeup reel—tail-end out—and rewinding just before using. These recordists include some of the more serious amateurs as well as professionals who make master tapes for disc or tape duplication. They have a need for tape that reduces the print level below that available from general magnetic sound tapes.

Print

Since the amount of print received by a given section of tape depends (among other things) upon the separation of that section from the section carrying the printing signal, the next outer layer of tape from the printing signal in a normal oxide-in wind will receive more print than the next inner layer. This is true because the printing field, to produce significant print, must reach the top surface of the oxide coating of the section undergoing print.

Thus, to print the next outer layer of the tape, the printing signal must pass through the thickness of the base material only. But to print the next inner layer of the tape, the printing signal must pass through both the thickness of the base and the additional thickness of a layer of oxide.

This you can easily see in the illustrations, whose elements have been blown up for clarity.

Fig. 1 shows recording direction. Fig. 2 shows tape stored on the takeup reel, with section C undergoing maximum print. On playback, section C goes past the playback head after the printing signal and is heard as post-print. Fig. 3 shows tape rewound to and stored on the stock reel, with section A receiving maximum print. On playback, section A precedes the printing signal past the head and appears as pre-print.

To answer the industry's need for a sound tape that reduces the print level below that available from general tapes, manufacturers developed low-print oxides. The Scotch Brand tapes, for example, offer the oxide on three backings: 1.5-mil cellulose acetate backing for economy and stretch resistance, 1.5-mil polyester for additional strength and resistance to temperature and humidity

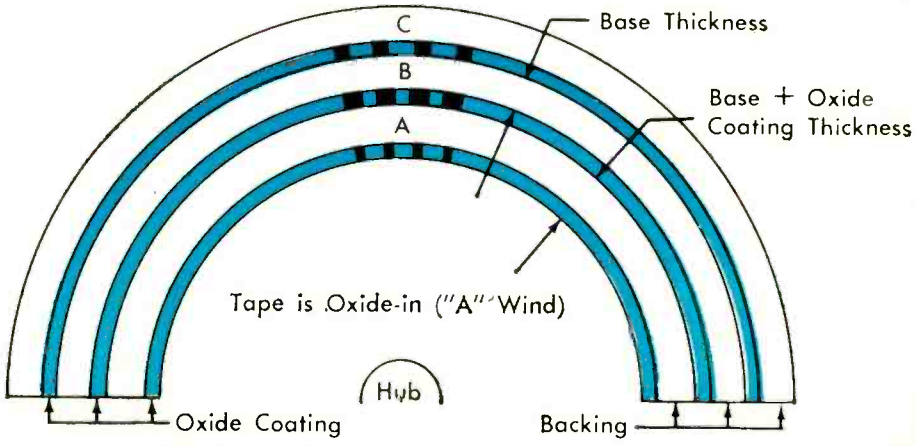


Fig. 2—Not rewinding tape after recording and playing makes any magnetic printing appear as post-echo, which is usually obscured by the actual material.

*Magnetic Products Div., 3M Co.

changes, and 1-mil polyester for 50% extra recording time.

The 3M oxide is coated to a thickness of 0.4 mil in each case, and the signal-to-print ratio is 6 db better than that of conventional tapes on the same thickness backings. The protection against layer-to-layer signal print holds even when tape is stored for long periods, and the signal-to-print ratio is achieved without sacrifice in output. In fact, if engineers can adjust their equipment to optimize the bias for these tapes, they can get a significant increase in high-frequency response.

Storage

The method of storage illustrated in Fig. 2 is recommended for master tapes because it results, upon playback, in the stronger of the two prints appearing as post-print and the weaker as pre-print. Post-print is less troublesome than pre-print because it is likely to be masked by the original signal. Pre-print, on the other hand, may be quite noticeable if it is strong, and if it is preceded by a quiet stretch of tape, as it frequently is.

The printed signal is transient; its level drops rapidly upon removal from the printing field. Measured a few minutes after removal from intimate contact with the printing signal, the printed signal will show a drop of 6 db or more from the level measured seconds after removal. This is another reason for suggesting rewinding just before playing: the printed signal is reduced and there is usually not sufficient time before playback for a new signal of bothersome strength to be printed.

A master tape is likely to have one or more splices. Storing the tape tail-end out necessitates rewinding before using, and this rewinding should release any sticking from splices.

Least physical distortion results if the tape is prepared for storage by winding it evenly with relatively low tension to produce a rather soft, stable roll. These conditions can best be met if the roll is last wound at playing speed on the takeup reel of a professional machine properly adjusted for takeup tension. High-speed winds are generally soft enough because of air trapped between layers, but an even wind is usually sacrificed in the process. The "weaving" that results may lead to serious physical distortion if the reel is subjected to adverse storage and handling conditions. This is especially true if the tape has a cellulose acetate base (many master tapes do). Cellulose acetate is more easily damaged than polyester and therefore requires more care in handling and storage.

Safe handling and storage

While tape can be recorded and played thousands of times without deterioration, it does require reasonable care to insure optimum performance, especially if it is to be stored for several years. Here are some suggestions for best results in preserving the physical and magnetic properties of recording tape.

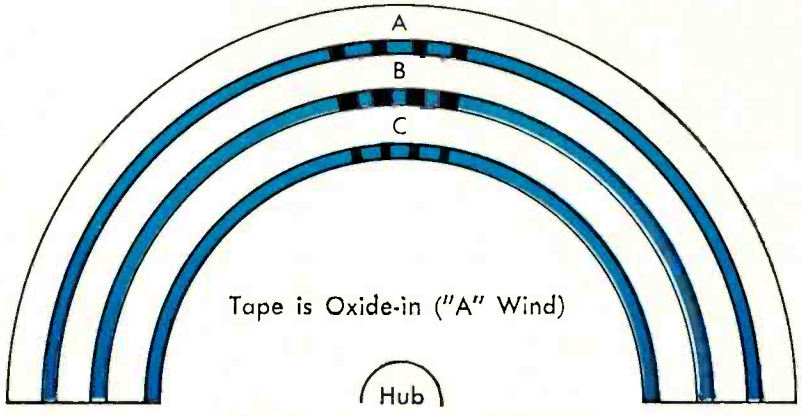


Fig. 3—Rewinding onto stock reel after recording and each playing does not affect intensity of print-through—just makes it more apparent, because it usually appears during silent passages before the start of the material.

