

# ELECTRONICS INSTALLATION & SERVICING HANDBOOK-1967

SIMPLIFIED TECHNIQUES

SAVE

TIME AND MONEY

STEREO/HI-FI

AUTOMOTIVE

PUBLIC ADDRESS

TV-CB-FM

ANTENNAS

INTERCOMS

**PLUS:**

COLOR TV SECTION

(WITH TRUE COLOR ILLUSTRATIONS)

**PLUS:**

HOW TO INSTALL

STEREO TAPE

IN YOUR CAR

**PLUS:**

TOOLS and TEST

EQUIPMENT SUMMARY

\$1.25



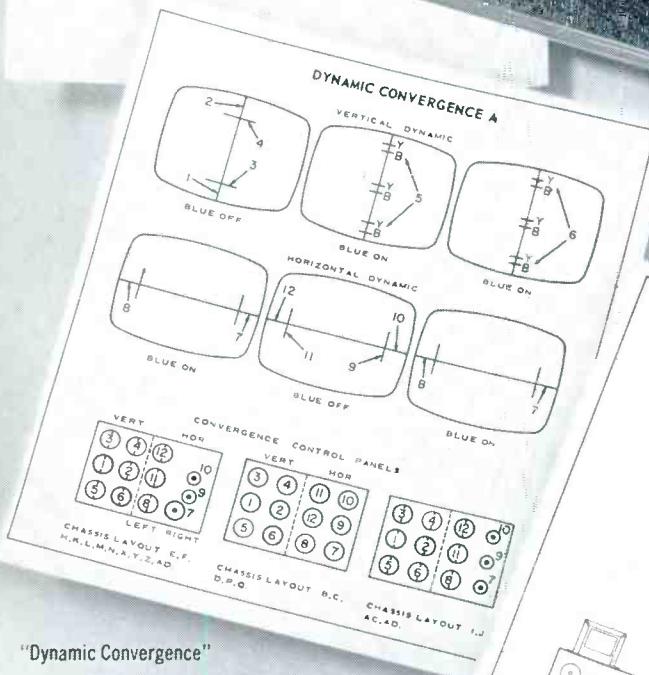
ZIFF-DAYTON  
PUBLICATION

# Now in one handbook...the service information you need for 12 makes of color TV sets

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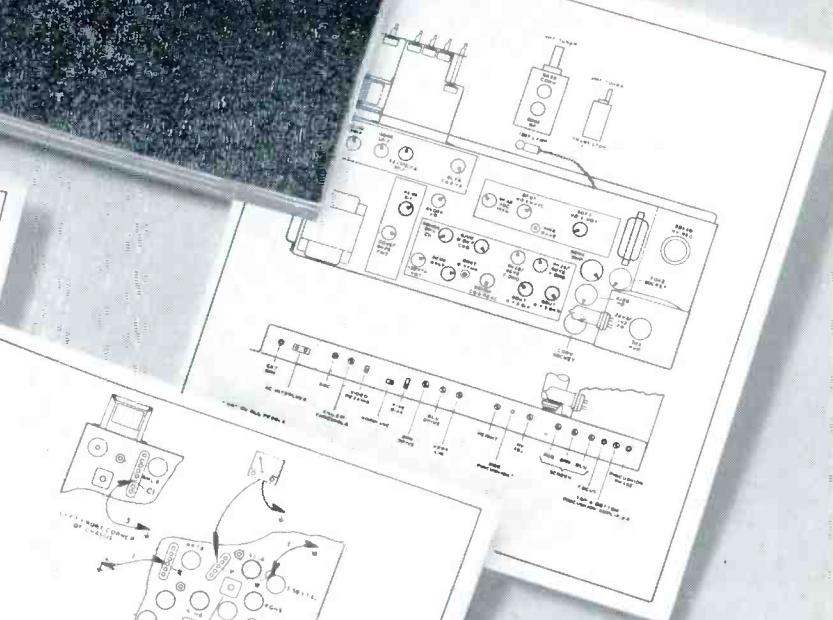
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## RCA COLOR TV SERVICE HANDBOOK



"Dynamic Convergence"

Just look up the chassis number of the set you are working on in the CHASSIS INDEX and you will be guided to the proper sections of the 140-page RCA Color TV Service Handbook. All the information is based on the manufacturer's own service notes. You'll want to carry a copy in your tube caddy on every color TV service call.



"Chassis Layouts"

"Color AFPC  
Field Adjustments"

TO KEEP UP WITH COLOR, SEE YOUR RCA DISTRIBUTOR ABOUT GETTING THE RCA COLOR TV SERVICE HANDBOOK (1A1553).

RCA's personal quality performance program aims for missile-type reliability in commercial receiving tubes. Under this program thousands of RCA people have pledged to strive for error-free-performance so that when you replace with RCA receiving tubes you're sure of a satisfied customer.

RCA ELECTRONIC COMPONENTS AND DEVICES, HARRISON, N.J.

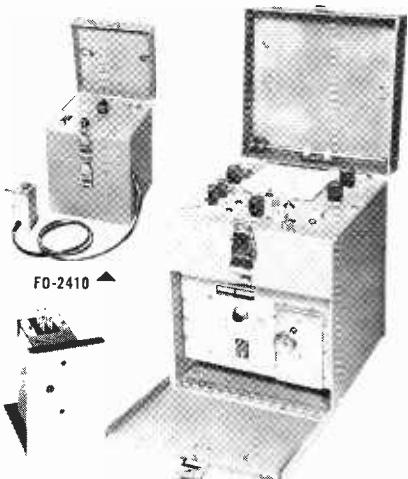


The Most Trusted Name in Electronics

# INTERNATIONAL FREQUENCY METERS

*designed for servicing!*

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:  $\pm .00025\%$ ,  $+85^\circ$  to  $+95^\circ\text{F}$ ,  $\pm .0005\%$ ,  $+50^\circ$  to  $+100^\circ\text{F}$ ,  $\pm .001\%$ ,  $+32^\circ$  to  $+120^\circ\text{F}$ . 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



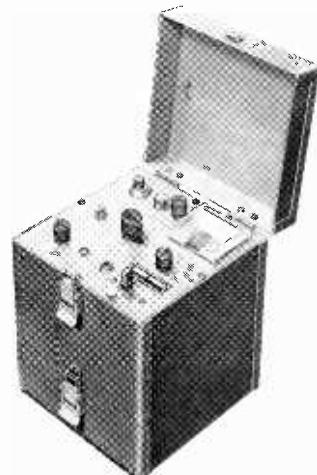
## C-12M FREQUENCY METER

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  $\pm .0025\%$ ,  $32^\circ$  to  $125^\circ\text{F}$ ,  $\pm .0015\%$ ,  $50^\circ$  to  $100^\circ\text{F}$ . 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  $\pm .01\%$  from  $32^\circ\text{F}$  to  $104^\circ\text{F}$  ( $0^\circ\text{C}$  to  $40^\circ\text{C}$ ). 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

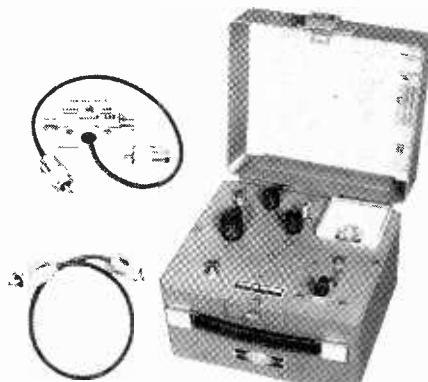


## Model 1110 SECONDARY FREQUENCY STANDARD

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  $40^\circ\text{F}$  to  $100^\circ\text{F}$ . 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  $\pm .0025\%$ ,  $32^\circ$  to  $125^\circ\text{F}$ ,  $.0015\%$ ,  $50^\circ$  to  $100^\circ\text{F}$ . 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

KEEPING YOU ON FREQUENCY IS OUR BUSINESS . . .



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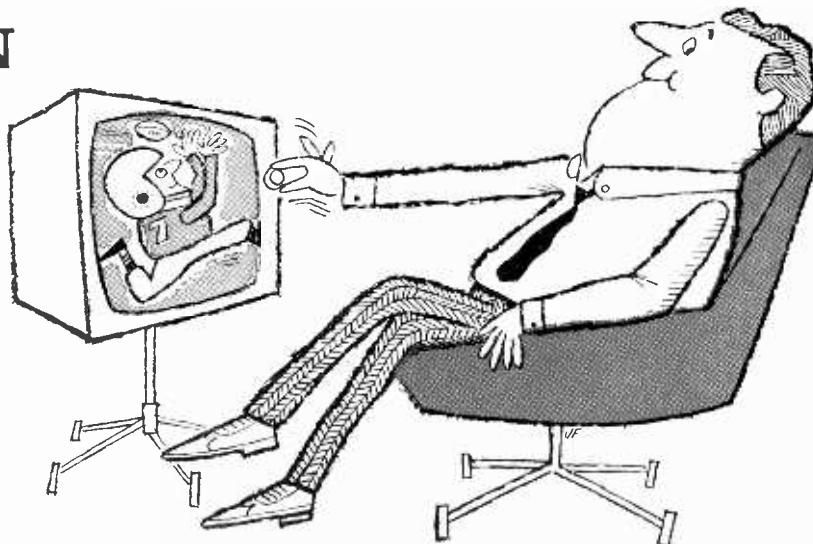
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CIRCLE NO. 8 ON READER SERVICE CARD

**GET SUPERIOR 82-CHANNEL  
COLOR TV RECEPTION WITH**

# **NEW BELDEN 8290**

**SHIELDED PERMOHM®  
LEAD-IN**



Until the introduction of Belden 8290 Shielded Permohm TV lead-in cable, there were serious limitations in the effectiveness of the various lead-in cables available, whether twin lead or coaxial.

Here Robert E. Sharp, electronic engineer of the Belden Manufacturing Company, discusses the problems and the reasons why Belden 8290 Shielded Permohm is the all-purpose answer for 82-channel and color TV reception.

**Q.** What problems have been experienced in using twin lead cables other than 8290?

**A.** Most installers have found out that using flat ribbon or tubular 300 ohm line for UHF and color installations is unsatisfactory. When these lines encounter dirt, rain, snow, salt, smog, fog, or industrial deposits, the impedance drops abruptly, the attenuation soars and the picture is lost.

To overcome this problem, Belden developed its 8285 Permohm line which encapsulates the flat twin lead in a low loss cellular polyethylene jacket. This keeps all of the surface deposits out of the critical signal areas—regardless of weather conditions.

Although this was a major improvement, there still remained the problem of electrical interference signals from automotive ignition systems, reflected TV signals and extreme electrical radiation which could be picked up by the lead-in to create ghosts and static lines in the picture.

**Q.** Then, is this why many people recommend coaxial cable as TV lead-in?

**A.** Yes. Because of the incorporation of a shield, coaxial cable has an advantage over unshielded twin lead.

**Q.** Then, why isn't coaxial the total answer?

**A.** Coaxial cable has much higher db losses per hundred feet than twin lead. Although the shield in coaxial cable does reduce lead-in pick-up of interference signals, it is not as effective as a 100% Beldfoil\* shield.

Another way to put this is that 8290 delivers approximately 50% of the antenna signal through 100 feet of transmission line at UHF while coaxial cable can deliver only 15% to 20%, frequently not enough for a good picture. Even at VHF, the higher losses of a coaxial cable may be intolerable, depending on the signal strength and the length of the lead-in.

The following chart spells this out conclusively. We have compared RG 59/U Coax to the new Belden 8290 Shielded Permohm. All 30 ohm twin leads, under ideal weather conditions, have db losses similar to 8290.



SHEIELDED PERMOHM FOR ALL CHANNEL TV

CHANNEL	MC	db LOSS/100' 8290	db LOSS/100' COAX (RG 59 Type)
2	57	1.7	2.8
6	85	2.1	3.5
7	177	3.2	5.2
13	213	3.5	5.9
14	473	5.4	9.2
47	671	6.6	11.0
83	887	7.7	13.5

**Capacitance:** 8290—7.8 mmf/ft. between conductors  
Coax—21 mmf/ft.

**Velocity of Propagation:** 8290—69.8%  
Coax—65.9%

**Q.** Won't the use of matching transformers improve the efficiency of a coaxial cable system?

**A.** No! The efficiency is further reduced. Tests show that a pair of matching transformers typically contribute an additional loss of two db, or 20% over the band of frequency for which they are designed to operate. Incidentally, transformer losses are not considered in the chart.

**Q.** How does 8290 Shielded Permohm overcome the limitations of other lead-ins?

**A.** 8290 is a twin lead with impedance, capacitance, velocity of propagation and db losses which closely resemble the encapsulated Permohm twin lead so that a strong signal is delivered to the picture tube. At the same time, 8290 has a 100% Beldfoil shield which prevents line pick-up of spurious interference signals. In short, 8290 combines the better features of twin lead and coaxial cable into one lead-in.

**Q.** What about cost?

**A.** In most cases, 8290 is less expensive than coax since matching transformers are not required. The length of the lead-in is also a factor in the price difference. The cost of coaxial cable installations can vary tremendously, depending upon the type and quality of matching transformers used. If UHF reception is desired, very high priced transformers are required.

**Q.** Is 8290 Shielded Permohm easy to install?

**A.** Yes! Very! It can be stripped and prepared for termination in a manner similar to 300 ohm line without the use of expensive connectors. It also can be taped to masts, gutters or downspouts, thus reducing the use of standoffs. There is no need to twist 8290 as the shield eliminates interference problems. It is available from your Belden electronic distributor in 50, 75, and 100 foot lengths, already prepared for installation, or 500' spools.



BELDEN MANUFACTURING COMPANY  
P. O. Box 5070-A • Chicago, Ill. 60680  
\*Belden Trademark Reg. U.S. Pat. Off.

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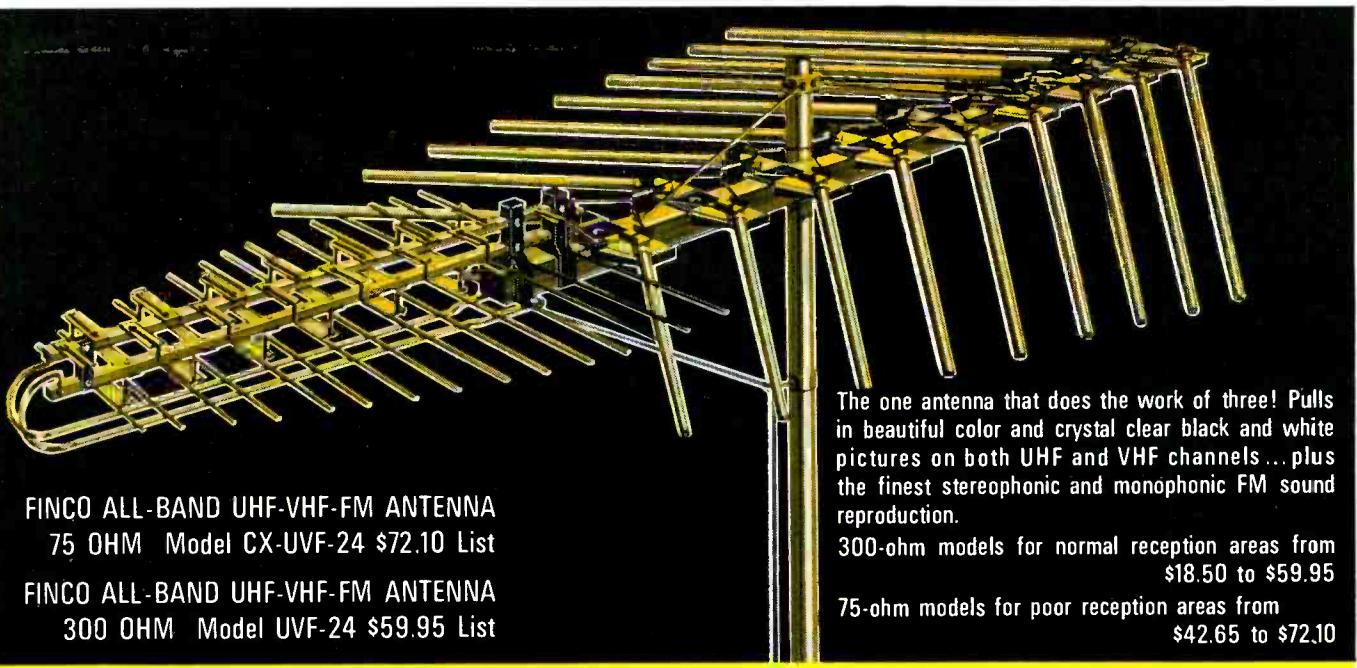
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**FINCO ALL-BAND UHF-VHF-FM ANTENNA**

75 OHM Model CX-UVF-24 \$72.10 List

**FINCO ALL-BAND UHF-VHF-FM ANTENNA**

300 OHM Model UVF-24 \$59.95 List

The one antenna that does the work of three! Pulls in beautiful color and crystal clear black and white pictures on both UHF and VHF channels... plus the finest stereophonic and monophonic FM sound reproduction.