Do not store unprotected tape. Storing tape in the original box protects it from dust and from physical damage to its edges. Boxed reels of tape should be stored on edge or flat individually on shelves. Stacking many reels one on top of the other should be avoided since the accumulated weight may distort the reels or damage the edges of the tape. Normally, cleaning is not necessary. If there is a great deal of dust, reels may be vacuumed and the tape may be cleaned by wiping with a clean dry cloth as it rewinds. To get rid of contamination that does not brush off easily, clean the tape with a cloth lightly moistened with Freon TF.

Avoid stray magnetic fields. While the magnetic properties of tape are very stable over long periods, care should be taken to avoid accidental exposure to magnetic fields. Weak magnetic fields will increase print signal. Permanent magnets and strong electromagnets very likely will cause erasure if placed within a few inches of the tape. (This is the principle of the bulk erasing process in which a whole reel of tape is demagnetized without unwinding.) For this same reason, *tape should not be stored in cabinets with magnetic door latches* if the tape is likely to come near the magnetic field of the latch.

Play tape periodically. Occasional use of recorded tapes improves their resistance to storage conditions. Running tape through a recorder is a simple way of relieving strains and adhesions before they seriously affect the tape.

Choose tape backings with an eye to storage conditions. Low humidity, as in heated areas during winter months, and high temperature over extended periods may cause the plasticizing agents in cellulose acetate tapes to evaporate, leaving the tape brittle. There are no plasticizers in polyester, so, if you know in advance that a recording will be stored for several years, use a polyester-backed tape. Temperature and humidity changes cause reversible dimensional changes. Polyester has 50% better resistance to temperature change and about 15 times better resistance to humidity change than acetate.

Control temperature and humidity. Ideally, magnetic tape should be stored at room temperature (60-80°F) with relative humidity controlled between 40 and 60%. The use of drying or humidifying agents is not recommended because of the difficulty in controlling the results.

Tape that has become brittle due to storage without temperature or humidity control can usually be restored to a playable state. The guiding rule is: let the tape return to equilibrium before it is played. Leaving a brittle tape out of its container at proper environmental conditions for 24 hours should bring it to equilibrium. A simple way to restore evaporated moisture is to leave a moistened sponge with the reel of tape in a closed vessel for 24 hours, being careful to keep the sponge from touching the tape. Similarly, a tape that has been exposed to extreme cold should be allowed to return to normal room temperature before it is played.

Clean recorder periodically. Occasionally cleaning the recording head, capstan, tape guides and other parts of your machine that touch the tape will promote long life for your tapes. END

TECHNOTES

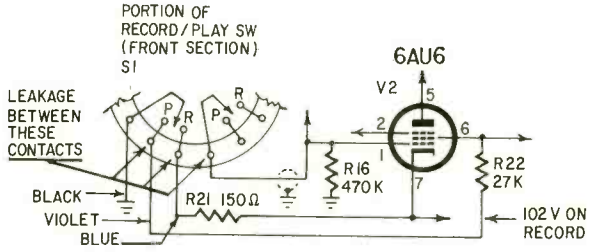
SONY TR103 RECORDER WITH TUNER

Fault: No recording. When monitor is on, radio is heard very faintly with record level up full. Playback level is too low on prerecorded tapes.

Trouble: Leakage between contacts on front deck of S1 record/play switch.

Leakage through the switch contacts biased the grid positive and blocked the stage on record. Attempts to clear the leakage by various chemical means failed. As a last resort a high voltage was placed across the contacts. This only burned the conductance path and made the leakage greater.

Remedy: Replace switch. The printed circuit must be removed to expose the switch. Note carefully how the



spring-loaded lever is oriented before disassembly. To save time and work take the new switch apart and use its front section to replace the defective part. The time it takes to pull the switch apart is considerably less than that required to solder the twelve connections onto the new rear section. —*Steve P. Dow*

SONY TR521 FOUR-TRACK STEREO

Symptom: Loud hum on upper channel on playback. no signal from prerecorded tape on this channel. Record-level indicator meter reads OK on record but nothing is recorded on the tape.

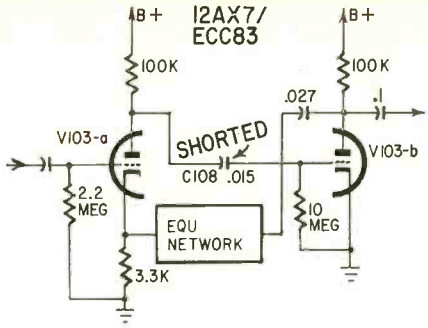
Fault: Appears similar to open head, defective record/playback switch or broken connecting lead. Actual fault was a broken lead on the hum-bucking pickup coil between the amplifier chassis and the motor. This coil is moved around on its flexible leads until a position is found where the hum field of the motor phases out the hum voltage induced in the head and leads. This coil is in series with the ground end of the head on playback.

Remedy: Reconnect broken lead and preferably replace both leads with heavier wire. Readjust coil position with unit on mono channel-1 playback, interlock cutout (automatic tape shutoff) defeated, and recorder output connected to scope to see 60-Hz level.—*Steve P. Dow*

NORELCO CONTINENTAL 400

A Norelco model EL 3536A stereo tape recorder wouldn't play or record on the right channel. Left channel was OK. We put signal into the right channel and it disappeared at V103-a. We had signal at the grid (pin 7 of the 12AX7) but no signal at all at pin 6 (the plate).

Plate voltage was down to 6. Supply was normal. Plate resistor measured OK at 100,000 ohms. Obviously a heavy current was passing through the plate resistor, *but it wasn't going through the cathode resistor*. Cathode voltage was zero. Cathode resistor measured OK at 3,300 ohms. When I pulled the tube, plate voltage came right up to the supply voltage (250). When I put it back, plate voltage fell to 6. Substituting tubes had no effect.



Where was the plate resistor current going?

Well, C108, the coupling capacitor to the second half of the tube, was shorted. The short didn't show up on resistance measurements to ground because of the high-value grid resistor in the next stage. When power was turned on the grid of V103-b became an anode and passed enough current through the plate resistor of V103-a to pull down the voltage drastically. It didn't show up on dc voltage measurements because the cathode of V103-b is grounded.