300-ohm models for normal reception areas from  
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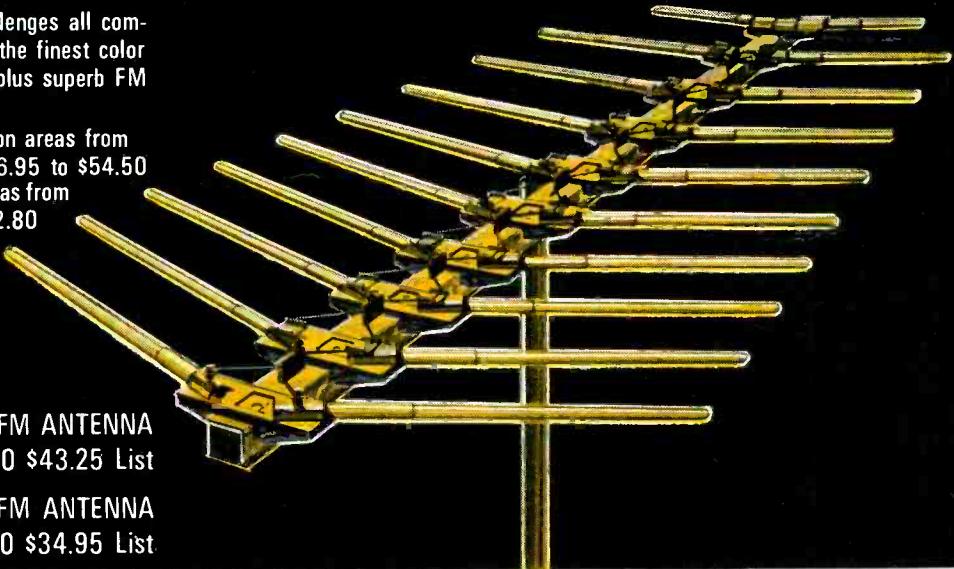
75-ohm models for poor reception areas from  
\$42.65 to \$72.10

# **FINCO**

## *introduces* / **75-ohm COLOR VE-LOG ANTENNAS FOR UHF - VHF - FM RECEPTION**

Finco's Swept-Element Antenna challenges all competition. Its unique design assures the finest color and black and white TV reception—plus superb FM and FM Stereo tone quality.

300-ohm models for normal reception areas from  
\$16.95 to \$54.50  
75-ohm models for poor reception areas from  
\$18.55 to \$62.80



**FINCO SWEPT-ELEMENT VHF-FM ANTENNA**  
75 OHM Model CXVL-10 \$43.25 List

**FINCO SWEPT-ELEMENT VHF-FM ANTENNA**  
300 OHM Model VL-10 \$34.95 List

**FREE!**

ALL FINCO CX-VL, CX-UVF AND UVF ANTENNAS COME WITH A FREE INDOOR SET-MOUNTED TRANSFORMER, VHF-UHF TRANSFORMER SPLITTER OR VHF-UHF SPLITTER.



**THE FINNEY COMPANY**

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CIRCLE NO. 6 ON READER SERVICE CARD

INSTALLATION & SERVICING HANDBOOK

## FOREWORD

# ELECTRONICS INSTALLATION & SERVICING HANDBOOK-1967

In this age of specialization, it may seem anachronistic to publish a Handbook to fulfill the needs of the "renaissance man" in electronics. Specialization has its pitfalls, however, and although basic electronics theory remains unchanged, the technician that has specialized in color TV is often at a loss if he attempts to peak up a CB transceiver. Conversely, the p.a. sound technician probably wouldn't be able to distinguish the R-Y from the B-Y demodulator in a color TV receiver.

The 1967 ELECTRONICS INSTALLATION & SERVICING HANDBOOK was purposely designed to broaden the general electronics knowledge of the specialist technician. Here, under one cover, a variety of authors present what they feel to be the most important aspects of their respective subjects. The principal themes are (1) getting the equipment installed and (2) keeping it working.

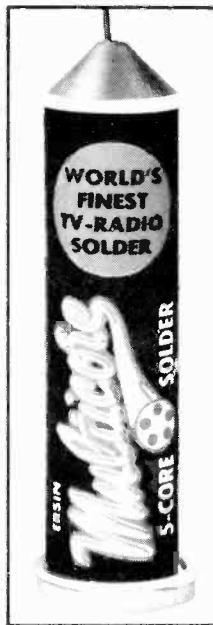
The extent and depth of the subjects covered in this Handbook are related to the impact a particular subject has upon the consumer. Thus, in this edition there is considerable information on maintenance of a color TV receiver. There is new material on transistor AM and FM radio receiver servicing and repair, while there is less space devoted to automotive electronics.

The ELECTRONICS INSTALLATION & SERVICING HANDBOOK is the only publication of its kind published for the electronics technician. I hope—speaking for the staff—that you find the information of use and value.

Oliver P. Ferrell, Editor



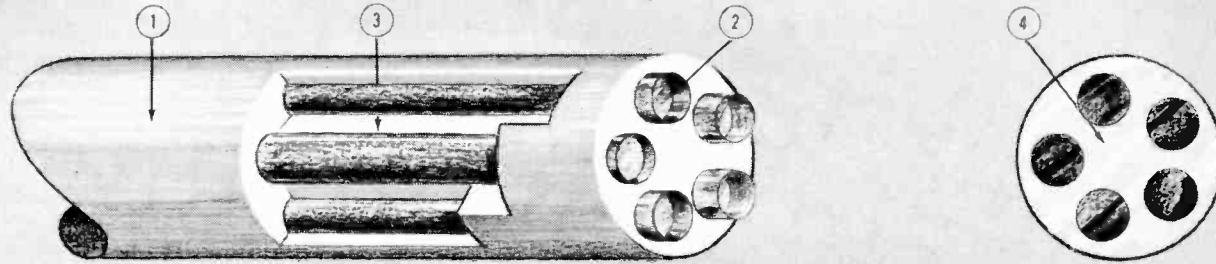
COVER ILLUSTRATION The items shown on the cover include: (A) eleven-inch color TV chassis, General Electric Model M213-CWD; (B) Mercury Electronics VTVM, Model 1700; (C) color bar dot generator, RCA Model WR-64-B; (D) CB test set, EICO "Trans/Match"; (E) CB transceiver, Pearce-Simpson "Companion III"; (F) twelve-volt power supply, Pace Model 5803; (G) tube tester, Seco Model 88; (H) VOM, B & K Model 360; (I) hi-fi amplifier, Electro-Voice Model 1144.



## THIS IS NO ORDINARY SOLDER...

Consider the importance, in your work, of perfect electrical conductivity and avoiding hidden dry joints. Even though the costs of individual solder joints are minuscule, the amount of difficulty which can result from poor or imperfect joints is such that it becomes well worthwhile to use only the finest... ERSIN MULTICORE SOLDER. Ask your radio parts distributor for Ersin Multicore Solder in the 7 lb. reel, 1 lb. box, or the convenient new 69¢ Easy Dispenser Pak.

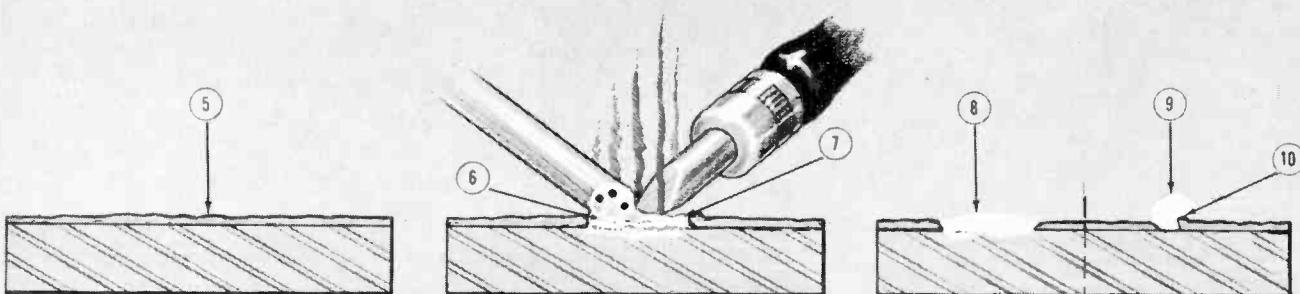
### ONLY ERSIN MULTICORE 5-CORE SOLDER IS MADE THIS WAY



These illustrations show the construction of ERSIN Multicore 5-Core Solder. Multicore solder is made only from pure virgin metals (1) with 5 cores of exclusive extra-active, non-corrosive ERSIN Flux (2). Multicore's special manufacturing process locates the 5 cores of ERSIN Flux close to each other and at the perimeter, so

that there is only an ultra-thin wall of solder between the cores of flux and the work (3). This unique core configuration (4) also keeps the flux near the heat source, to melt faster — wet the metal more effectively. This enables ERSIN Multicore solder to produce the consistently reliable joints for which it is known.

### ONLY ERSIN MULTICORE 5-CORE SOLDER WORKS THIS WAY



All metals are covered with a non-metallic film or oxide (5) which prevents the fusing of solder to the metal. In fact, the oxide has a surface tension which isolates the metal from the solder. For a reliable solder joint this oxide must be released and removed instantaneously during the application of the solder. ERSIN Multicore's exclusive construction guarantees an uninterrupted and vigorous fluxing action from 5 cores instead of the single core of flux found in ordinary solders. Yet, there is no greater percentage of flux to solder than in the usual single cored solders. In operation, the ERSIN Flux prewets the work, and Multicore's ultra-thin wall of solder becomes instantly fluid (6)...flows rapidly and con-

sistently on to the wire or metal. The ERSIN Flux has loosened and removed the oxides from the surface (7). Unimpeded by these oxides, the ERSIN Multicore solder is molecularly fused with the metal. ERSIN Multicore guarantees instant spreading and actually alloys with most "difficult" metals used in electronic applications. The result is an evenly spread, reliable joint (8). Lack of sufficiently vigorous fluxing action, characteristic in ordinary solders, results in a cold joint or ball (9). A portion of the oxide, unseen but still in the joint (10) acts as an insulation resulting in high resistance and costly rejects. ERSIN Multicore prevents this, and insures excellent electrical conductivity.

**MULTICORE SALES CORPORATION, WESTBURY, N.Y. 11591**

DIVISION OF BRITISH INDUSTRIES CORPORATION

CIRCLE NO. 11 ON READER SERVICE CARD

# **TOOLS AND TEST EQUIPMENT FOR SUCCESSFUL INSTALLATION AND SERVICING**

By JAMES G. LEE

## **HAND TOOLS**

Screwdrivers and Nutdrivers

Pliers, Cutters, and Grippers

Wrenches

Hole Cutting Tools

Soldering Tools and Solder

Sinks and Clamps—Those Extra Hands

Sheet Metal Tools

Safety and the Work Area

## **TESTING AND TEST EQUIPMENT**

VOM's and VTVM's

Oscilloscopes

Audio Generators

R.F. Signal Generators

TV Sweep and Color Generators

Capacitor Checkers

GDO and SWR Bridge

Tube Testers

Transistor Testers

Accuracies and Errors

**N**othing is very difficult when you know how to do it, but the proper tool at the right time can make even difficult jobs a lot of fun. Electronic installation and servicing can call for muscle at times. But more often, it requires a light touch—the right touch—to bring out the ultimate performance in electronic equipment, be it FM antenna, color TV, CB mobile communications, intercom, or daughter's small "transistor" that never seems to be turned off.

Installation and servicing differ but slightly. Installation can be compared to original construction where you drill holes, make fittings, brackets, wire connections, and initially adjust the components to operate properly. Servicing generally means you don't do any original work. You repair or check what is there and make any necessary replacement to restore proper operation.

Whether you are installing new electronic equipment or replacing repaired equipment, there are certain hand tools and test equipment you must have. The hardest part of any job is learning not only what is the proper tool to use but precisely when to use it. Let's begin by looking at the hand tools you will need to work efficiently and successfully in installation and servicing.

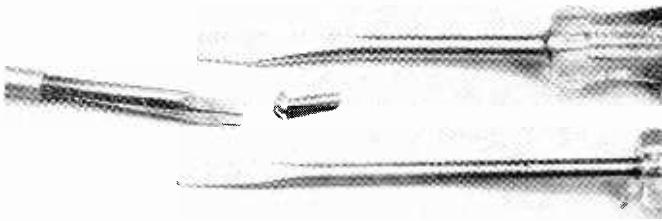
## **HAND TOOLS**

The time has passed in installation and servicing work when just one size of each tool would do everything. Each job you tackle will be different, but fortunately, the sizes of nuts, bolts, and screws you will encounter are not many, so that the variety of tools required will be at a minimum. Certain tools are equally helpful in both areas, while others will find more use in one or the other.

Tool quality can make a difference in installation and servicing. The most frequently used tools should be quality tools, though generally they will cost a bit more. Quality shows up in better grips on the handles, good alignment of joints, and sharper cutting edges, all resulting in less danger to you and the equipment you are working on. Knowing what to look for in selecting tools, however, will enable you to buy quality tools at minimum costs.

Take a look in your tool box. If it doesn't have a set of tools comparable to the ones described below, then you are probably expending a lot of extra effort and still not getting the job done well.

**SCREWDRIVERS AND NUTDRIVERS** It is axiomatic that you can't have enough screwdrivers for electronic work. Screwdrivers come in all shapes and sizes, with different blade styles and many specialized uses. The three most common screwdriver blade styles are the standard "keystone" blade, the cabinet blade, and the Phillips blade. These blades can be found not only in the simple common screwdriver shape, but in special shapes such as offset, screwholding, ratchet,



**COMMON SCREWDRIVER BLADES** The keystone blade is shown at upper right, a cabinet blade at lower right. The split blade at the left, center, is the handy "screwholding" driver.

and stubby. There are even screwdriver blades made to fit a carpenter's brace.

Next to quality, the most important factor to consider in selecting a screwdriver is the match of the blade tip to the screw. The blade tip should occupy about 75% of the screw slot. If it is wider than the slot, you chance scratching the surrounding surface as the screw seats. Too narrow a tip offers no driving power and can twist in the slot. The correct tip thickness is proportioned by manufacturers to the correct width so that the driver will have less chance to slip and possibly ruin both screw and tip.

In electronics, the most common screw sizes lie between #2 and #10, so initially you'll only need three screwdrivers ( $\frac{1}{8}$ ",  $\frac{1}{4}$ ", and  $\frac{5}{16}$ ") to work these sizes. If you plan to use these screwdrivers only on electronic work, choose the cabinet tip. It has a constant

## ESSENTIAL TOOLS FOR THE REPAIRMAN

TOOL	USE	APPROX. COST
Adjustable open-end wrench, 6"	Volume control nuts, sheet metal screws, bending, tightening	\$2.75
Diagonal cutting pliers, 4½"	Cutting wire and component leads, stripping wire and cutting insulation	\$2.75
Needle-nose pliers, 4½"	Parts positioning, wire bending, and lead forming	\$2.50
Nutdriver, $\frac{1}{4}$ " x 6", hollow shaft	Tightening and removing sheet metal screws and all #4 and #6 nuts; needed for disassembly of most radio, TV sets	\$1.00
Neon test light 55-600 volt, a.c.-d.c.	Measuring voltage and polarity; testing for "hot" circuits and chassis	\$0.35
Rosin-core solder	Soldering	\$2.00 per lb.
Screwdriver, $\frac{1}{4}$ " and $\frac{5}{16}$ " blades, 6" long, cabinet tip	Mounting hardware, positioning parts, general mechanical assembly	\$0.60
Screwdriver, $\frac{1}{8}$ " blade, 3" long	Mounting small parts, particularly knobs; also for tight work and probing circuits	\$0.40
Soldering gun, 100 watts or dual capacity	Soldering	\$5.00 up
Soldering iron, 30-40 watts or multiple capability	Soldering	\$1.00 up

width for the entire shaft from handle to tip. It can slip through small holes where the keystone tip can't go.

A square shaft on a screwdriver can be gripped by a wrench when you need extra twisting power, but a round shaft allows easy rotation between the fingers and has become the most popular type for electronics.

You'll need a Phillips head screwdriver (#2 or #3) for installation and servicing. This is the connoisseur's screwdriver. Its cross-bladed tip is precisely matched to the slots in the Phillips screw and is much less likely to damage the slot. Because the matching features between slot and tip are not dependent upon width in the same fashion as the flat-blade driver, a single size Phillips screwdriver can be used on a wider range of screws.

Only two special kinds of screwdrivers are really useful in electronic work. They are the offset and the screwholding driver. The offset can be quite useful in tight corners and comes in a variety of tips. The screwholding driver is almost "a third hand" when you need to insert a screw in hard-to-reach places.

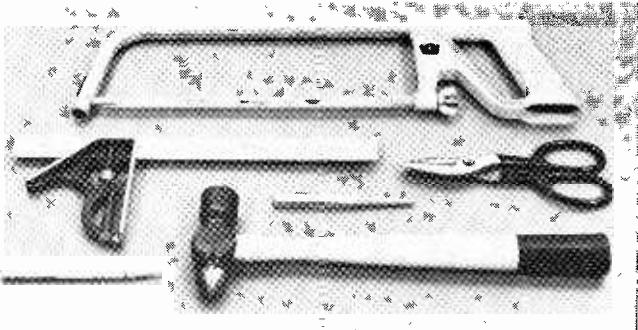
Electronics technicians may also find the so-called insulated screwdrivers of use. These are generally screwdrivers with insulating sleeves drawn over the shaft. You can make your own insulated screwdriver by simply slipping a length of plastic tubing over a bare metal shaft. If the screwdriver must be non-magnetic, look for a tool with a beryllium-copper blade.

Quality in a screwdriver is found in the tip, the tip taper, and the seating of the shaft in the handle. The tip should have curved, lateral cross-ground marks, which provide the gripping power of a screwdriver. Poorer quality pressed blade tips are smooth and shiny, and easily climb up the sides of the screw slot. Tip taper should be about 8 degrees. The best screwdrivers have this taper plus short parallel faces at the extreme tip so that the slot in the screw will not be spread apart, thereby increasing the possibility of slippage. The shaft should have "ears" where it extends into the handle; they make it impossible for the shaft to turn inside the handle under heavy twisting loads.

Virtually every piece of electronic equipment uses sheet metal screws, and to assemble or dismantle you'll need nutdrivers. The most common and most necessary size is the  $\frac{1}{4}$ " nutdriver, and an investment in the  $\frac{3}{16}$ " and  $\frac{5}{16}$ " size nutdrivers makes for a good starter set. However, since nutdrivers are sold in sets of six different sizes, purchase of a complete set should be seriously considered.

Practically every technician who uses nutdrivers eventually winds up tightening the nut rather than turning the screwdriver. This is probably because most of us still ruin a screw slot occasionally. With the nutdriver, you can slip and usually nothing is damaged.

Nutdriver quality points are the shell, shaft, and handle. The shell wall should be strong and thin so that the driver will fit into tight spaces. The shaft should be hollow to allow the driver to tighten a nut



**METAL-WORKING LAYOUT TOOLS** These are a few of the tools required for metal-working. Invest in a good hacksaw and be sure to buy a variety of blades. With tin snips—like scissors—you get the sharpness, ease of handling, and durability that you pay for. The combination square-center punch and ball peen hammer are real "musts." At lower left is a carbide scriber.

Some of the tools already discussed will be useful in sheet metal work, but you'll need others like the hacksaw, center punch, combination square, tin snips, files, and a hammer.

Buy a well-constructed hacksaw, 12" long, with a comfortable handle, and with blade holders that swivel. Always use a finetooth blade. You should have at least three teeth of the blade in contact with any metal you saw. Thus, a 32 teeth-per-inch blade will let you cut metal as thin as  $3/32"$ . This is the thickness for which use of tin snips becomes increasingly difficult. Suitable blades are those with 24 or 32 teeth-per-inch and they should be "all-hard." This means that the entire blade is hardened, not just the teeth. The waviness of the teeth is for chip removal, so if you have to cut through thick, soft metal, choose a 14 or 18 teeth-per-inch blade since the coarser teeth will not clog as easily.

A center punch is used to mark the precise spot for drilling holes. The most useful type is the automatic center punch. It costs a bit more, but it has an adjustable tension on the spring, and is no larger than the one-piece hammer-driven punch.

The combination square should be used more than it actually is in electronics. Look for one that has not only a good steel sliding rule and accurately faced stock, but has a level bubble and a small scriber included. The scriber can mark centers for your center punch, and the level bubble can tell you when the TV mast is vertical or that new console model is sitting squarely on the floor. Check the fit of the sliding rule in the stock groove for easy movement when loose, and no wobble when tight, before you buy it.

Sheet metal work usually suggests the ball peen hammer, but for installation work the claw hammer serves quite well. The most popular size is the 16-ounce weight. Be sure it has a crowned face which will strike a good blow at any angle and not a flat face which will give you many bent nails. The face should be smooth and polished. The neck should be slanted toward the handle to give you a more natural arm position as you use the hammer. Drop-forging is the only type to buy, but you do have your choice between

wood, fiberglass, tubular, and solid steel handles.

Tin snips and shears come in various sizes, but the most common types resemble scissors in looks and action. For occasional work, the 6" size is adequate, but if you contemplate a lot of cutting, get the larger 10" or 12" size. Again, drop-forging means quality, and make sure the pivot joint is one with a hex-nut in case future tightening becomes necessary. Shears are a product of the aircraft industry and are double-action, precision tools. They have serrated cutting edges and are capable of much finer work than the tin snips. They are more expensive and not really necessary in electronic work.

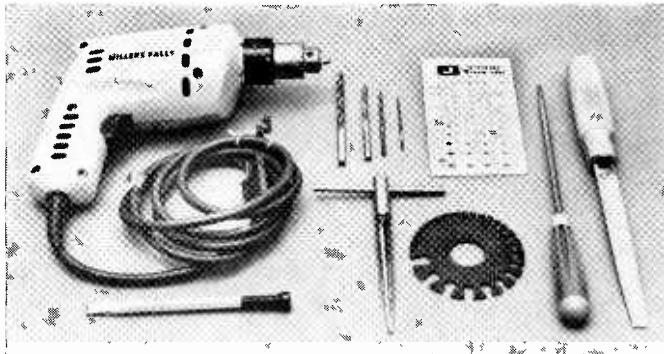
Files were invented for one purpose—removal of bulk material—and there are over 100 different types and styles. In electronics the file is used primarily as a smoothing tool and as a burr-remover. The best file for this work is the double-cut machinist's file, in both large and small sizes. Try to buy ones with handles attached because the comfort is worth the extra pennies.

The file blade is actually an array of tiny chisels which have been cut into the hardened metal. The double-cut file has a cut made first in one direction, then a cross-cut made at a different angle. The most useful shapes are the flat, half round, round or "rat-tail," and the three-square or "triangular" blades. Files work best when clean, so a "file-card" or file-cleaning brush is handy to have around your work-bench.

Two other tools which find considerable use when a lot of sheet metal work is done are the sheet metal

## "THERE MUST BE AN EASIER WAY" TYPES OF TOOLS

TOOL	USE	APPROX. COST
Chassis punches: $1\frac{1}{32}"$ to $3\frac{1}{8}"$	Cutting tube socket and capacitor holes in chassis	\$2.50
Circle cutter	Cutting large round holes for meters, dials, etc.	\$2.00 up
Crimping tool	Setting stake-on terminals, neatly cutting bolts, wire stripping, cutting	\$4.00 up
Nibbling tool	Neatly cutting large holes in panels and sheet metal chassis	\$4.00
Nutdriver set $3\frac{1}{16}"$ to $9\frac{1}{16}"$	Mounting hardware, tightening and removing nuts and components	\$6.50
Riveting tool	Cheaper, quicker, better way of mounting semi-permanent components, sockets, brackets, etc.	\$5.00
Socket and ratchet set (automotive)	Tightening volume control and switch nuts, etc.	\$3.00 up
Traverse cutting pliers, 5"	For close cutting of leads in tight corners; perfect for printed-circuit work	\$3.00
"Vise Grip" pliers, 7"	Holding and clamping, positioning large parts prior to soldering, heavy cutting	\$1.60

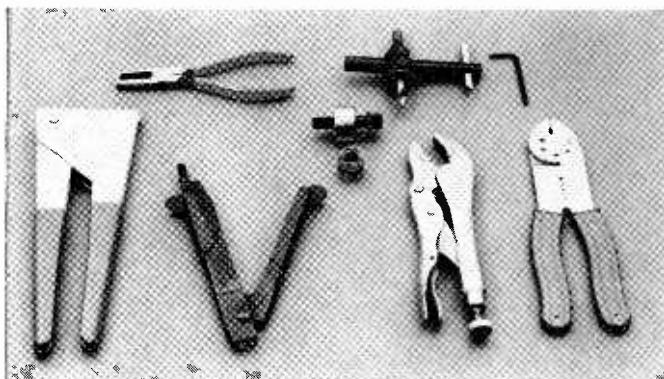


**DRILLING, REAMING AND FILING** Every electronics installer or repairman is faced with the prospect of buying a power drill. For a few extra dollars, you can get a drill that has a built-in speed control (through the trigger) and even reversal of the direction of rotation. The above drill doesn't require a three-wire power cable—it is housed in a shockproof plastic case. Only four twist drills are shown here, although a twist drill index is a valuable addition to any workbench.

brake and the forming shear. The brake can make up chassis, shields, and odd-shaped brackets; but unless you do a lot of this type of work, it will spend most of its time gathering dust in a corner. The shear forms, punches, shears, and rivets metal up to 1" wide and up to 16 gauge; it is ideal for making special straps for holding masts, components, or complete units securely. These tools are primarily shop tools and are not too easily carried out on the job. If you survey the installation job beforehand, however, you can pre-fab the straps in the shop.

You may find use for the "Pop" Rivetool and the Adel nibbler. Hand-operated, the Rivetool permits blind rivet fastening of metal, plastic, or thin wood. The rivets won't loosen or vibrate loose, and they can be soldered; they will fasten materials together faster and stronger than nuts and screws. The nibbler is a hand-operated cutting tool with which you can make round or odd-shaped holes in sheet metal or tubing; it "munches" its way along, taking a bite about  $1/16$ " by  $1/4$ " in size.

**SAFETY AND THE WORK AREA** When you think about the tools that have been described, they all



**LUXURY TOOLS** These tools are handy, but infrequently used by the installer or repairman. They should be included in any workshop that does a lot of repair work, however. From left to right are: Rivet-All, traverse cutters for printed circuit use, an Adel nibbler, Greenlee punch, circle cutter, vise gripping pliers, Allen wrench, and Vaco crimper and cutter.

either cut, squeeze, strike, or burn something when in use. You need to make sure that something isn't a finger, hand, or some other part of you. Just before you put your muscles to work, stop and see if you are unduly exposing a limb, or hand, to possible injury. The few seconds it takes is good insurance against injury.

For example, if you must have a hand near a screw when tightening the nut, try to keep it protected so that if the screwdriver slips you won't get a gouged hand or finger. Always try to pull a wrench toward you and not toward the work. If the wrench slips, or the nut suddenly loosens, no damage will be done. If you must push toward the work, use the heel of your hand on the wrench, and you may save a few skinned knuckles.

A clean work area, well lit and properly laid out, can be not only a safe area but an efficient area as well. A sturdy workbench is the first requirement, closely followed by the need for efficient storage and accessibility of the most often used tools and test equipment. Develop the habit of putting tools back where they are normally kept immediately after using them. You'll find that your work efficiency will be increased and your work area will be cleaner at all times.

## TESTING AND TEST EQUIPMENT

Installation and servicing, whether performed together or separately, constitute testing. This is because testing consists of measurements and checks; and though measurements and checks may seem to overlap in meaning, they are separate functions.

For example, low measured power output of a mobile CB transmitter would call for corrective action. A check of frequency is an inspection, or preventative action, taken to assure that a corrective action is not necessary. Measurement implies precision—check implies superficiality. The block diagram on page 13 illustrates the difference, but points out that all paths lead toward one goal—proper electronic equipment operation.

Basic measurements involve the fundamental quantities of voltage and current along with the inherent component characteristics of resistance, capacitance, and inductance. Component characteristics determine the voltage and current distribution, so voltage and current measurements give information about circuit conditions.

Generally, current measurements are too tedious to make since a connection usually must be broken to insert the ammeter. Resistance and voltage measurements are made instead; and if a wiring schematic is available, it will often show these values and state how they were measured.

Additional types of tests commonly made are for power, frequency, waveform, modulation, and standing-wave ratio (SWR). They are made for both pre-

ventative and corrective maintenance, and give more information than would be available from the basic measurements of voltage and current.

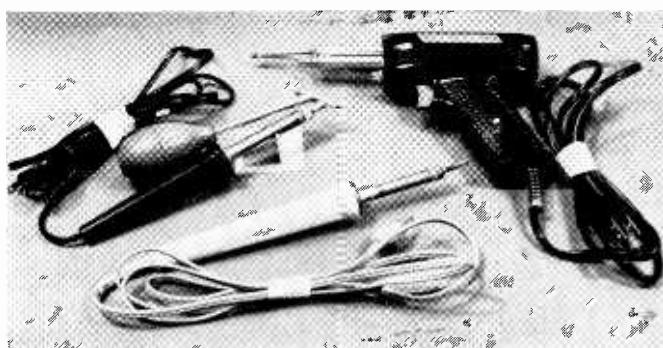
Tubes and transistors need not be tested unless experience or other measurements indicate they are suspect. While up to 50% of the troubles in a TV receiver may be due to tubes, the smart technician also checks the immediate associated circuitry to see if there was a contributory cause to the tube failure.

When you make an initial installation, not only must each unit be operating properly, but they must all work together as a system. Each new installation poses its own problems. Equipment that works well in the shop usually needs special adjustment or some limited testing when installed elsewhere.

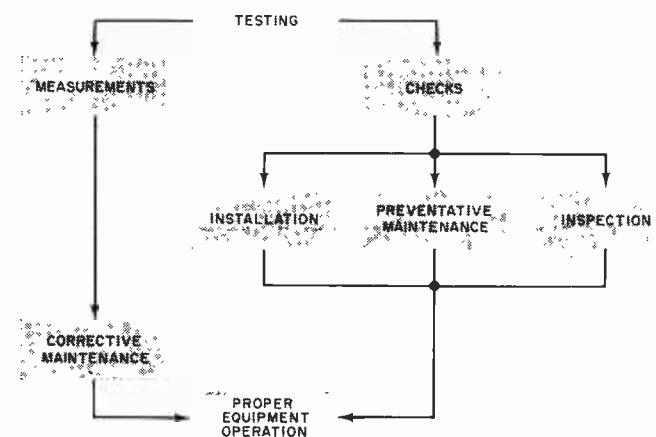
A periodic inspection of previously installed, properly operating systems is preventative maintenance which anticipates problems and corrects them before they develop. If you install and maintain such equipment as TV antenna distribution systems, p.a. systems, or fleet communication systems, use of preventative tests and maintenance techniques can level out your work load and help your reputation as a technician grow.

Like tools, certain types of test equipment are indispensable. Other test units have limited use and you can get along without them. If you have one of each type described below, there is almost no job in installation and servicing you can't do.

**VOM'S AND VTVM'S** Basic and complex measurements all require proper test equipment. How you choose your test equipment makes a difference in the results you get. You first must understand what you want your VOM or VTVM to measure. It must have sufficient range, sensitivity, accuracy, and frequency response to make the correct measurement. It must be of reasonable physical size, have proper terminals, and an easily read scale. The pointer design must be such that you can accurately read the scale value. Operating position can be important since some meters change calibration accuracy when moved from an upright position to a 60° angle.



**SOLDERING TOOLS** In addition to the soldering gun and the soldering iron, a third tool is coming into its own—the desoldering iron. This tool is required if you intend to repair any device incorporating a printed circuit board. The desoldering iron sucks the molten solder away from the connection so that defective parts can be removed or replaced.



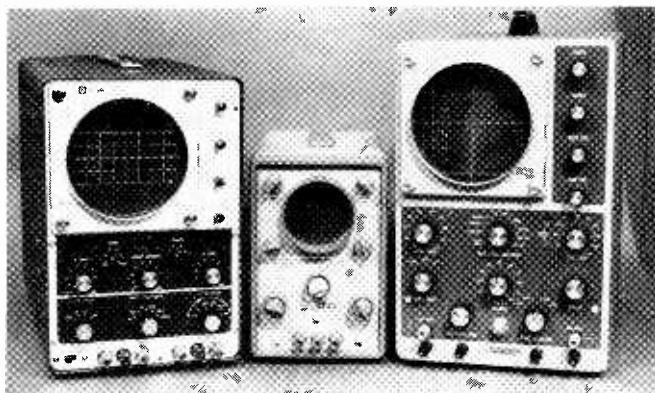
**WHAT IS TESTING?** The practicing, or even the part-time, electronics technician should understand that the testing of operating or malfunctioning equipment can take either of two paths. The differences are explained on the facing page.