Besides, I was so sure the trouble was in V103-a. Of course when I pulled V103-a I pulled V103-b also (same envelope). Drove me nuts.—*Eugene Shube*

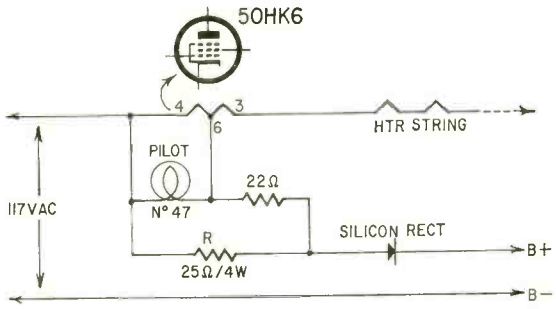
HARMAN-KARDON TUNER OSCILLATES

In a Harman-Kardon Citation III, the NE-2A neon bulb in the converter stage may become defective and cause the tuner to oscillate at an audible frequency for a few minutes after being turned on. Simply tapping the NE-2A may interrupt the oscillation. Removing the NE-2A by disconnecting one lead will stop the oscillation and still permit operation of the tuner. Merely replace the NE-2A with a new one to restore original operation.

The converter shield must be removed for access to the neon lamp.—*Louis H. Steinberg*

ARVIN 33R68 AM-FM STEREO POPS TUBES AND PILOTS

The unusual pilot-lamp and power-supply surge-resistor network in this set is worth close scrutiny by any technician interested in saving himself the price of several pilot lamps and 50HK6 power amplifier tubes. In three cases, this receiver came to the shop for a burned-out No. 47 pilot lamp and 50HK6, to which the bulb is connected. But the very



next day the set was back on the bench again for the very same reason. And then once more.

The defective component proved to be a third circuit element, R, a 25-ohm, 4-watt wirewound resistor. It had opened and allowed the charging capacitive load of the filters to pop first the pilot lamp, then the tube, after they had been operated in an overloaded condition for several hours—or long enough to have damaged the filament structure of both.—*George D. Philpott* END

HIGHER FI—NO *continued from page 50*

octave is virtually eliminated by even the finest speakers, leaving the range from 32 to 20,000 Hz.

Now, if the full ultra-wide frequency range never gets into the amplifier, it surely cannot come out (except as distortion, at the extreme frequencies). Since, in addition, the subsonic frequencies are not reproduced by the speaker, it is hard to see how anything can reach the ear that would enable it to tell whether or not the amplifier has passed the ultra-wide range.

Not only is the reproduction of an ultra-wide band unnecessary; it is undesirable. These undesirable effects have been dealt with at length in a recent paper[1].

The input signal unfortunately contains components that were not in the original program material. Low-frequency signals are caused by warped and eccentric records, mechanical feedback, acoustic feedback, turntable rumble, and room vibrations due to traffic and walking about the room. High-frequency interference occurs from the FM stereo pilot and subcarrier, SCA subcarriers, high-frequency distortion components of pickup and tape signals, co-channel interference, and 10-kHz whistle on AM.

The interfering signals can be great enough to reduce the signal-handling capability of the amplifier—by riding on top of the program material, so to speak. Some of them can be great enough to be audible. The peaks of all unwanted signals should be kept more than 20 db below the peak power rating of the amplifier to avoid an increase in distortion. To insure inaudibility of this interference as well, the amplifier should have a 12-db-per-octave rolloff in the bass range and 6 db per octave in the treble. With 3-db points at 20 Hz and 30 kHz, the amplifier frequency range still has a generous safety margin over the requirements of high-fidelity reproduction, and listening quality superior to that of ultra-wide band amplifiers.

END

1. Power Bandwidth, Frequency Response, and Music Spectra, Victor Brociner, Journal of the Audio Engineering Society October 1965 Vol. 13 No. 4

HIGHER FI—YES *continued from page 51*

affect materially the power-handling capabilities of the system.

A similar case may be made for noise above the music spectrum. By maintaining low distortion and good phase linearity in those regions we can avoid intermodulation with the high-frequency content of the program source.

Another form of noise, however, is of concern to the amplifier designer: the noise that falls directly into the audible spectrum, such as record noise and any sort of background hiss. Here our experience has been that with a phase-linear, wide-band system the noise appears to be separated from the music content of the program source in much the same way that the individual instruments become distinct from each other. This reduces listening fatigue dramatically. In the narrow-band amplifier, this noise fuses with the program source, causing much more objectionable noise interference.

Most wide-band, high-quality reproducing systems on the market today furnish high- and low-cut switches capable of smoothly rolling off frequencies above and below the normal range. Thus the wide-band system at least furnishes the listener a choice. Field surveys indicate, however, that such switches are rarely used.

The narrow-band designer forces upon the listener a mediocre, "canned" quality of sound reproduction, regardless of the quality of the program source and the remaining portion of the reproducing system. This, in my opinion, stifles further technological progress toward better sound and thus is contrary to the very essence of the modern high fidelity industry.

END

TRY THIS ONE

COMBINATION TV/PHONE TRANSMISSION LINE

Recently, I was confronted with a combination job of installing a private two-way telephone system between two homes and providing a TV antenna lead-in from a high-gain tower-mounted antenna. The nearest television station is 80 miles away, and a tower-mounted antenna (65 feet high) is necessary to get a good picture.

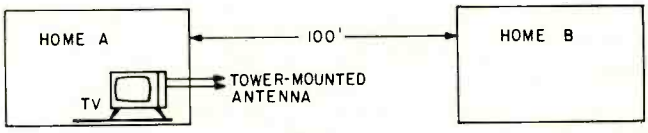


Fig. 1

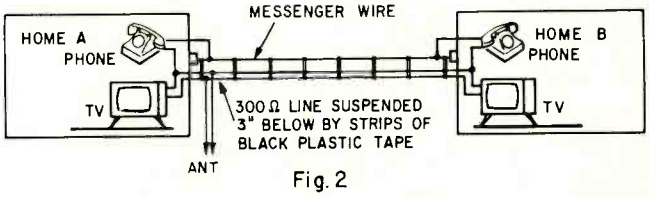


Fig. 2

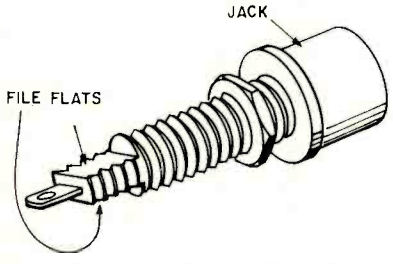
The distance between the homes is approximtely 100 feet and the tower is located 6 feet from home A, where a TV set was previously installed using 300-ohm ribbon lead. Home B did not have a TV set or antenna. Fig. 1 shows the original situation.

No. 10 copper wire was necessary to support the ribbon-lead extension lead-in to Home B. I decided that the two-wire circuit used for the intercom telephones could be made using one wire of the TV lead for one line, and the supporting wire for the other. Fig. 2 shows the existing hookup.