**ABOUT THE VOM** The volt-ohm-milliammeter, or VOM, is a very useful piece of test equipment both in the shop and in the field. Accurate measurements are quite possible when the limitations of the VOM are understood. When reading a.c. or d.c. voltage, keep the meter range high enough so the pointer deflection is about  $\frac{1}{3}$  to  $\frac{2}{3}$  of full scale. This will keep circuit loading—a VOM's main limitation—to a minimum.

How much the VOM loads the circuit under test is a function of its sensitivity. VOM's have sensitivities from 1000 ohms per volt up to 20,000—or even 50,000—ohms per volt. Higher sensitivity means higher series resistance in the meter circuit and less effect on the circuitry being measured. Most meters are less accurate in the first  $\frac{1}{3}$  of the scale, but the higher resistance on the higher range can offset the lower accuracy and give you a reliable reading.

For general use, the 20,000-ohm-per-volt meter is a good compromise between capability, ruggedness, and cost. On a.c., this meter has a sensitivity of only about 5000 ohms per volt since it is necessary to rectify the a.c. to get a d.c. meter reading. As the rectifier is nonlinear, to preserve scale linearity the meter is shunted to cause more current to flow through the rectifier. The penalty for this is lower sensitivity.

The a.c. voltage to be measured by a VOM is assumed to be a sine wave of low frequency—less than 10,000 hertz. The copper-oxide rectifier used in VOM's has a capacity near  $0.01 \mu\text{F}$ , so its reactance decreases as the frequency is raised. Thus, the meter reads progressively less and less—about 1% per 1000 hertz—as the frequency is raised to about 30,000 hertz. This is roughly the upper frequency limit for a.c. voltage readings using the VOM. Though calibrated to read r.m.s. voltage, the VOM actually responds to average values. Since complex waveforms like voice, or music, have markedly different average values than the sine wave, the VOM will not give accurate readings for them.



**OSCILLOSCOPE KITS** No workbench need be without an oscilloscope because of high cost. Scope kits are some of the best bargains in test equipment. Examples of current models and prices are: (left to right) the Knight-Kit KG-635 for about \$110; the EICO 435 at \$100; and the Heathkit IO-12 at \$80.00. Assembly time varies from 12 through 20 hours.

Current measurements are possible with a VOM by adding shunts across the meter for the various ranges desired. The most common wiring method is the "ring" shunt, which consists of several resistors of proper value connected in series with each other and with the meter. One meter terminal is used as a common lead and the other lead is shifted to the proper resistor junction for the range desired. The advantage of this shunt is that the shunt resistance values are relatively high and can be more accurately achieved.

There are two common types of ohmmeter circuits—the series and the shunt ohmmeter. As the names imply, unknown resistances are placed either in series or in shunt with the meter. Both types have the disadvantages of producing nonlinear scale readings, and the inability to accurately measure low values of resistance. The shunt type cannot read high values of resistance either because of little or no current change. Modern VOM's use a combination of the two circuits.

The internal voltage used to measure resistances with a VOM can vary from 1.5 volts all the way up to 45 volts in meters designed to read very high value resistances. You should know what voltage your VOM uses and also the polarity at the test leads. Some meters have positive voltage at the black, or negative, lead instead of the red, or positive, lead. This is not important for measuring resistors, but semiconductors can be damaged by the wrong polarity or a high current flow. Electrolytic capacitors should be checked with the leads in both positions, and the highest value of leakage resistance is the correct one.

Three advantages the VOM has over the VTVM are: (1) complete portability requiring no external power; (2) operational capability in r.f. fields which would adversely affect the VTVM; and (3) current measuring ability which the VTVM does not have.

**ABOUT THE VTVM** Vacuum tubes are used in the VTVM to amplify and rectify unknown voltages, and

have a greater sensitivity than the VOM. Below certain meter ranges, the VTVM will not load circuitry as much as the VOM, and it can measure both very low and very high values of resistance. Tubes require a power supply, and this limits the portability of the VTVM.

Contrary to what you may have heard, the VTVM is not always superior in accuracy to the VOM. Above 500 volts d.c., a 20,000 ohm-per-volt VOM has at least 10 megohms input resistance compared to the VTVM's 11 megohms. On a.c., the VOM has 250,000 ohms impedance compared to the 1 megohm of the VTVM. Above 1000 volts, the VOM is equal to—or superior to—the VTVM in accuracy.

The VTVM's capability of measuring lower voltages more accurately makes the VTVM preferable for tuning and alignment measurements. A distinct advantage of the VTVM is its "zero-center" capability for FM detector alignment, bias measurement, or where polarity changes can occur. The VOM cannot begin to equal the 100-MHz (with special demodulator probes) upper limit of the VTVM. Low-capacity probes for the VTVM are available to further reduce the test lead capacity when working with r.f. circuits.

Since the VTVM can read both high and low resistances accurately, you can check capacitors for leakage using the high resistance scales. To do so, make sure the capacitor is shorted momentarily to remove any charge, then connect the leads from the VTVM and observe the pointer deflection. It should "kick" toward zero, then return up scale toward a high value. Good mica, paper, or ceramic capacitors should read above 10 megohms. Electrolytics should read in excess of 100,000 ohms, although low-voltage, high-capacity electrolytics can read 25,000 ohms and be good.

Power transformer lead identification is easy if the leads are color-coded or marked. Those transformers with unmarked terminal-board-type winding connections can be identified by their resistances. The highest resistance you record between a pair of terminals will be the secondary winding, and the next highest will be the primary. Note that the secondary may be center-tapped and this terminal should give you exactly half the resistance to each side of the secondary. The secondary will read several hundred ohms while the primary will generally be between 10 and 100 ohms. All windings less than 1 ohm will be filament windings.

When making measurements with any VTVM, always connect the ground lead to the chassis or ground bus of the equipment. The VTVM is very sensitive to stray a.c. on the lower ranges and erroneous readings can result if this precaution is not taken. When making r.f. measurements, clip the ground lead to the chassis as close as possible to the point of measurement. As with the VOM, the a.c. scales are calibrated to read r.m.s. and peak-to-peak on sine waves—any other waveform will not give a true reading.

## COLOR-CODING

Installation and maintenance can be simplified through the consistent use of color codes for chassis wiring, house wiring, control wiring.

COLOR	WHERE USED IN ELECTRONICS
Black	Equipment ground returns
Red	Highest output voltage from power supply B-plus
Orange	B-plus voltage at reduced level (screen grid feed)
White	All miscellaneous wiring not at ground potential
Gray	117-volt a.c. wiring beneath chassis deck
Brown	Filament leads
Yellow	Cathode wiring (or transistor emitter connections)
Blue	Plate circuit wiring (or transistor collector wiring)

HOWEVER, in control and house wiring, the following code is used:

Black	Full line voltage
White	Grounded or neutral conductor
Green	Equipment grounding lead

## TRANSFORMERS

A special color-coding is applicable only to power transformers.

### COLOR/STRIPE WINDING

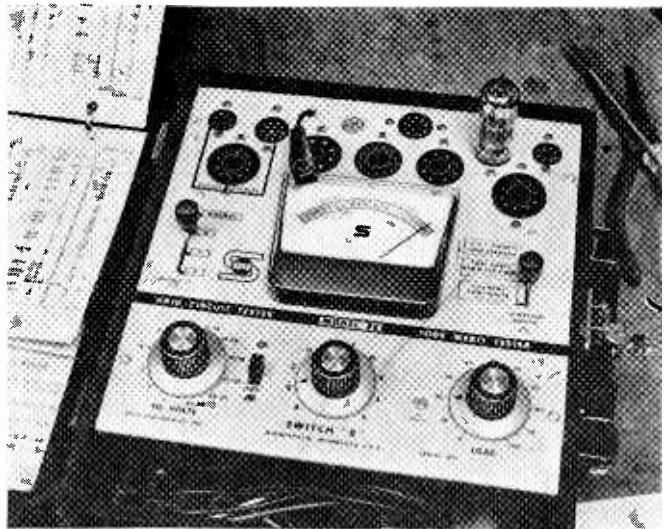
Black	Common leads of primary (no taps)
Black/Yellow	Input tap connection of primary
Black/Red	Finish lead of primary (if tapped)
Red	Secondary high voltage (2 wires)
Red/Yellow	Center tap of secondary
Yellow	Rectifier filament
Yellow/Blue	Center of rectifier filament
Green	Filament No. 1
Green/Yellow	Center tap of above
Brown	Filament No. 2
Brown/Yellow	Center tap of above
Slate	Filament No. 3
Slate/Yellow	Center tap of above

HOWEVER, audio transformers use this coding:

Blue (or Brown)	Plate lead of primary
Red	B-plus input lead of primary
Green (or Yellow)	Grid lead of secondary
Black	Ground return of secondary

HOWEVER, intermediate frequency transformers use this color-coding:

Blue	Plate lead of primary
Red	B-plus lead of primary
Green	Grid (or diode) lead of secondary
Black	Ground (or a.v.c.) return of secondary



TUBE TESTERS An all-purpose tube tester costs about \$75 to \$80. This Seco Model 88 is small, accurate, and easy to use. Somewhat similar priced models are available from B & K, Sencore, etc. Tube testers are also available as low-cost kits.

**OSCILLOSCOPES** The oscilloscope is truly "man's best friend" in electronic servicing. Like the automobile, there are many chassis and body styles to choose from, depending upon your needs and pocket-book. There are big ones, small ones, wide-band models, narrow-band models, and some highly specialized scopes like ignition analyzers and instruments used only to monitor digital computer outputs. For installation and servicing work, particularly with color TV, you'll need a scope which has at least a 5.0 MHz bandwidth. The larger 5" screen is generally preferable to the smaller 3" screen if only for ease of viewing.

You may not need d.c. capability in your scope, but it should have good frequency response down to 5 or 10 hertz. It should have a sweep speed of at least 150 kHz, and it helps if the sync points for TV vertical and horizontal oscillators are marked on the sweep scale.

Although your scope is really just a large a.c. VTVM, it gives you the one thing you need for complete testing. It presents a picture of what is happening at the measurement point. It provides not only waveform, but amplitude, phase, and frequency information. This is far more than any other single instrument will give you, and the scope's versatility is almost unlimited.

The scope can be used as a signal tracer, peak-reading voltmeter, phase shift monitor, modulation indicator, harmonic analyzer, frequency meter, curve tracer for tubes, transistors, and hysteresis tests of transformers, ripple measurements, alignment; and with some ancillary equipment, like the voltage calibrator and electronic switch, it can also measure inductance and capacity. Some general uses will be touched on here and the following chapters will describe in more detail applications of the scope to specific problems in testing.

Since the scope has both vertical and horizontal display capability, it is necessary to know the shape of one of the signals contributing to the display. Normally, the horizontal amplifier section of the scope uses a known signal, either internally or externally generated, and the unknown signal is applied to the vertical amplifier.

When the scope is used as a signal tracer for audio amplifiers or AM receivers, it is only necessary to supply an input signal to the unit under test, and then, beginning with the audio output stage, connect the scope input progressively toward the unit's input until a signal is located. The stage at which the scope responds to the amplified input signal indicates the last properly operating part of the circuit. At this point, other troubleshooting measures can be taken with the VOM or the VTVM.

Once a complete operating path from input to output of a piece of equipment is obtained, more precise measurements can be made with the scope. Let's assume you're testing an audio amplifier. An audio generator capable of producing a good sine wave with

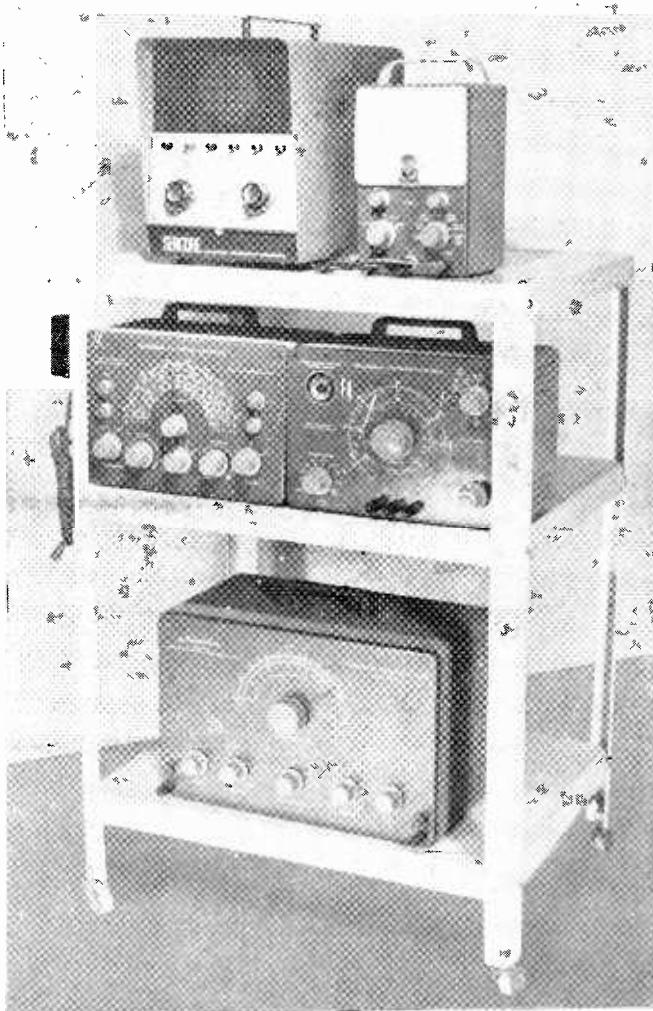
minimum distortion should be connected to the amplifier input. Adjust the input signal to provide a less-than-maximum output from the amplifier to avoid any possibility of overloading. Connect the scope across the amplifier load, and adjust the sweep speed to that of the input signal.

If the input signal is a sine wave, then the output signal displayed on the scope should also be a sine wave. Any distortion of the waveform, such as peak flattening, or ripples in the peaks, indicates a problem within the amplifier.

If a good square-wave generator is available, it can give even more information about the amplifier performance. The square wave is composed of many harmonically related frequencies and provides an easy means of testing the response of the amplifier at frequencies far removed from the fundamental square-wave input. As with the sine wave, the square wave should be reproduced faithfully.

The scope finds its greatest usage in the service and alignment of TV receivers. Here, it can serve as a signal tracer to inspect waveforms at various points in the video and i.f. stages and to compare them with the expected patterns. This requires a demodulator probe for stages ahead of the video detector since the picture information is still essentially an r.f. signal. After the video detector stage, no probe is required. Chapter 2 in this Handbook will give you more complete information about TV service using the oscilloscope.

But the scope can be useful just about any place in a piece of equipment where there is a.c. voltage present. You are limited only by the capabilities of the particular instrument and your own ingenuity.



**MOBILE BENCH** Don't overlook the possibility of using a kitchen table to mount your most-used test equipment. Equipped with a multiple-tap 117-volt a.c. outlet, the table above has room for a scope, VTVM, signal generator, capacity analyzer, and audio generator. The author recommends this arrangement.

**AUDIO GENERATORS** Audio signal generators are generally of two types—sine-wave or square-wave devices. Occasionally, functions of both are combined in the same instrument. Whichever you choose, there are three characteristics audio generators must have to be really useful in installation and servicing. First, the output should be constant, or nearly so, across the frequency range of the instrument. Next, the output should be adjustable from a few millivolts up to 5 volts r.m.s., or more. Finally, the waveform should be of excellent quality. Sine-wave generators fill these qualifications easily, but the square-wave generator has stiffer requirements because of the greater frequency response necessary for low distortion output.

An audio generator can be used to measure input or output impedances of amplifiers, loudspeakers, microphones, small capacitors, filters and inductors. It can substitute for bias and erase oscillators for testing tape recorders and, if its range permits, you can even troubleshoot and align AM receivers with an audio generator.

Most audio generators have an output impedance between 50 and 800 ohms. To measure an impedance higher than the generator impedance, you simply

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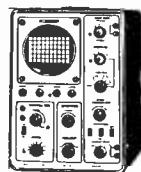
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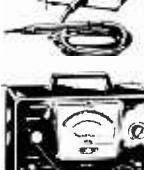


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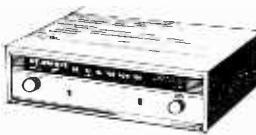
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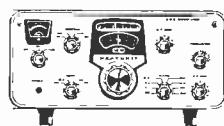
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connect the generator to the unit to be measured through a series variable resistance. Set the generator to about 20 hertz and connect a scope or a.c. VTVM across the unit you're measuring. Change the series resistance until the measured voltage is half the initial value. The ohmic value of the series resistance is the value of the input impedance of the unit under test.

To measure low impedances, connect the generator and scope in exactly the same fashion, but make the series resistance fixed and at least 10 times the expected unknown impedance. A shunt resistor across the input of the unit under test is varied until the initial voltage is reduced by one-half. The value of the shunt resistor is now equal to the input impedance.

Filters can be tested by terminating them with a resistor equal to their characteristic impedance and hooking a scope or a.c. VTVM across the output. Then connect the generator to the filter using a series resistor equal to the filter input impedance. Sweep the generator across the frequency range, noting the voltage at discrete points. Plot this information on semi-logarithmic graph paper, and you'll have a record of the cutoff frequency of the filter plus the slope beyond cutoff.

If you have mismatched the filter, there will be dips and peaks near the cutoff frequency. When the match is perfect, the curve will be smooth all the way out to



**AUDIO GENERATORS** You have a wide choice of audio generators. You can buy either wired units or kits, and sine-wave or sine-plus-square-wave generators. The instrument at left is the popular Heathkit IG-72 (kit and sine-wave) while the unit at right is the Lafayette TE-22 (wired and sine/square).

the "knee" and then roll off at a constant slope. Conversely, this technique will let you determine the proper filter impedances if they are not known. You simply repeat the above procedure using different terminating resistors until you get a smooth curve.

Unknown inductances can be paralleled with a suitable capacitor—from 0.0001  $\mu$ F to 0.01  $\mu$ F—and checked by the resonance method. Connect a scope or a.c. VTVM across the parallel combination, and connect the generator to them using a series resistor to keep the voltage to about one-tenth that available from the generator. Again sweep through the frequency range, and when the indicator reading is maximum, that is resonance. From the formula for resonance, which is found in most electronic handbooks, you can calculate the inductance.

If your generator has square-wave output capability, it can be useful in TV servicing. Connect the square-wave generator to the input of the first video amplifier, and set it to 60 hertz. Connect a scope to the output of the first video stage and check for proper frequency response in the same way as for audio amplifiers. Check the second video amplifier in the same way. If you don't have a scope handy, and the picture tube shows a good raster, you can simply observe the effect on the raster.

With good low-frequency video-amplifier response, one-half the screen will be white, the other half black. Which half is which depends on how the vertical sweep syncs with the 60-hertz square wave. Poor low-frequency response makes a portion of each half of the screen gray. Too much low-frequency amplification causes the opposite effect. The top and bottom of the raster will be lighter than the center.

**R.F. SIGNAL GENERATORS** These generators earn their keep in troubleshooting or aligning AM/FM receivers and certain portions of TV receivers. Since detailed procedures for alignment of these receivers will be given elsewhere in this Handbook, only two

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unusual applications of the r.f. generator will be described here.

The r.f. generator is often used as a marker oscillator for FM and TV alignment in conjunction with a sweep generator and scope. It provides a movable "pip," visible on the scope, to show you bandwidths and spot frequencies. If the sweep generator has a marker input, connect the signal generator to it. If no such input is available, connect a 10-ohm resistor between the sweep generator ground lead and the receiver chassis. Now connect the signal generator across this 10-ohm resistor and the marker pip should be visible on the scope screen.

Injecting an AM modulated signal from the r.f. generator to the grids of video i.f. stages (in a TV receiver) should produce horizontal bars across the raster. If the bars are not of equal size and equally spaced, the vertical linearity in the receiver is off and needs adjustment.

Available in three types, r.f. generators are sold as general alignment instruments with no frills; "laboratory" instruments with limited frequency coverage and calibrated output meters; and the more specialized FM and multiplex stereo alignment generators. The generator you choose should have suitable frequency coverage on fundamentals, internal or external modulation with level control, and a coarse and fine output adjustment; FM and stereo generators should have a built-in sweep generator, should be able to generate a composite FM signal plus a phase test signal, have internal audio modulation and sine-wave signal output from 19 to 72 kHz to setup bandpass networks.

**TV SWEEP AND COLOR GENERATORS** Sweep generators are r.f. generators designed for the specialized requirements of TV and FM servicing. They are indispensable if you do a lot of TV servicing. When you purchase one, make sure it covers all of the TV and FM frequencies and either generates or has provisions for a marker signal input.

The sweep function should be completely electronic, rather than mechanical, for best and most consistent results. The output should be on fundamentals to eliminate any possible spurious signals, and the output should be variable from a few microvolts up to at least 100,000 microvolts to avoid overloading high-gain stages in the TV receiver.

Color bar generators should have certain features to insure precise servicing. A variety of patterns must be available for servicing both black-and-white and color TV receivers. Cross-hatching, dots, color bars, and shading bars will allow precise convergence and linearity adjustments. The generator must have good stability.

The audio-r.f. carrier relationship in a color bar generator should be fixed. This is normally done by making the 4.5-MHz spacing crystal-controlled in the generator. The color subcarrier should be crystal-controlled to assure proper phasing. Again, the output voltage should be variable. Detailed

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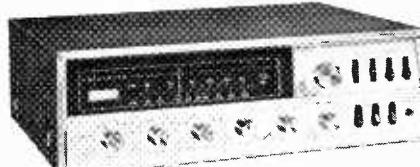
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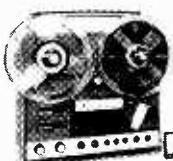


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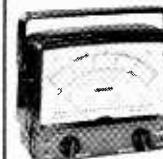


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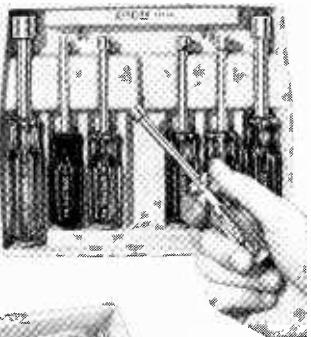
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use of these two generators is covered in other chapters.

**CAPACITOR CHECKERS** Capacitor checkers range from very simple "Go-No Go" testers up to complex analyzers that measure capacity, leakage, and shorts, both in and out of the circuit. Two basic circuits are used in capacitor checkers.

The complex analyzers and the simple "Go-No Go" testers use a high-frequency r.f. oscillator and measure the effect of unknown capacitors on the circuit. The "in-between" priced checker uses an a.c. bridge circuit for capacity measurement and power factor determination; if the capacitor is open or shorted, there will be no indication on this type of checker—a definite disadvantage.

**GDO AND SWR BRIDGE** If you install or service mobile or fixed communications equipment, there are two units you will find very useful. They are the grid-dip oscillator (GDO) and the standing-wave ratio (SWR) bridge.

The GDO is a versatile unit used not only for communications work, but also as a signal generator for radio and TV work when general troubleshooting is required but not precise alignment. It is a test instrument utilizing the fact that grid current change in an oscillator is a much more sensitive indicator of resonance than a plate current change whenever the GDO is coupled to a tuned circuit. A GDO is usually designed so it can function as a non-oscillating detector for coarse frequency measurements or field strength indications.

With the GDO operating as an oscillator, you can align or check the alignment of tuned circuits without power being applied to the equipment under test. Receivers, transmitters, antennas, i.f. traps, filters, and transmission lines can be pre-aligned and then trimmed to exact resonance after power is applied.

The GDO can measure inductance from 0.1 to 100 microhenrys and capacitances from 2 to 1000 pF. To use it in place of local oscil-

lators in AM, FM, or TV receivers in troubleshooting, make a coupling probe consisting of a pair of twisted wires with a two-turn coil at one end and a one-turn coil at the other. Slip the two-turn coil over the GDO coil, and couple to the mixer or suspected oscillator coil. Tuning the GDO to the proper frequency will result in receiver operation if the fault was in the original oscillator.

The GDO can also be used as a marker signal for TV or stereo alignment in conjunction with a sweep generator and scope. It is not an accurate generator but will provide a close enough check to speed your servicing.

The SWR bridge is almost mandatory for mobile or fixed communications work. It is a special r.f. instrument which measures "forward" and "reflected" power in terms of voltage. Zero "reflected" power is ideal and the antenna or feed line should be adjusted with the aid of the SWR bridge for minimum reflected power. The "forward" power position is a useful output indicator.

Keep in mind that you'll need an FCC-issued commercial radiotelephone or telegraph license before you will be permitted to make any repairs on transmitting equipment. The effort required to get a Second Class Radiotelephone license is not excessive and it can increase your business considerably. You may service and test all other kinds of equipment except transmitters without a license.

**TUBE TESTERS** The tube tester is probably the most misunderstood piece of test equipment in the world. There are more varieties of tube testers, with vast differences in measurement capabilities, than any other type of test equipment.

Although tube testers can indicate to a limited degree certain specific characteristics of vacuum tubes, it should be recognized that no tube tester can give an accurate picture of how a tube will perform when it is plugged into the appropriate socket of operating equipment. Certain types of tubes cannot be adequately tested on a tube

tester—they must be "set-tested." That is, they must be used in the actual circuit to see if they perform properly. Typical tubes are power output tubes, vertical and horizontal TV deflection amplifier tubes, and transmitting tubes.

Tubes fail predominantly from mechanical defects, gas, filament burnout, physical damage, and shorts. Mechanical defects and gas are the result of the manufacturing process. Filament burnout is frequently caused by repeated sudden "turn-on" of full filament voltage. Modern tubes with controlled warm-up times have, however, reduced this type of failure. Physical damage is self-explanatory, and shorts are due either to faulty manufacturing or overloads which cause elements to change shape and touch inside the envelope.

Of course, no service bench should be without a tube tester. Get one that checks tube emission, static and/or dynamic transconductance, presence of gas and shorts.

These basic tests will prevent you from disposing of an otherwise good tube and will occasionally save you time which would be wasted looking for circuit defects hidden in the tube envelope. Be sure that your tube tester can be updated and that the manufacturer supplies additional data sheets on new tube types at least once a year.

**TRANSISTOR TESTERS** As with tubes, the majority of transistor testers are not capable of giving you an accurate picture of how the transistor will perform in the circuit. This is because practically all transistor testers only give you d.c. characteristics; and when even low radio frequencies are reached, the d.c. values are no longer accurate. Transistor parameters change with applied voltage and current, and also with frequency.

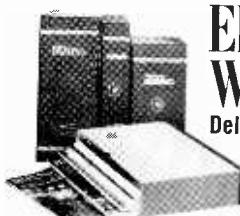
Transistor testers are really specialized ohmmeters. This means that you can use your VOM provided you always stay on the  $R \times 10$ , or  $R \times 100$  range. The VOM is quite satisfactory for "Go-No Go" testing of transistors. For more accurate measurements, get a tester designed to measure these values.

**ACCURACIES AND ERRORS** Accuracies are a direct reflection of the quality of, and how you use, your test equipment. Using the wrong meter or poor testing techniques produces errors. In installation and servicing, precision measurements are necessary in very few areas. Most measurements need not be more accurate than 5 or 10 percent.

You can maintain good accuracy with the proper equipment if it is kept in calibration and checked every six months. Your test bench area should permit use of short leads and good grounds; and when you're using more than one unit of test equipment, the ground points should be common to avoid "loops."

Be sure to read each instruction manual carefully so that you have the greatest understanding possible about each meter. Only through such understanding can you obtain the best in performance from your equipment.

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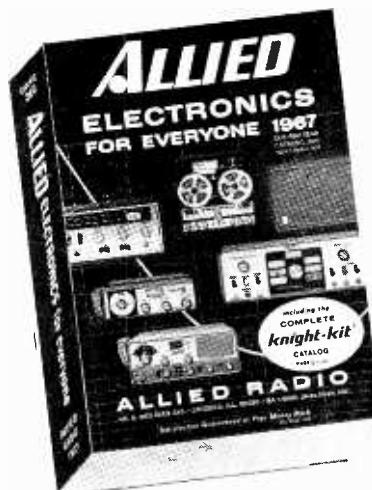
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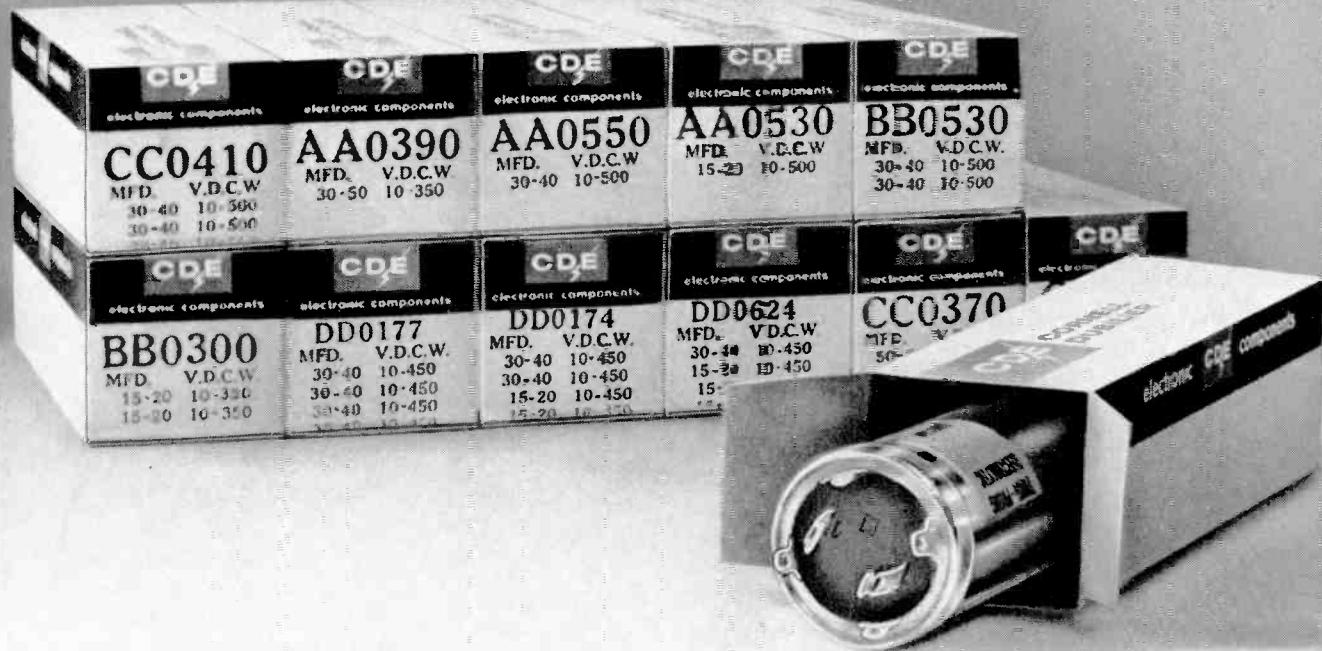
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# **NEW TECHNIQUES IN BLACK & WHITE AND COLOR TV SERVICING**

**By ROBERT CORNELL  
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## **SERVICING A TV SET**

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- Function Ladder
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- Trouble Symptoms & Their Solution
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- Low Line Voltage
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## **COLOR TV INSTALLATION**

- Color TV Controls
- Convergence Adjustments
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- Actual Color Photos

**B**igger and better antennas, better TV sets, better TV signals, and an awareness on the part of the viewer as to what a good TV picture should look like are just a few of the reasons why good TV installation and servicing practices are demanded, both for black-and-white and color sets. Color TV receivers, particularly at the time of transition from crate to living room, require more critical attention to controls, adjustments, location, and signal conditions than black-and-white sets. But it's axiomatic: a good color installation is automatically a good black-and-white installation.

Regardless of the type of set, the detailed explanations in this chapter of how to make a good installation, and how to check the effects of each function or control, should prove to be a valuable addition to your everyday experience. In order to give you a feeling of actual operating situations, the color and black-and-white photos of TV screens on the following pages have not been retouched.

If you are particularly interested in color TV installation, you can skip to page 48 and learn how to set up a color receiver. If your concern is with servicing a specific circuit in a TV set, you can start scanning the symptoms and troubleshooting procedures which begin on page 28. However, it is recommended that you first study the Function Ladder concept illustrated in Figs. 2 and 31.

## **SERVICING A TV SET**

Servicing a TV set can be easy or it can be difficult, but much depends upon the type of trouble you have and how you go about finding and correcting it. While there is no substitute for experience and expertise, the material presented here is designed to lead you to the trouble in the most direct manner and to help you make the needed repairs. Naturally, the more electronic theory you have under your belt the better, but it is possible and practical to bypass much of the pure theory, substituting a systematic, functional approach to TV servicing instead.

In order to make such a system work, however, you have to know what each section of a TV set is supposed to do and how to recognize what constitutes "normal" and "abnormal" operation. Fortunately, your eyes and ears are the only "tools" you need to pinpoint most of the trouble symptoms in a TV set. It stands to reason that if what you see or hear is not as it should be, the set isn't working properly. But, before assuming that there is anything wrong with the set itself, you should see that: (1) the set is plugged into an outlet providing proper voltage and current; (2) the on/off switch and other primary controls, such as brightness, contrast, channel selector, fine tuning, etc., are set to approximately their correct operating position; and (3) that the antenna is connected and that it is in good condition.