This system has proved very satisfactory for both TV reception and intercommunication. No ill effects can be seen in the TV picture when talking over the phone. A ringing telephone momentarily interrupts the program, but this is not considered a serious disadvantage. The supporting wire, bare of insulation, was strung between insulators at both ends of the line. The lightning arrester installation at the tower was not disturbed.—*James F. Sutherland*

FILED FLATS HELP GRIP JACK DURING TIGHTENING

When installing tip and banana jacks, it is difficult to prevent the jack from turning while the nut is being tightened. This is especially true of those



jacks where the insulator merely slips over the jack instead of being integrally molded. As a result, the nut is usually not tightened enough and loosens up later.

A way around this difficulty: file a couple of flats at the back end of the jack. These flats can be gripped with pliers or a wrench while the nut is being tightened. Since the filing process may upset the threads slightly, run the jack through a ⅜-28 die afterward to clean them up. Or thread a nut onto the jack before filing. Taking it off again after filing usually smooths the threads.—*Charles Erwin Cohn*

[Some better jacks come with flats on them to simplify installation.—*Editor*]

FOAM PLASTIC USEFUL IN SHOP

Blocks of Styrofoam can be of real help around the shop. I use it to block up chassis; the styrofoam is soft enough so it does not mar surfaces but firm enough to hold a lot of weight. I use it to hold coil/capacitor combinations when checking them for frequency resonance with a grid-dipper. I also use a piece to hold loose tubes taken out of equipment, so they won't roll off the bench; just stick the tube pins in the plastic foam.

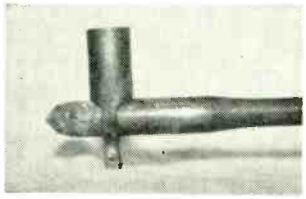
Styrofoam makes excellent insulation for crystals and transistors if they must be mounted near tubes that get hot —it is a sound and shock insulator as well as thermal insulator. To hold deli-

cate parts for soldering or other work, carve out a place for them in a block of styrofoam—it can be cut with a knife, melted with a soldering iron (yet it does not burn) and is inexpensive.—*Tom Jaski*

[The stuff should be available at florists' shops and florist supply houses.—*Editor*]

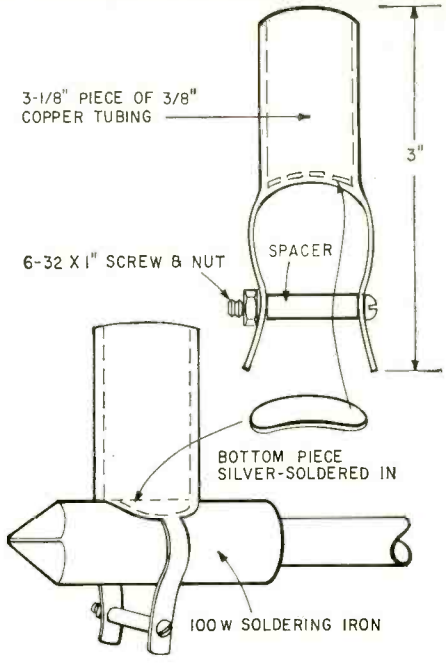
BLEACH LOOSENS RUSTED SCREWS

For rust-frozen nuts and bolts, such as you're likely to find when you want to replace an outdoor antenna lead-in, squirt ordinary laundry bleach generously around the hardware. In a short time, you'll find you can remove the nuts easily.—*Noble C. Travis*



SIMPLE SOLDER POT

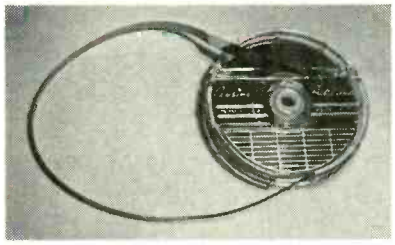
A quickly made solder pot for dip-soldering clean tinned connections is shown in the photo. It requires no modifications to the iron.



The drawing shows how to make it. The pot is designed to be used with a 100-watt iron, and should give you a full pot of melted solder 5 minutes after the iron is hot.—*Peter Legon*

TAPE CARTRIDGE HINT

Tape repeater cartridges like the kind in the photo use a graphite lubri-



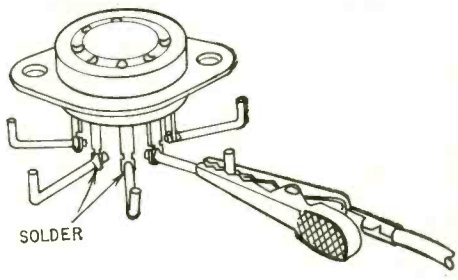
cant which clogs felt pressure pads on recorders. The graphite lost to the pads shortens the life of the cartridge by causing the tape to stick and wind unevenly. Pads saturated with graphite are difficult to clean and become stiff. When normal tape is used, uneven pressure from them causes trouble.

Place a small piece of polyethylene over the pressure pads and secure it with splicing tape. This won't bother cartridge tapes and can easily be removed for normal tape use.—*Steve P. Dow*

QUICK EXPERIMENTER'S SOCKETS

For quick breadboarding with clip-leads, solder stiff No. 16 brass brazing-rod pieces to tube socket lugs. Bend the ends of the rods to give the alligator clips a good grip. Make the rods long enough to stick out about a half inch. The sockets will stand by themselves on the bench.—*Tom Jaski*

[Remember when using this method that you'll be looking at connections



from the *top* of the socket instead of the bottom as usual. Count pin numbers the other way around.—*Editor*] END

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WHAT'S YOUR EQ?

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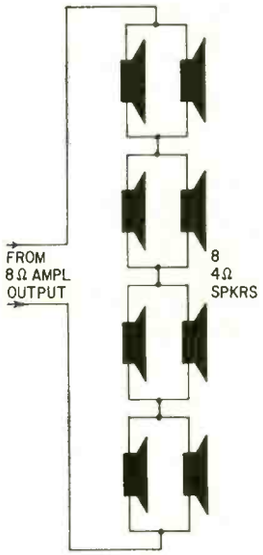
Connections

Nothing is *wrong*, exactly, except that the cross-connections between the vertical groups of speakers are absolutely unnecessary. They affect nothing for good or for bad. Assuming speakers of *identical* characteristics, the potential at both ends of each cross-connection at any instant is the same. Therefore there can be no current through the wires and it matters not a whit whether they are present or absent.