Assuming that no one has touched the secondary

# BLOCK DIAGRAM OF TYPICAL BLACK-AND-WHITE TV RECEIVER

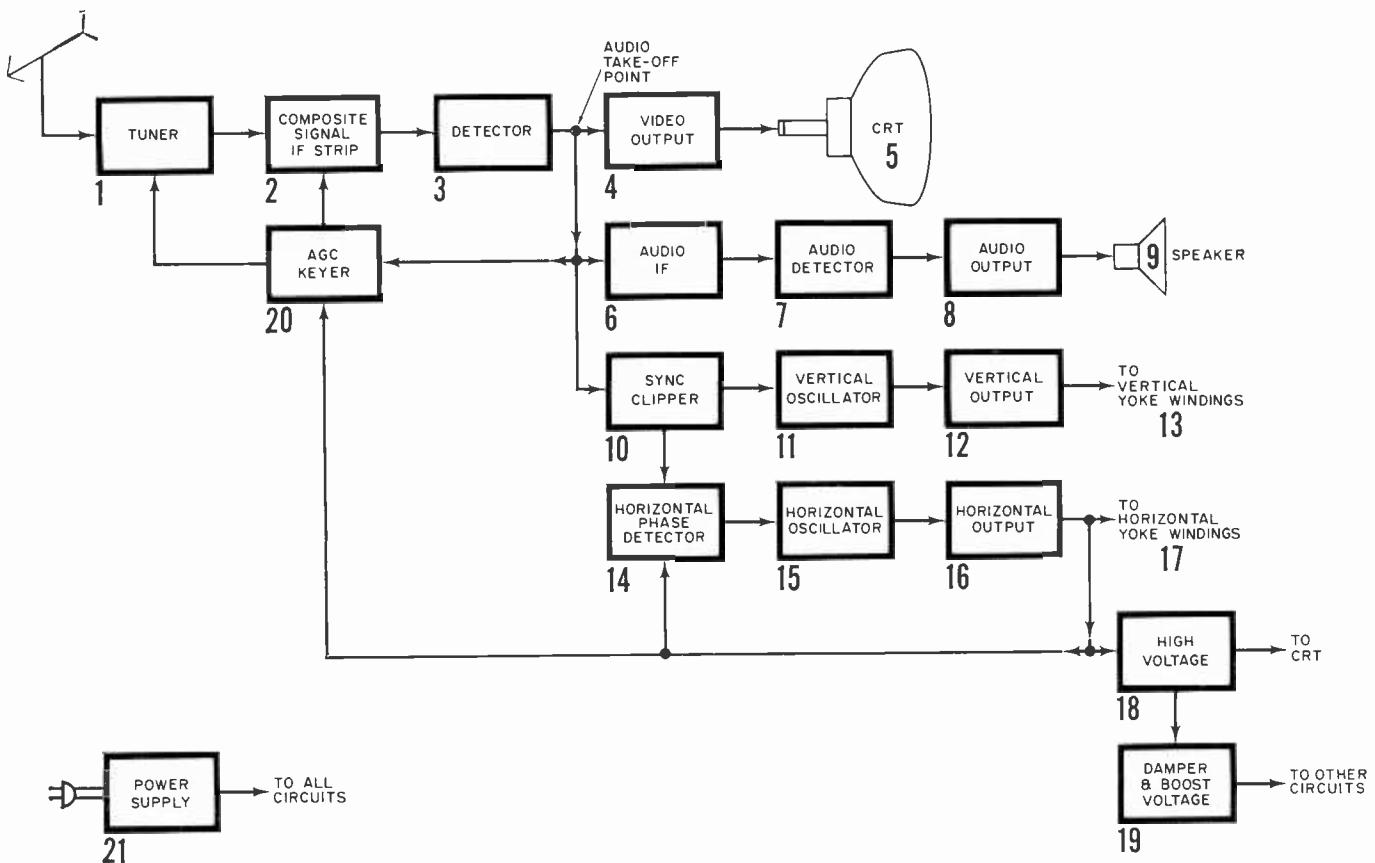


Fig. 1. Each block of circuits in the TV set performs one or more specific functions and contains one or more tubes or semiconductors. The composite black-and-white TV signal consists of video, audio, and sync superimposed on a radio frequency (r.f.) carrier. Color programs also inject a band of color signals. The tuner 1 selects the desired channel (r.f. carrier), amplifies the signal and steps it down to a lower intermediate frequency (i.f. carrier) which can be handled more efficiently and without distorting the composite signal. The i.f. carrier and signal are passed on to the i.f. strip 2 for additional amplification, and then to the detector 3. The detector separates the composite signal from the i.f. carrier and puts the signal into proper form and polarity for the other circuits in the TV set. Once the composite signal gets past the detector, the video, sound, sync, and color signals are separated and fed to appropriate circuits. The exact point of signal separation in a particular TV set is an optional matter and while it is shown here between the detector and the video amplifier 4, most set makers move the take-off point past the video amplifier to take advantage of the additional stages of amplification. Regardless of the exact take-off point, the video signal is passed on to the picture tube 5 and modulates the electron beam in the tube. The audio signal at the take-off point, because of the TV set's design, is still riding on a 4.5-MHz i.f. carrier which has to be removed from both the audio and the video circuits. One or more traps in the video circuit effectively prevent this audio signal from reaching the CRT. One of these traps is usually relied upon to "suck out" a portion of this audio i.f. carrier and feed it to the audio i.f. amplifier 6. As with the composite signal, the audio i.f. is amplified and passed on to the audio detector 7 where the carrier is stripped, allowing only the audio signal to be amplified 8 some more before it finally gets to the speaker 9. The sync clipper 10 separates the sync pulses from the video and audio signals and allows only the sync pulses to pass. Horizontal and vertical sync pulses are interrelated and have to be further separated and fed into respective circuits. Vertical sync pulses are derived through an inert integrator resistor-capacitor circuit between the sync clipper and the vertical oscillator 11. The vertical oscillator is a free-running circuit operating at a

nominal frequency of 60 Hz. It depends upon the vertical sync pulse to keep it running at exactly the same speed as the vertical scanning circuits back in the TV studio. The vertical output circuit 12 amplifies the output of the vertical oscillator, shapes it into a sawtooth waveform, and couples it to the vertical windings in the yoke 13 around the neck of the CRT. Magnetic forces set up by the current in these windings deflect the CRT beam in a vertical manner. When combined with horizontal deflection, the beam scans the entire face of the picture tube, one horizontal line at a time. The horizontal windings in the yoke 17 get their driving voltage from the horizontal output circuit 16. Here the horizontal sweep signal is developed by a free running oscillator 15 which is controlled by the horizontal phase detector 14. The phase detector gets its name from the circuit action. It compares the phase of the sync pulses it receives from the sync clipper with the pulses at the horizontal output. If the two signals are not in-phase, a corrective voltage is developed by the phase detector which causes the horizontal oscillator to speed up or slow down as required. Horizontal output voltages are also fed to a high-voltage flyback transformer and rectifier 18 where potentials on the order of 16,000 volts are developed and fed to the CRT to attract the electrons from the gun to the screen. Picture tube brightness depends, among other things, upon the "forceful" bombardment of phosphors by the electrons from the electron gun. The damper and boost circuit 19 is an essential part of the high-voltage and horizontal-deflection circuits. It also bootstraps some energy from the high-voltage circuit and furnishes a secondary source of B+ voltage. This voltage is used in various parts of the TV set. An automatic gain control circuit 20 found in most TV sets, samples the strength of the signal at the output of the detector and controls the gain of the r.f. amplifier in the tuner and one or more stages in the i.f. strip. By keying the horizontal sync pulses to the a.g.c. circuits, the gain control voltage is determined by the level of the sync pulses, which are constant for a given signal strength as opposed to the constantly varying video signal. Power supply 21 feeds B+ voltages to all circuits (tubes or transistors) and filament voltage to all tubes (if used) except the high-voltage rectifier.

controls (vertical and horizontal hold, vertical and horizontal linearity, a.g.c., etc.) accidentally or otherwise, the fact that these controls need adjusting can be indicative of either normal wear and tear or the first sign of trouble. In either case, these controls should be adjusted to obtain the best possible picture, before you decide to repair the set.

One other relatively simple step to take before launching a full-scale troubleshooting job is to try substituting tubes in those circuits which are suspected of improper operation. A tube tester may or may not be able to pinpoint a troublesome tube. Sometimes a tube tester will spot a defect that is causing an unnoticed trouble which will become noticeable in the future. You need a certain amount of "know-how" to properly evaluate and interpret the readings you get on the tube tester—not all tubes that read "bad" are bad, neither are all tubes that read "good" necessarily good in a particular circuit.

If you know which tubes to suspect, which controls to check, and how to interpret the symptoms, you can repair most TV sets. Even the more difficult types of problems, involving capacitors, resistors, coils, and transformers, can be ferreted out with proper symptom analysis.

A certain amount of test equipment is always helpful. Sometimes it only contributes to the speed of servicing but many times it is the only way to do the job.

**THE TV SIGNAL** Basically, a TV station transmits a composite signal consisting of video, audio, and sync. In the case of color transmissions, the color information is added to the composite signal. Color troubles should be considered separately and only after you have eliminated all the faults in the black-and-white circuitry.

Once the composite signal gets past the tuner, it makes no difference which channel it came from because the superheterodyne action makes all channels look alike to the TV set. Thus, if the set can receive at least one channel loud and clear, chances are that everything beyond the tuner is okay. Figure 1 is a block diagram of a typical modern TV receiver. Note how the video, audio, and sync travel together through the tuner, i.f. strip, and detector. Beyond the detector they separate and continue on to their individual circuits to perform a specific task.

The audio signal eventually winds up at the speaker and the video signal at the picture tube (CRT). The sync signal is further subdivided into a horizontal and a vertical component which ultimately positions the electron beam in the receiver's CRT in step with the electron beam in the TV studio's vidicon.

Therefore, if the sound fails, but you still get a picture, the trouble is most likely between the point where the audio and video separated (sound take-off point) and the speaker. If you have sound but no picture, then it is logical to look for a break in the video path, after the sound take-off point. If both the

sound and the picture are gone, chances are that the trouble is in the circuits leading up to the sound take-off point. Of course, it is possible that there is a fault in the audio circuits, and another fault in the video circuits, but this is unusual. It is more likely that only one tube or component in one circuit is faulty.

Knowing the history of the set is helpful in pinpointing troubles. If the set has been neglected and allowed to operate with a defective sound section and then a video problem crops up, you will, of course, have two troubles to correct. Like a diagnostician, you should try to find out how the set was behaving before it finally broke down.

As in many other multi-function devices, there are bound to be some really difficult troubles. There are circuits which interact with other circuits and there are multiple-function circuits to make life more interesting, or more miserable, depending on your point of view. For example, the power supply affects the entire receiver; if nothing seems to work—no audio, no brightness, not even a buzz—there is no sense in trying to troubleshoot anything else except the power supply, or possibly an open series-string of tubes, or a blown fuse. Even the "rat-race" type a.g.c. circuits can be easily tamed by a systematic, symptomatic approach.

**FUNCTION LADDER** To make your job easier, observe the symptoms and locate the proper step on the Function Ladder of Fig. 2. Start at the top of the ladder, and check the most obvious things first in the circuits indicated, controls, tubes, etc. This ladder is designed to keep you from wasting time tracking down certain secondary effects caused by interacting circuits. For example, loss of high voltage which shows up as no brightness (no raster) could also cause the audio in some sets to be distorted or noisy. Correcting the trouble that caused the loss of raster in these sets would automatically take care of the apparent audio defects. To try to clean up the audio before correcting the loss of raster might eventually lead to the troublesome circuit, but it is a difficult and round-about way of finding it. Therefore, correct a major defect first before you attempt to optimize any given circuit.

Here's another example. There is no point in trying to stabilize the vertical sync if the picture is also running horizontally. Absence of the sync pulse at the output of the sync clipper stage (block 10, Fig. 1) will allow both the horizontal and vertical oscillators to run freely. Incidentally, if the hold controls can cause the picture to run one way and then the other way and sometimes even bring the picture momentarily into proper position, chances are good that there's nothing wrong with the oscillator circuits.

If, after you have located the proper step on the Function Ladder and you have checked out the controls and tubes associated with that step, you still have trouble, you can signal-trace, signal-inject, measure voltages, or check components in the suspected

## BLACK-AND-WHITE TV RECEIVER FUNCTION LADDER

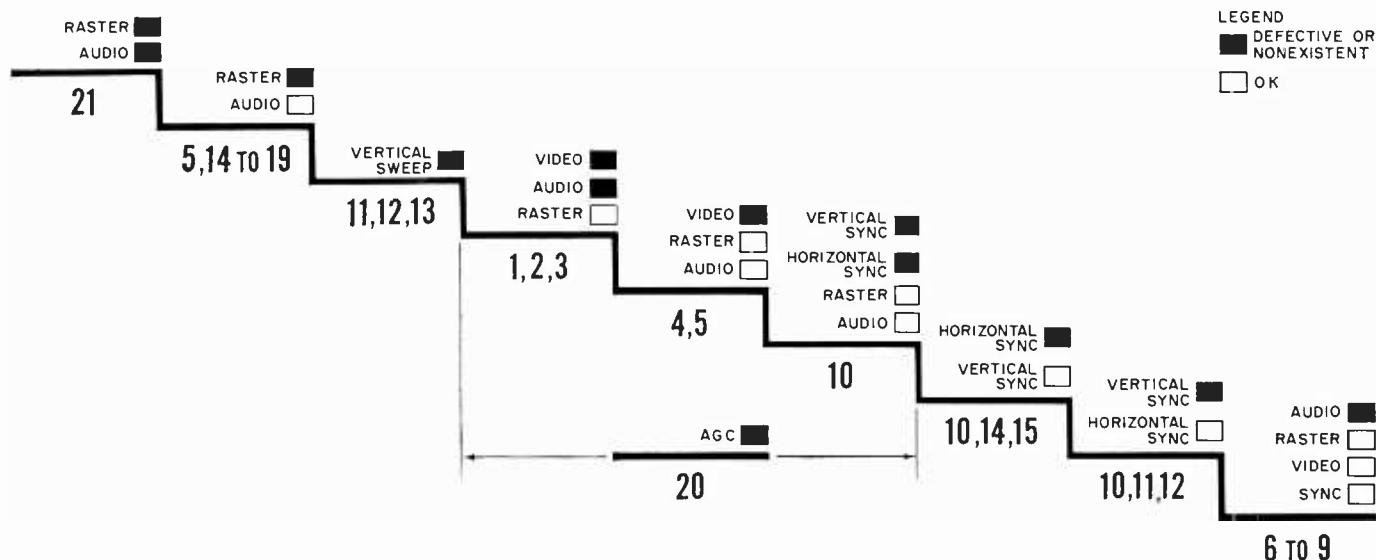


Fig. 2. The "Function Ladder" is designed to help you combine observable TV receiver symptoms with specific circuits. Start at the top of the ladder and work your way down. Select the step that coincides with what you see and hear, then inspect the circuit associated with that step as indicated by the numbers under the step. These numbers refer to the block diagram on page 26. For example, if you have a sound problem, you would expect to work on circuits 6 through 9. If you have a video defect, you climb halfway up the ladder and examine circuits 4 and 5. The Function Ladder can save you valuable time.

circuits. Any technique or combination of techniques can be used, but troubleshoot logically and systematically.

Don't jump all over the place. It doesn't make any difference if you start at the beginning of a circuit or chain of circuits and work forward, or start at the end and work back, as long as you are consistent. Many experienced service technicians prefer to start in the middle to determine which half has the trouble, and then "cut" the troublesome half in half again until the defect is isolated.

**SIMPLIFIED TV SET REPAIRS** To determine which circuit to work in, pinpoint the symptoms and compare them with the symptoms which are itemized below together with the ways to check them out—and to make repairs. If necessary, re-examine your set to further clarify your symptom findings, and refer to the Function Ladder (Fig. 2).

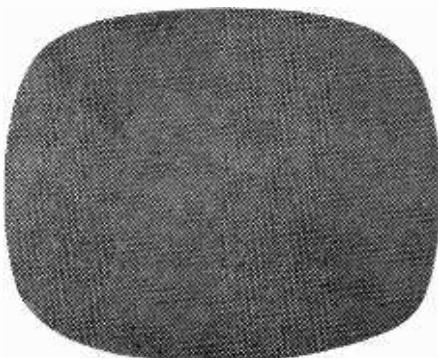


Fig. 3. A totally blacked out TV screen should not be confused with the appearance of a thin white line across the screen.

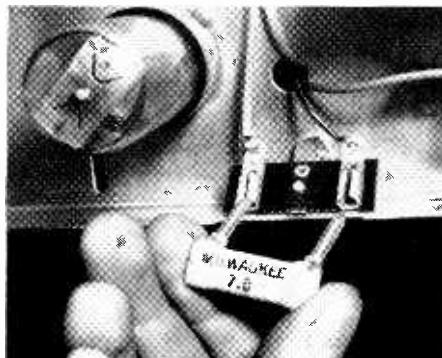


Fig. 4. This plug-in Fusistor acts like a combination resistor and fuse to protect the receiver against overloads and surges.



Fig. 5. Loss of height and width of the TV picture is usually due to insufficient B+ voltage or very low house line voltage.

NO SOUND; NO BRIGHTNESS; NO TUBES LIT Your first goal is to get all the tube filaments to light up normally. Determine how they are wired—in series or parallel—and then make the following tests.

In the case of the parallel-wired filaments, check the line cord, interlock, line fuse (usually 2 amperes or better), and "on-off" switch. You can check the line cord with a continuity tester or by substitution. Examine the interlock visually for charring or unsoldered connections. The "on-off" switch can be tested for an open condition by externally connecting the switch terminals together with a jumper wire, and then plugging the set into an outlet.

You make the same checks for series-wired filaments as for the parallel-wired set, but, in addition, each of the tubes in the TV set (including the CRT) must also be checked. Because the tubes are wired in series, when one filament opens, the rest of the string dies out. Some series TV sets have circuit

breakers that become underrated with age and keep opening prematurely. If you have to reset the circuit breaker repeatedly, and if the rest of the set works normally, install a new one.

**NO SOUND; NO BRIGHTNESS; TUBES LIT** In parallel sets, the classic trouble is a low-voltage rectifier tube going bad. Some sets use one or more solid-state rectifiers instead of a tube. A rectifier can go bad over a period of time, just from normal service, or it can break down from an overloaded condition. Leaky electrolytic filter capacitors or defects in other circuits can draw too much current. In any event, a few voltage checks in the B+ circuitry will put you on the right track. However, variations in voltage readings from the manufacturer's specifications can be as high as 20%, with nothing wrong, and in most instances can be ignored.

Also check the low-voltage fuse. Some TV sets are wired so as to leave the filaments lit even when this fuse is blown. It is also possible that a combination of troubles, such as one in the high-voltage section which causes a loss of brightness, and one in the sound section which causes a loss of sound, will result in the same combination of symptoms. A blacked out screen is shown in Fig. 3.

Some series-wired sets have a 7.5-ohm, 4-watt or other appropriate value resistor (*Fusistor*), installed in series with the power line. It is designed to burn out if a short develops in the TV set. Sometimes this resistor burns out from age and the usual and unusual current surges it has been exposed to, even though there is nothing wrong with the set. Install a new one—most of them just plug in (as shown in Fig. 4). You can use a jumper wire to bridge this resistor temporarily; if the set comes on and plays normally, replace the resistor but be alert for any other defects. If the set still doesn't play, or if you smell something burning, or see the slightest trace of smoke, remove the jumper immediately and investigate further.

If some of the filaments in a series string are lit, while some of the others are dead, the ones lit will usually be overly bright because the full line voltage is being distributed across fewer tubes. A shorted tube or other component may be prematurely completing the filament circuit to ground.

**PICTURE TOO SMALL; BLACK BORDER ON TOP, BOTTOM, AND SIDES; SOUND MAY OR MAY NOT BE NORMAL; FOCUS MAY OR MAY NOT BE OUT; PICTURE MAY OR MAY NOT BLOOM WITH ADJUSTMENT OF BRIGHTNESS CONTROL** Overall shrinkage of the picture, as shown in Fig. 5, or often just the loss of width is usually due to an excessive drop in B+ voltage (loss of vertical size alone is not necessarily a B+ problem) and quite often can be caused by a weak low-voltage rectifier tube like a 5U4.

Weak selenium rectifiers, if used instead of a 5U4, can cause the same symptoms. You can test the

seleniums by bridging them with known good replacements. Be sure to observe polarity. If the picture spreads out appreciably you should replace the selenium rectifiers. Be alert for possible defects elsewhere in the set that may be drawing too much current from the seleniums.

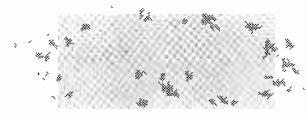
Silicon rectifiers usually do not deteriorate enough to cause four-sided shrink. They either open up or become shorted; there is usually no "in between" condition. If, in a voltage doubler, only the parallel-connected silicon rectifier opened up, it could cause the same symptoms. A quick test can be made by measuring the forward and reverse resistance. The reverse resistance should be about 100 times (or more) greater than the forward resistance. Replace rectifier if the ratio is considerably lower than 100 to 1.

Other possible defects that can reduce the size of the picture can sometimes be detected by certain accompanying secondary symptoms. For example, the damper circuit also causes non-linearity; insufficient high voltage causes blooming; and insufficient drive to the horizontal output circuit can cause vertical white lines to appear on the screen. The vertical output and audio output circuits can be at fault, but can be quite deceiving because they may or may not be the cause of other seemingly unrelated symptoms.

**HUM IN PICTURE OR RASTER; WIDE HORIZONTAL BLACK AND WHITE BARS ON SCREEN; AUDIBLE HUM MAY OR MAY NOT BE PRESENT; TENDENCY TO LOSE VERTICAL SYNC** A cathode-to-heater short in one of the tubes can introduce a 60-Hz hum in the picture or raster since the filament voltage is 60-Hz



Fig. 6. A large horizontal light and dark area is typical symptom of 60-hertz hum.



a.c. Sixty-hertz hum bars look like one large horizontal black area and one large horizontal white area on the screen, as shown in Fig. 6. While it is a good practice to replace a tube having a cathode-to-heater short, this type of defect will not cause any hum trouble in a circuit where the cathode is grounded.

Two alternate light and dark areas, consisting of four bars (two light and two dark) are indicative of 120-Hz hum which could be injected by a poorly filtered full-wave rectifier power supply, such as the typical 5U4 tube and transformer arrangement. However, the half-wave rectifiers and voltage doublers put out a 60-Hz ripple and, if not adequately filtered, will introduce 60-Hz hum.

If the hum is introduced by a defective tube in the signal circuits before the detector, chances are that the hum bars will be seen only in the presence of a picture, that is, with the picture removed the raster remains "clean." Hum coming from the power supply or from a bad tube past the detector stage, in the video amplifier, for example, usually shows up on the raster, with or without a picture. The degree of severity of hum depends on which tube is shorted and whether the short is a direct one or just a very high-resistance leakage path. The larger the hum signal, the more noticeable it will be.

Shorted, gassy or other defects in r.f. and i.f. tubes can cause the picture to weave from side to side or make it appear that a person's head or body is being pulled to the side, without any show of hum bars. Sometimes the trouble appears only after the set has been on for some time, or it may come and go without any particular regularity. Tubes tend to act up when they heat up, and power supply filter capacitors tend to heal and break down and heal again in a random fashion.

Direct substitution of suspected tubes is recommended, as a tube tester may or may not be able to spot a high resistance leakage path in a tube, and many tube testers cannot detect gassy tubes. Bridging a suspected filter capacitor with a good capacitor of like value, or larger, will help you determine if trouble is coming from the power supply. In a parallel-string set, you can pull out one tube at a time to find the tube that is causing the trouble. Work your way forward from the tuner to the picture tube. When more than one tube is responsible for this trouble, you have to replace the last tube you pulled with a new one, and repeat the procedure, working your way forward again.

**NO BRIGHTNESS; SOUND OKAY** Actually, what is meant here is no raster as opposed to insufficient brightness, or no control over being able to vary the brightness. When there is no brightness on the screen, you can't tell by looking at the screen if video



Fig. 7. Use a well-insulated screwdriver to check for the presence of CRT high voltage. DON'T ground the screwdriver!

is reaching the CRT, or if it is, what condition it is in. By the same token, you can't tell anything about the sync circuits either. Be sure to try adjusting the brightness control and check out any other controls and switches that affect the raster. Some combination radio, phono, TV sets have a function switch which "shuts off" picture tube brightness when the instrument is operating in either the radio or phono position.

Defects in the horizontal oscillator, horizontal output, damper, and high-voltage rectifier circuits as well as the CRT and its circuitry can cause a loss of brightness. If, after checking out the tubes and controls, you haven't been able to restore brightness, your next logical step is to check the high-voltage circuits for the presence of high voltage—a very common source of trouble.

Handle all parts carefully, especially wires whose insulation has dried out, loose caps on tubes, etc., to avoid causing additional damage. The leads from the high-voltage transformer break easily, especially if the set is a few years old. And, of course, you should be alert to the potential shock hazards and the uncontrolled reflex actions that come immediately after receiving a shock.

When you're trying to draw an arc with a screwdriver, be sure your hand is on the insulated handle and away from any metal parts of the screwdriver. And watch out for a screwdriver whose shaft goes all the way through the handle and comes out on top—it can become a veritable lightning rod.

Remove the high-voltage cage and turn the set on. Hold a screwdriver about  $\frac{1}{2}$  inch away from the cap of the high-voltage rectifier, as shown in Fig. 7. Do not ground the screwdriver. If you draw a  $\frac{1}{2}$ -inch arc, or better, you can assume that all is well up to the cap of the rectifier tube and that you have sufficient a.c. high voltage. Now turn off the set, attach a jumper wire to ground and to the screwdriver shaft, and with the screwdriver grounded in this manner, touch it to the tip of the high-voltage lead connected to the second anode of the CRT. If there is a high-voltage charge built up at this point, you will see a spark and hear it discharge. Chances are that all's well with the high voltage if you are able to "pull" a spark in this manner, but in order to be certain, continue with the following tests.

Remove the high-voltage lead from the CRT and dress it away from the set. Turn on the set and try to draw an arc from the lead to the grounded screwdriver. If a healthy spark flies, you have d.c. high voltage. (If the anode connector is exposed, you can check for high voltage without removing the high-voltage lead from the CRT.) That eliminates high-voltage rectifier circuits and points a "finger" at the CRT, a.g.c., and possibly the video amplifier as the source of trouble.

If there is high voltage going to the high-voltage rectifier tube, but not to the CRT, the rectifier tube may be open or weak, or a high-voltage filter capacitor

may be shorted. Do not draw an arc for more than a very brief moment, to prevent any other damage.

If you were unable to draw an arc from the top of the high-voltage rectifier tube, shut off the set, remove the cap from the tube, and dress the lead away from the chassis. Then turn on the set and, with the ungrounded screwdriver, try to draw an arc from the cap end of the lead. If you do get a good-sized arc, about  $\frac{1}{2}$  inch, or more, look for trouble in the high-voltage rectifier tube and circuit.

If there is no high voltage going to the top of the rectifier tube, the trouble is not in the high-voltage rectifier circuit—at least not the immediate trouble. How good or bad the rectifier circuit is can best be determined in the presence of high voltage. The horizontal output, the damper, and the horizontal oscillator circuits, as well as the low-voltage rectifier and horizontal phase detector can affect high-voltage output, and should now be considered.

An intermittent or dead short in the damper tube will blow the low-amperage fuse (found in many sets) in the horizontal output and damper circuits. A defect in the vertical output transformer and the audio output circuit can, in some sets, kill the high voltage.

**LOW BRIGHTNESS** You can immediately identify the two main types of troubles that cause a low brightness condition. If the picture is full size and doesn't bloom as you advance the brightness control and the CRT is more than three years old, the trouble is probably due to a weak CRT. If the whites in the picture appear shiny or silvery as you advance the brightness control, the CRT is bad. However, there is also a possibility of trouble in the CRT input circuits. Don't overlook the ion trap on the neck of the CRT when one is used. It should be checked and repositioned before condemning the tube.

Before you replace the CRT, try installing a booster, as shown in Fig. 8. However, don't be too hasty in condemning the picture tube. Insufficient B+, boost voltage, or high voltage can make a picture tube look bad.

**FIXED BRIGHTNESS** When the brightness level remains constant even though the brightness control is adjusted, the components in the brightness control circuit, including the CRT, are the most likely cause of trouble.

Sometimes loose debris in the electron gun in the CRT causes a short which can be removed by tapping the neck of the tube. Do this gently with your fingers or with a pencil. (The glass can be broken, so go easy!) If you see strong flashes across the screen while you are tapping the tube, you have found the trouble. The flashes, if you look closely, will have the appearance of a normal picture in comparison to the dull, smeary fixed-brightness picture.

If you do get flashes, you can try bypassing the short by installing an isolation-type CRT brightener or you can try burning out the short with a CRT tester

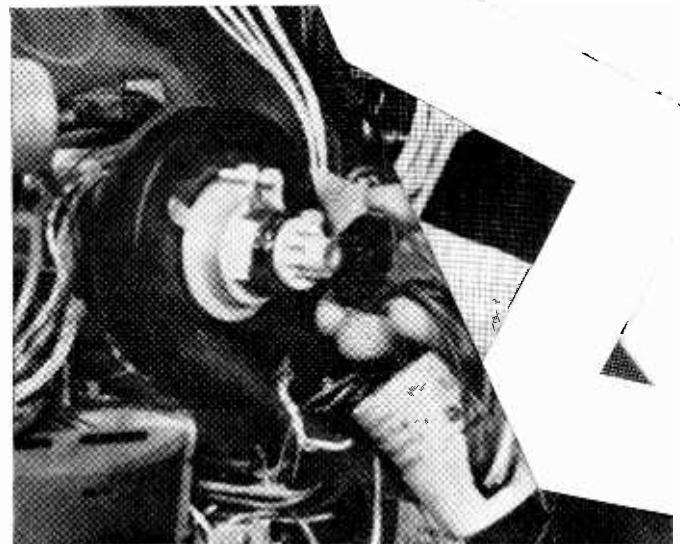


Fig. 8. Several types of picture tube boosters are available to correct for shorts, opens, or low emission. The use of a booster is a temporary measure, but may add months of life.

and rejuvenator. A picture tube tester can tell you if the CRT is at fault, can correct some of the faults, and, in many instances, restore low emission to normal levels.

If there is even a very slight difference in brightness level when the brightness control is adjusted, devote your attention to external circuits feeding the grid and cathode of the CRT.

**PICTURE NOT IN FOCUS** Defocusing is usually a secondary symptom caused by low voltage. Check the low-voltage rectifiers, horizontal output, damper, and audio output tubes. Quite often a weak audio output tube or other upset in this circuit will not be great enough to noticeably affect the sound, but it will be great enough to upset the focus. Some sets have a focus adjustment. Some have a special focus rectifier tube and some sets have a link on the CRT socket. An example of good focus can be seen in the close-up photo in Fig. 9.

**KEYSTONE PICTURE** The keystoneed picture, as shown in Fig. 10, is almost always due to a bad deflection yoke. In some cases a capacitor wired across one of the yoke windings may become shorted and cause the same effect. Simply disconnect one side of the capacitor and check the picture. If the picture comes back to normal, replace the capacitor. Also check any other component before condemning the yoke.

**BLOOMING** Blooming is a form of brightness trouble and is due to insufficient high voltage. The picture seems to inflate or blow up like a balloon as the brightness control is advanced, and it deflates as the control is turned down. There are many degrees from extreme blooming, where the picture is only available at one critical setting of the control, to the case where the picture just expands and contracts a little. Poor high-voltage filtering creates a condition of repeated

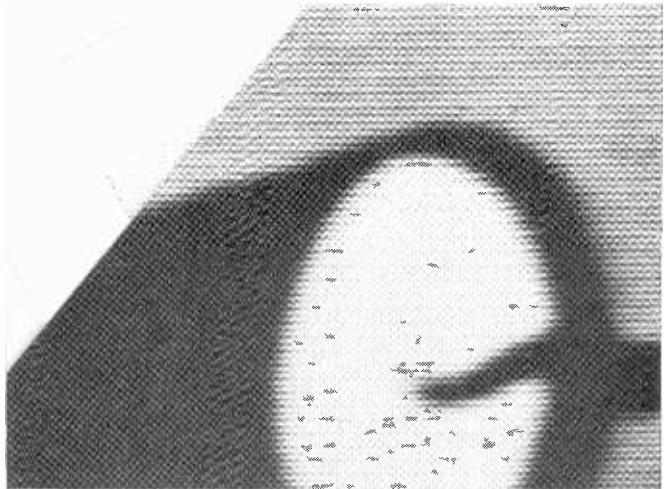


Fig. 9. In this same-size portion of the TV picture, note the sharp definition of the lines, indicating excellent focusing.

expansion and contraction, in a pumping-like action, even while no one is touching the brightness control. Poor high-voltage regulation could cause the picture to expand as the brightness control is turned up. Troublesome blooming is usually accompanied by a loss of focus and a loss of brightness.

A weak high-voltage rectifier tube is the most likely cause of trouble. The low-voltage rectifier can also cause the trouble, as can the damper and the horizontal output tubes. Horizontal drive, width, and horizontal linearity controls should also be checked.