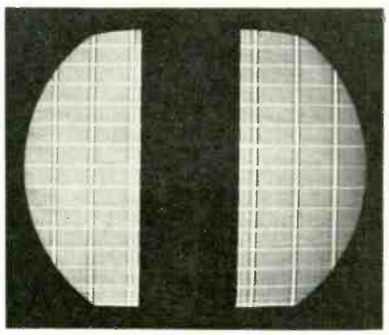
Actually there are two ways of accomplishing the same thing; they differ only in a practical way. One is to have two paralleled strings of four speakers each (like the hi-fi annual's answer but without the cross-connections). The other is shown here—four groups of paired, parallel speakers, connected in series.

The magazine's answer may have resulted from some editor seeing this diagram and deciding to save space by eliminating the vertical links.

What Is It?

There's nothing wrong with the set. I got the patterns (see next column, too) after a "friend" borrowed my bar-dot generator, and used a little screwdriver on the frequency-divider adjustments. While trying to fiddle it back into alignment without a scope, I hit these perfectly locked, but odd, patterns and photographed them.

They are caused by a very bad misadjustment on the frequency-divider (countdown) stages of the crystal-controlled bar–dot generator. The mistriggering of the multivibrators apparently caused a complete cutoff of the mixer at some point in the cycle by clipping a



pulse at the wrong place. That gives us the blacked-out parts of the signal, making the "vertical bar."

The stability of this whole pattern is due to the crystal oscillator, which controls all of the bar and dot frequencies, starting at 189 kc. Some of the lower frequencies are way off here, but the fundamental is still OK.

This is more proof of the fact that you *cannot* readjust one of these instruments "by hand." Read the instruction book and follow the correct setup procedure, using the scope and the correct coupling to get the right patterns.

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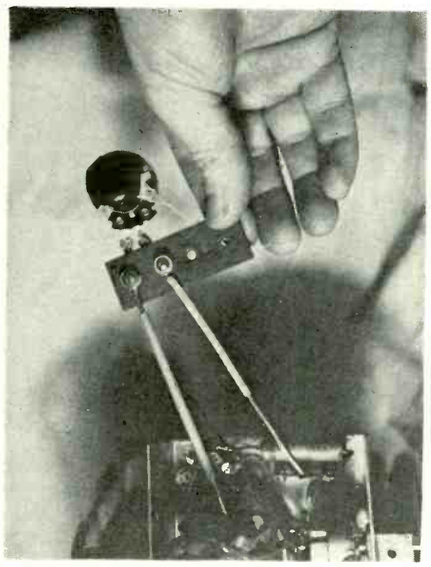
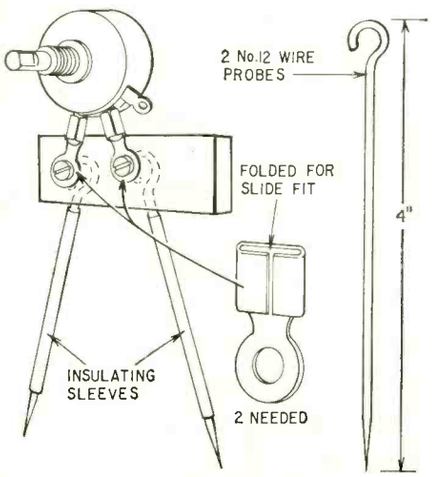
Pot Subs for Sub Box

Potentiometers can be as useful as substitution boxes for determining the exact value of resistance needed in a circuit. To use a pot as a resistor substitute, fold two clip-on connecting lugs for a snug slide fit over typical potentiometer lugs. Fasten the folded lugs to



a Masonite or plastic strip with two sharpened prods about 4 inches long, formed from No. 12 wire. (Tin the sharpened ends to prevent tarnishing.)

To use the rig, slide the center terminal and one end terminal of the pot into the folded lugs, insert the prods



into the circuit and adjust the pot for the correct value (until the circuit works right). Remove the pot without disturbing the shaft and measure the value. Replace with a fixed resistor of the nearest standard value.—*Peter Legon*

AR-2's ARE CONVERTIBLE

In the report on the Acoustic Research AR-2a^x speaker system on page 67 of the January issue, RADIO-ELECTRONICS neglected to mention that conversion kits are available from AR, Inc. to make an AR-2 into an AR-2^x and an AR-2a into an AR-2a^x. The kits are available from AR dealers, or directly from AR, Inc., 24 Thorndike St., Cambridge, Mass. 02141, for $15 each, postpaid.

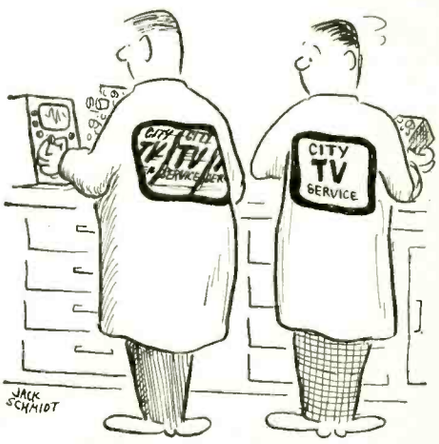
The essence of the alteration is that, in the AR-2, the dual-tweeter array is replaced by a single 3½-inch tweeter; in the AR-2a, the dual midrange speaker array is replaced by a single 3½-inch speaker. The grille cloth color and mounting frame have also been changed. The conversion kit contains the new speaker, an adapter plate, sealing putty, hardware and instructions.

In the New Products announcement "Aerosol Canned Air" on page 90 of the February issue the manufacturer's address was omitted. It is: Miller-Stephenson Chemical Co., Danbury, Conn.

CORRECTION

Mr. Pugh has picked us up on a couple of errors in Fig. 3 of his article "Transistorize Your Tube Portable" on page 36 of the December issue. First, there should be a dot indicating a connection between D6's base and the junction of R9 and R10.

The second error is the direct connection shown between Q5's collector and the junction of D1, R6, C7 and R7. This connection must be removed. Otherwise the set won't work properly. This error managed to creep into the diagram while another mistake was being corrected. END



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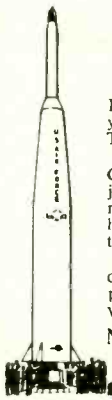

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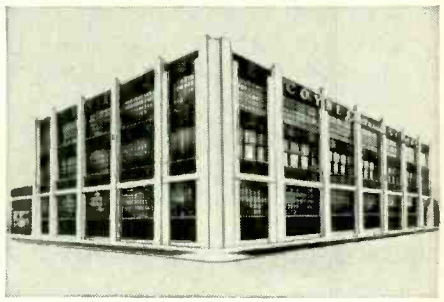

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REPRODUCTION OF SOUND, by Edgar Villchur and HIGH FIDELITY SYSTEMS, by Roy F. Allison. *Dover Publications, Inc., 180 Varick St., New York, N. Y. 10014. 5½ x 8½ in., 92 pp. each. Paper, $1 each.*

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MUSICAL INSTRUMENTS AND AUDIO, by G. A. Briggs. *Wharfedale Wireless Works Ltd., Idle, Bradford, Yorkshire, Eng. 5½ x 8½ in., 238 pp. Cloth, $4.00*

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6GT5	1.54
6GU5	1.47
6GU7	1.15
6GV5	1.65
6GV6	1.85
6GV8	1.12
6GW6	1.39
6GW8	1.08
6GX6	.86
6GX7	1.70
6GX8	1.31
6GY5	1.49
6GY6	.88
6GY8	1.29
6GZ5	.98
6HA5	1.39
6HA6	1.88
6HB5	1.52
6HB6	1.59
6HB7	1.08
6HD5	2.19
6HE5	1.34
6HF5	2.69
6HF8	1.42
6HG5	.73
6HG8	1.48
6HJ5	2.10
6HJ8	1.12
6HK5	1.19
6HL8	1.11
6HM5	1.37
6HQ5	1.72
6HR6	.98
6HS6	.98
6HS8	1.08
6HT6	1.19
6HZ6	.98
6HZ8	1.85
6H6	.94
6J4	2.95
6J5G	1.10
6J5M	1.25
6J6A	.67
6J7	1.69

Type	Price
6J7GT	1.49
6J7G	1.50
6J8	2.50
6J10	2.02
6J11	1.82
6JB6	2.25
6JC6	1.36
6JC8	1.04
6JD6	1.19
6JE6	3.05
6JE8	1.35
6JG6	2.08
6JH6	.89
6JH8	1.48
6JK8	1.35
6JM6	1.67
6JN6	1.59
6JN8	1.30
6JS6	2.95
6JT6	1.72
6JT8	1.45
6JU8	1.09
6JV8	1.33
6JZ8	1.28
6K6GT	.90
6K7	1.69
6K7G/GT	1.49
6K8M	2.59
6K11	1.29
6KA8	1.38
6KD8	1.01
6KE8	1.72
6KL8	.93
6KM8	1.16
6KT8	1.25
6KU8	1.63
6KV8	2.12
6KY8	2.65
6KZ8	.94
6L5G	1.50
6L6G	.98
6L6GA	1.48
6L6GB	1.50
6L6GC	1.61
6L6M	3.00
6L7M	2.48
6L7G	1.75
6LB8	1.49
6LC8	1.40
6LF8	1.28
6LM8	1.52
6M11	1.81
6N7M	1.75
6P5	2.50
6Q7	1.95
6Q11	1.29
6R7	2.10
6S4	.76
6S7	1.95
6S8GT	1.50
6SA7GT	1.39
6SA7M	1.49
6SB7Y	2.19
6SC7	1.52
6SD7	1.49
6SF5	1.08
6SF7	2.19
6SG7	1.55
6SH7	1.05
6SJ7GT	1.49
6SJ7M	1.72
6SK7GT	1.30
6SK7M	1.38
6SL7GT	1.19
6SN7GT	.89
6SQ7GT	1.25
6SR7	1.42
6SS7M	1.88
6ST7	1.75
6SU7	2.00
6SV7	1.25
6SZ7	1.25
6T4	1.75
6T8	1.15
6T10	1.54
6U5/6G5	2.35
6U8	1.12
6U10	1.32
6V3	1.67
6V4	.59
6V6GT	.74
6W4	.83
6W6GT	.98
6X4	.56
6X5GT	.72
6X8A	1.05
6Y6GA	1.45
6Z4/84	1.22
7A4	2.25
7A5	1.95
7A6	2.25
7A7	2.35
7A8	2.75
7AD7	1.25
7AF7	2.10
7AG7	2.85
7AH7	1.95
7AU7	.83
7B4	2.35
7B5	2.75
7B6	1.25
7B7	2.50
7B8	2.00
7C4	1.15
7C5	1.19
7C6	2.69
7C7	1.23
7E5	2.00
7E6	1.25
7E7	1.95
7EY6	1.06
7F7	2.59
7F8	3.00
7G7	1.99
7H7	1.65
7HG8	1.29
7J7	2.50
7K7	2.96
7L7	1.99
7N7	2.61
7Q7	1.85
7R7	2.25
7S7	1.79
7V7	1.65
7W7	2.39
7X6	1.35
7X7	2.75
7Y4	2.35
7Y7	1.79

Type	Price
7Z4	2.25
8AU8	1.39
8AW8	1.26
8B10	1.22
8BA8	1.24
8BH8	1.23
8BN8	1.11
8BQ5	.99
8CG7	.86
8CM7	.98
8CN7	.96
8CS7	.98
8CW5	.98
8CK8	1.60
8EB8	1.48
8EM5	1.19
8ET7	1.50
8FQ7	.94
8GJ7	1.31
8GN8	1.29
8JV8	1.32
8KA8	1.40
8LC8	1.40
9A8	1.33
9AU7	.94
9BR7	1.14
9CL8	1.07
9EA8	1.09
9U8	1.05
10AL11	1.53
10BQ5	1.45
10C8	1.41
10DE7	1.14
10DR7	1.49
10DK8	1.05
10EG7	1.54
10EM7	1.62
10EW7	1.45
10GN8	1.29
10HF8	1.70
10HT8	1.21
10JA8	1.29
10JY8	1.49
10KU8	1.73
10Y	.95
11AR11	1.48
11CY7	1.10
11JE8	1.39
11KV8	2.15
12A4	.94
12A5	1.25
12A6	.89
12A7	2.95
12A8	2.95
12A11	1.69
12AB5	1.15
12AC6	.75
12AD6	.80
12AE6	.80
12AE7	1.35
12AF3	1.25
12AF6	.94
12AG6	1.49
12AH7	1.89
12AJ6	.86
12AL5	.65
12AL8	2.23
12AL11	1.51
12AQ5	.86
12AT6	.59
12AT7	1.03
12AU6	.71
12AU7	.83
12AV5	1.48
12AV6	.56
12AV7	1.22
12AW6	1.10
12AX3	.94
12AX4	.85
12AX6	.91
12AX7	.87
12AY3	.96
12AY7	1.55
12AZ7	.94
12B4	.97
12BA6	.56
12BA7	1.90
12BD6	.77
12BE3	.93
12BE6	.59
12BF6	.68
12BH7	.96
12BK5	1.28
12BL6	.89
12BN6	1.48
12BQ6/CU6	1.53
12BR7	1.08
12BS3	1.21
12BT3	1.00
12BV7	1.20
12BW4	.99
12BY7	1.09
12BZ6	.76
12BZ7	1.35
12C5/12CU5	.84
12CA5	1.00
12CN5	1.18
12CR6	.94
12CS6	.95
12CT8	1.45
12CU6/BQ6	1.53
12CX6	.98
12D4	.99
12DB5	.94
12DE5	.92
12DE8	1.12
12DK6	.82
12DK7	1.00
12DL8	2.12
12DQ6	1.44
12DQ7	1.18
12D57	1.35
12DT5	1.12
12DT7	1.10
12DT8	1.30
12DU7	1.39
12DV8	1.33
12DW7	1.10
12DW8	1.25
12DY8	2.90
12DZ6	.94
12EA6	.91
12EC8	1.22
12ED5	.98
12EG6	1.03
12EK6	.98
12EL6	.69
12EL8	.95

Type	Price
12EM6	1.14
12EZ6	.83
12F5	1.60
12F8	.99
12FA6	.97
12FK6	.79
12FM6	.79
12FQ8	1.08
12FR8	1.48
12FV7	1.25
12FX5	.91
12FX8	1.31
12GA6	.87
12GC6	1.25
12GE5	1.40
12GN7	1.43
12GT5	1.65
12GW6	1.15
12H6	1.40
12J5	1.61
12J8	1.58
12JB6	2.05
12JN6	1.43
12JT6	1.97
12K5	1.19
12K7GT	2.25
12K8G	1.50
12K8M	2.95
12L6	1.18
12L8	.50
12Q7GT	1.39
12Q7M	1.50
12R5	1.07
12SA7	1.49
12SC7M	1.89
12SF5	1.30
12SF7	2.23
12SG7M	1.54
12SH7	1.75
12SJ7	1.40
12SK7GT	1.35
12SK7M	1.47
12SL7GT	1.28
12SN7	.70
12SQ7GT	1.29
12SR7	1.79
12U7	.90
12V6	1.15
12W6	1.15
12X4	.68
13CW4	1.60
13DE7	1.01
13DR7	1.15
13EM7	1.61
13FD7	1.66
13FM7	1.08
13GB5	1.36
13GF7	1.70
13J10	1.83
14A4	1.45
14A5	1.35
14A7	1.85
14AF7	1.85
14B6	1.85
14B8	1.95
14C5	1.75
14C7	2.19
14E6	1.39
14E7	1.39
14F7	2.95
14F8	2.23
14GT8	.95
14H7	1.95
14J7	1.95
14N7	1.95
14Q7	1.95
14R7	2.35
14S7	1.95
14W7	1.85
14X7	1.75
14Y4	1.75
15AF11	1.64
15BD11	1.73
15CW5	.92
15FM7	1.28
15FY7	1.18
15HB6	1.25
15KY8	1.63
16AQ3	.92
16GK5	.93
16GK6	1.15
16GY5	1.90
17AX3	.91
17AX4	.92
17AY3	.92
17BE3	.98
17BF11	1.57
17BH3	.98
17BQ6	1.65
17BS3	1.12
17C5	2.30
17C9	2.40
17D4	.96
17DA4	1.10
17DE4	1.12
17DM4	1.05
17DQ6	1.33
17DQ7	1.75
17EW8	.99
17GE5	1.34
17GJ5	1.82
17GV5	1.48
17GW6	1.38
17H3	.79
17HC8	1.24
17JB6	1.89
17JG6	2.02
17JM6	1.65
17JN6	1.70
17JZ8	1.19
17L6	1.45
17LD8	1.35
17W6	1.15
18A5	1.34
18FW6	.68
18FX6A	.74
18FY6A	.63
18GD6	.64
19	1.00
19AU4	1.26
19BG6	1.95
19BQ6	2.35
19C8	1.25
19CL8	1.17
19EA8	1.09
19GQ7	1.99
19H56	.85
19HV8	1.23
19JN8	1.04

Type	Price
19Q9	1.15
19T8	1.14
2050	1.25
21EX6	1.95
21GY5	1.32
21HB5	1.65
21HJ5	1.62
21KA6	1.75
22	1.15
22BH3	1.07
22BW3	1.21
22DE4	.98
22JG6	1.95
23Z9	2.69
24A	1.35
25A7	3.25
25AC5	2.50
25AK4	1.19
25AV5	1.54
25AX4	.94
25BK5	1.14
25B8	1.93
25BQ6	1.45
25C5	.65
25CA5	.98
25CD6	1.94
25CU6	1.48
25DN6	1.95
25EH5	.92
25F5	1.25
25L6	.77
25W4	.87
25W6	.95
25Z5	1.50
25Z6	.94
26	1.40
27	1.60
27GB5	1.49
28D7	1.50
30	1.25
31	1.50
32	1.15
32ET5	.80
32L7	.85
33	1.15
32GY7	1.95
34	1.15
34DG5A	.95
34GD5	.71
35-51	1.50
35A5	1.94
35B5	1.07
35C5	.66
35EH5	.74
35L6	.86
35W4	.35
35Y4	1.62
35Z3	1.54
35Z5	.58
36	1.50
36AM3	.51
37	1.10
38	1.10
39/44	.95
41	1.40
42	1.98
43	2.85
45/2A3	3.25
45Z3	.55
46	.95
47	3.00
48	4.00
49	3.50
50	1.75
50A1	2.60
50A5	2.10
50B5	.86
50C5	.65
50DC4	.63
50EH5	.72
50FE5	1.44
50FK5	.79
50FY8	2.50
50HC6	.86
50HC8	.89
50HK6	.77
50L6	.81
50X6	1.96
50Y6	1.49
50Y7	1.42
53	3.50
55	2.75
56	1.25
57	1.50
58	1.50
59	3.00
60FX5	.87
70L7	.89
71A	1.25
75	2.62
76	1.50
77	1.50
78	1.65
80	1.25
81	1.35
82	1.49
83	1.75
83V	3.00
84/6Z4	1.35
85	.98
89	1.50
89Y	2.00
417A	5.25
117L7	3.29
117M7	3.25
117N7	4.25
117P7	4.25
117Z3	1.56
117Z6	2.23
5881	2.05
6146	2.50
6146W	5.95
6336	4.75
6336A	9.50
6550	3.25
6550MP	7.00
7258	2.50
807	.75
809	3.75
ECC83/12AX7	.90
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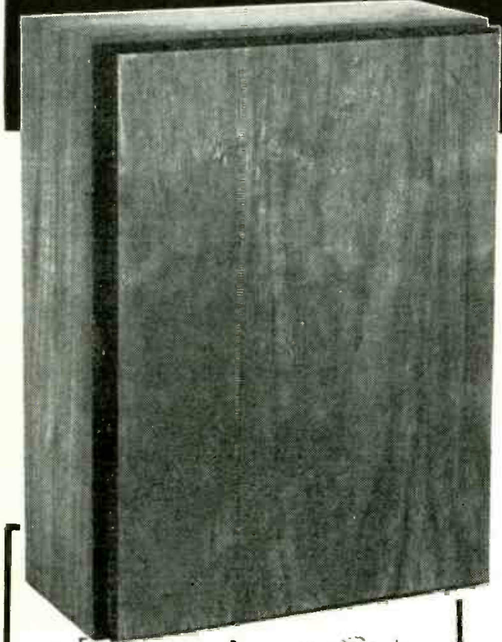

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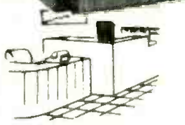
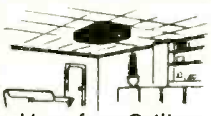
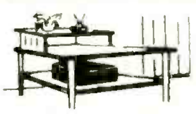


Use in the Office

. . . Out on the Patio



Hang from Ceiling



. . . Tuck on a Shelf

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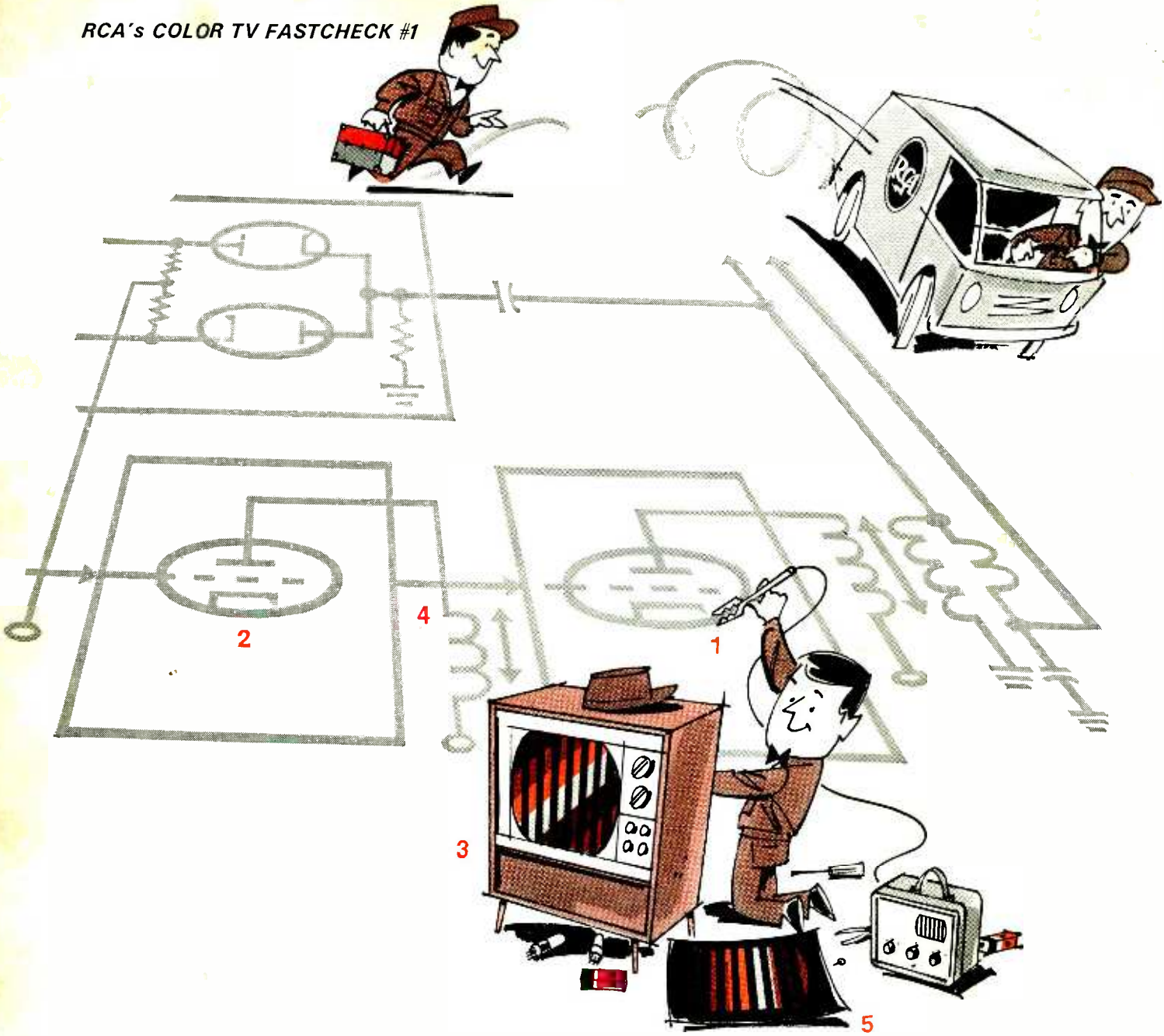
RCA's COLOR TV FASTCHECK #1



Loss of color sync?

TRY ADJUSTING THE PLATE COIL...

Loss of color sync is often caused by a defective 3.58-Mc/s oscillator. In some receivers, it may also be caused by misadjustment of the plate coil in the reactance tube control circuit. Next time you run into this trouble, follow this simple procedure and it may save you a time-wasting callback.

1. Connect a color-bar generator such as the RCA WR-64B to the receiver and get the ten-color bar pattern on the picture tube.
2. Short the control grid of the reactance tube to ground.
3. The bars may have bands or blocks of color across them. These bands are "beats" resulting from difference between the local oscillator and transmitted signal frequencies. These colors may drift diagonally across the bar giving a "barber pole" effect, or they may be locked into the bars in blocks of different hues.
4. Slowly adjust the reactance tube plate coil with an alignment tool. Turn the slug in the direction which reduces the number of color bands or blocks across the bars.
5. Adjust for a zero-beat condition. At zero beat, the bars will display individual solid colors from top to bottom. These colors may be locked in or they may drift slowly from bar to bar. Remove the short from the reactance tube grid and re-adjust the plate coil for solid lock-in of the color bars.

If you can get an exact zero-beat condition, it is an indication that the oscillator tube is good. If it is necessary to replace the oscillator tube, be sure to adjust the circuit for zero-beat as shown in step 5.

This color TV service hint is the first of a series of service hints from RCA. For satisfied customers and fewer callbacks, always replace with ultra-reliable RCA receiving tubes.

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