**PICTURE TOO SMALL ON SIDES; SOUND NORMAL**  
Horizontal shrinkage of the picture may range from a small black space on one side of the screen to a very narrow picture with several inches of blackness on either side. Sometimes the set will come on fine at the start and, after a few minutes of operation, will begin to lose picture width. Sometimes the picture will suddenly collapse into a white vertical line in the center of the screen, perhaps disappear altogether, and then reappear, and do the same thing over again.

The prime suspect in this case is the horizontal output tube. On occasion, the horizontal oscillator and damper tube may be at fault.

The horizontal drive control, width control, and horizontal linearity control all influence the width of the picture. Try adjusting these controls for small deficiencies in width. Weak selenium rectifiers and

5U4's in the B+ power supply usually cause a loss of width before any other trouble symptoms appear.

Low line voltage can also cause a loss of width. One way to check the effects of line voltage is to plug in an electric iron or any heater drawing about 1000 watts or more while you observe the picture.

**HORIZONTAL NONLINEARITY** Different degrees of this trouble range from a shrunken picture having white vertical bars to an almost normal picture except for a noticeable difference in the width of letters appearing across the screen or in the relative size of a performer's right and left shoulder . . . one shoulder broader than the other. Poor linearity can be due to an inherent quality of a TV set. There is little you can do about this. You are not expected to redesign a circuit when repairing it.

The damper tube and its related circuitry have considerable effect on linearity. Notice when you first turn on a TV set how the picture spreads. If it starts off good on the left, then gradually spreads out to the right, the damper tube is heating up more slowly and may not be performing at its best. Try a new damper tube.

Nonlinearity is also affected by the horizontal output tube. If the tube becomes weak and its lower output is compensated for by turning up the horizontal drive, width, and linearity controls, control "tracking" is lost. A new output tube should restore the "tracking" of the adjustments and bring back a linear picture. Here again, new rectifiers in the B+ circuits may make a big difference. Different B+ levels or line-voltage conditions usually affect linearity.

The white vertical lines you see in severe cases of nonlinear horizontal sweep are actually places where the beam has slowed down or retraced itself and formed a type of foldover picture, as shown in Fig. 11. Check the damper tube for this trouble.

**FLASHING LINES, SPOTS OR STREAKS, POSSIBLY ACCOMPANIED BY CRACKLING SOUNDS FROM SPEAKER AND SOMETIMES FROM INSIDE OF SET IN VICINITY OF HIGH-VOLTAGE SECTION** Relatively high voltage potentials across the filament and cathode in the damper tube frequently arc over and create a random display of flashing specks in the raster. This arcing can radiate enough energy to get



Fig. 10. At left is a classic example of "keystoning." This is the obvious symptom when the deflection yoke is defective.

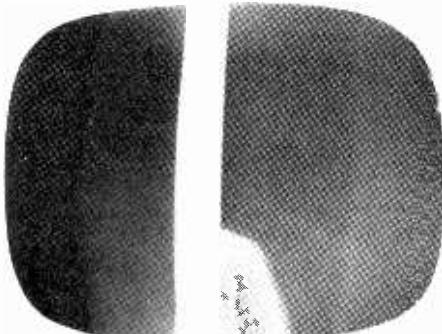


Fig. 11. In the severe case of foldover at right, the portion of the picture that should be on the left side of the screen is concentrated in the vertical bar.

into the audio circuits, and sound off in an alarming manner. In many instances the arcing can be seen in the damper tube. Continuous arcing will blow the fuse, if present, in the high-voltage section.

Internal arcing in the horizontal output, high-voltage and low-voltage rectifier tubes, as well as in some of the components in these circuits, can cause the same symptoms. The high-voltage filter capacitor, underneath the high-voltage rectifier tube, is a common offender. If this capacitor is exposed enough to allow you to touch it with the bottom end of a dowel stick (about a foot long), you can put your ear to the top of the stick and listen for internal arcing. Another way is to disconnect this capacitor from the circuit and see if the arcing symptoms disappear.

Don't overlook leakage from dried out insulation on the high-voltage second anode lead—dress the lead away from the chassis and reinforce the insulation with a few turns of high-voltage tape. Arcing can take place in or near the second-anode connection (Fig. 12) on the CRT, usually in a humid environment—clean the area around the high-voltage connection.

When the high voltage leaks off the cap of the rectifier tube or the flyback transformer and spews through the air in a very fine spray to the closest piece of metal, it gives off a slight, but telltale, hissing sound. The spray may be too fine to see in broad daylight or even in a fairly well lighted room. If you dim the lights and look carefully in the direction of the hissing, you may see the corona. If you don't, you can use a dowel stick as a wand and move it slowly through the suspected area. If you interrupt the corona path, you will hear a change in pitch or intensity of the hiss.

The cure here is to improve lead dress, round off sharp points or apply insulation, such as high-voltage tape or dope. There may be a tendency to neglect or otherwise overlook a slight corona problem. To do so is a mistake and will lead to more serious difficulties. If the insulation in a flyback breaks down internally, you have no choice but to replace the transformer.

**PICTURE PULLS OR WEAVES FROM SIDE TO SIDE**  
Symptoms vary from an occasional slight pulling or hooking at the top of the picture to a deterioration of the picture into a substantial "S" curve, as shown in Fig. 13, accompanied by hum bars in the picture and

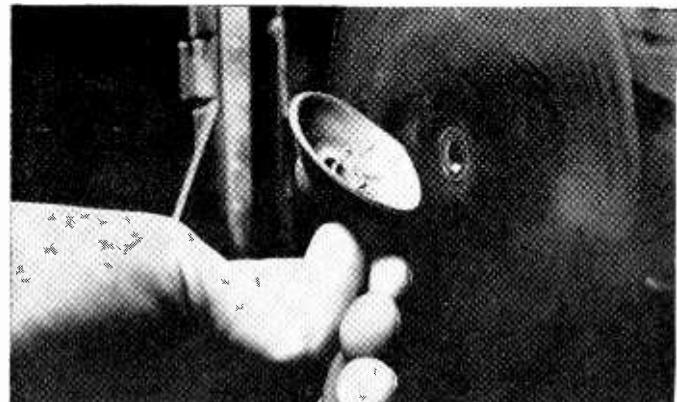


Fig. 12. A collection of dust, plus a humid environment, will cause arcing around high-voltage lead. Keep CRT area clean.

hum in the sound. If hum bars are present, troubleshoot for this first. See item on "HUM IN PICTURE OR RASTER."

If there are no hum bars, the trouble could still be caused by a cathode-to-filament short in a tube, but it is more likely to be one or more gassy tubes in the r.f. amplifier, composite signal i.f. strip, sync, a.g.c., horizontal a.f.c., and sometimes the horizontal sections. Picture pulling can also come from improper removal of the video signal from the sync signal in the sync separator stage. If the sync separator is not at fault, the trouble could be due to an abnormal relationship between the relative amplitudes of the sync and video signals. Normal relationship of sync and video amplitudes can be upset by improper a.g.c. settings or operation. Many a.g.c. circuits also depend upon a pulse from the horizontal output. Therefore, try adjusting the a.g.c. control, the contrast control, the horizontal frequency control, and the horizontal phase control. When adjusting any controls for troubleshooting purposes, note the original setting, and if the control does not correct the condition, return it to its original position.

A quick way to spot an upset in the a.g.c. line is to watch out for undesirable control grid current. The i.f. tubes normally do not draw grid current; therefore, there should be no voltage drop across any resistor in series with the grids. Grid current would offset a.g.c. and other grid voltage conditions. For the same reasons, there should be no voltage drop across any of the resistors in the a.g.c. line. Also the control



Fig. 13. The picture at left is weaving from side to side. On occasion hum bars may be visible. Check for grid defects in the r.f. and i.f. tubes, improper a.g.c. action, and anything that might upset the relationship between the amplitudes of the sync and video signals in the set.

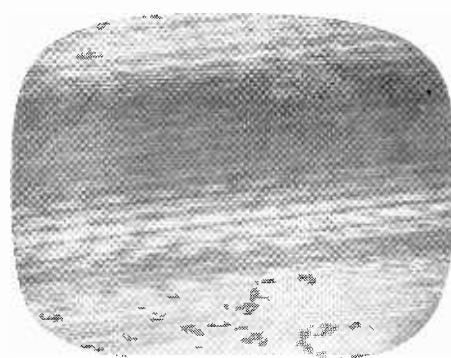


Fig. 14. The picture at right will appear when there is a complete loss of horizontal sync. Check to see if the vertical sync has also been affected by trying to get some sort of a picture while adjusting the horizontal oscillator coil.

grid should not be positive with respect to its cathode in the r.f. and i.f. amplifier tubes. Use a VTVM to check this out. The type of tube defect that can cause undesirable grid current will not show up on many types of tube testers. What is needed is a tube tester that can reveal a grid leakage path on the order of about 10 megohms, or substitute known good tubes.

A defective amplifier circuit operating too close to cutoff or saturation region can also upset the proper relative amplitudes of sync and video.

**VERTICAL BARS SUPERIMPOSED ON PICTURE OR RASTER** Vertical bars on the screen come in several varieties: light bars, dark bars, black beady bars, narrow bars, wide bars, single bars or several bars, and sometimes one or more combinations of these. Sometimes these bars are quite prominent and at other times they are hardly noticeable.

Barkhausen oscillations cause a beady chain-like appearance on the left side of the screen. Replacement of the horizontal output tube usually eliminates this trouble. An old trick is to mount an ion trap on this tube and rotate it until the bars disappear. Beady bars on the right side of the screen, sometimes called "snivets," are usually due to radiation from the horizontal circuits into the tuner section of the set. This is a common trouble when rabbit-ear antennas are used. The snivets may appear on only one or on several channels. Move the antenna away from the tuner to a different part of the set, or away from the set altogether. The farther away the better.

White bars in the center of the screen can be caused by improper adjustment of the horizontal drive control or improper working conditions between the horizontal oscillator and the output tube. Improper "tracking" or operation of the damper tube and its circuitry can also set up a number of different types of vertical bars in the center of the picture.

Sometimes after a yoke has been replaced, several bars may appear on the left side of the screen, the bar on the extreme left being the brightest and each successive bar to the right being a bit lighter. This is a form of ringing and is due to improper yoke match

to the flyback transformer. Exact replacement yokes should be used and the resistor-capacitor network from the old yoke should be installed.

**HORIZONTAL OR SLANTED LINES; ONE OR MANY COMPLETELY SLANTED PICTURES** When a picture is drastically out of horizontal sync, as shown in Fig. 14, it is difficult to determine if the vertical hold is in or out of sync. However, before you proceed to troubleshoot the horizontal oscillator and horizontal hold control circuits, it is necessary to determine if the loss of sync is only horizontal or if it is both horizontal and vertical. If it is both, then the trouble is probably not in the horizontal circuits. Adjust the horizontal hold controls and any other secondary controls such as horizontal phase, lock, range, etc., and even the a.g.c. control to try to restore the picture or as much of it as you can, even momentarily. Then check the vertical hold control to see if you can lock in vertically whatever picture you have. If the picture locks in vertically, you can concentrate on the horizontal section. If it doesn't, skip this section and tackle the sync circuit.

If rotating the horizontal hold controls varies the number and thickness of the lines, or if you can get a complete picture even momentarily, or if the lines will slant first one way and then the other as you vary the hold control, or if you can get the picture but it slides past the screen slowly, chances are that the horizontal oscillator and the hold control are okay and that the trouble is in the horizontal sync circuit. Keep in mind that what looks like a horizontal sync problem may actually be due to an oscillator circuit that won't respond to corrective voltage from the sync circuit, or be loading down the sync circuit to the point where it can't function properly.

Another way to isolate or separate the oscillator from the sync circuit is to disable the horizontal a.f.c. and see if the horizontal hold control will restore the picture even momentarily. Without a.f.c., the whole picture will seem to float across the screen when the horizontal oscillator is working at the correct frequency. You can disable the a.f.c. circuit by grounding the grid of the horizontal oscillator tube or by pulling the a.f.c. tube or the solid-state dual diodes, as shown in Fig. 15.

**VERTICALLY SPLIT PICTURE** When the picture seems to lock horizontally, but with the horizontal blanking bar in the middle of the picture, and the left-hand side of the picture on the right and the right-hand side of the picture on the left, the trouble is improper horizontal phase. This could be due to improper setting of phase adjustments, defective or unbalanced "matched" components in the a.f.c. circuits. Drift in value of components, due to heat or age, is common. Sometimes readjustment is all that is necessary, but in most instances replacement of the troublesome components that keep changing in value will reduce the number of times the set has to be serviced.

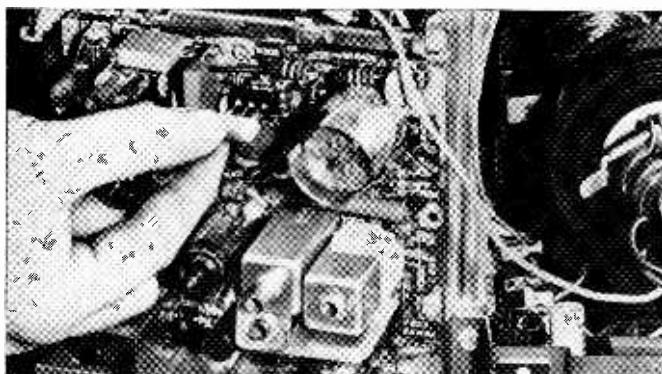


Fig. 15. In some TV receivers you can unplug the horizontal a.f.c. diodes. If unplugging these encapsulated diodes makes it possible to restore the picture horizontally, even for a few moments, the trouble is not in the horizontal oscillator.

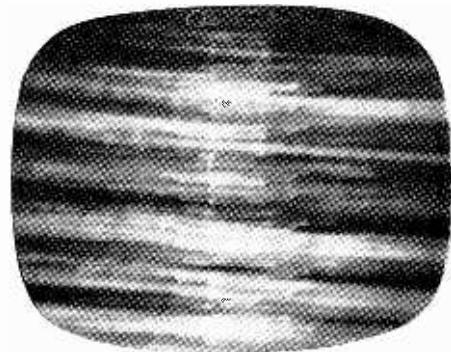
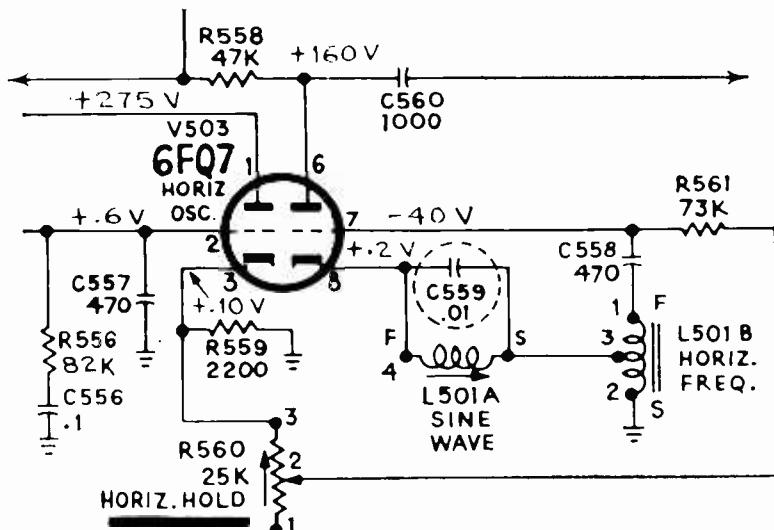


Fig. 16. The visual effect above, accompanied by a loud buzzing noise in the receiver, signifies "squegging." The pattern—called "Christmas Tree"—is a parasitic oscillation in the horizontal oscillator. Try replacing capacitor C559 (Fig. 17, schematic at left) even if it checks out to be good.

**SEVERE STREAKING ACTION IN PICTURE OR RASTER (SQUEGGING) OFTEN ACCCOMPANIED BY RELATED NOISE** Second only to smoke or fire, this "Christmas-tree" effect, as it is commonly known (shown in Fig. 16), acts as a trigger to the viewer to make a dash for the "on-off" switch. The action on the screen is quite violent and the buzzing sounds are not comforting. The trouble is a form of parasitic oscillation that sets in when the horizontal oscillator is operating at the correct frequency. You can often kill the squegging simply by adjusting the horizontal oscillator control, but the picture will then be out of horizontal sync. Returning the oscillator control to its proper setting brings the parasitic right back. Of course, you can try replacing the horizontal oscillator and horizontal a.f.c. tubes, but this usually does not eliminate the symptom.

A resonant condition for the parasitic frequency is responsible for this trouble, and unfortunately occurs within range of the horizontal hold control. Generally, those sets equipped with a horizontal oscillator transformer and a phase coil, all in the same can, as shown in Fig. 17, are prone to this type of parasitic. Usually the phase coil has an external  $0.01-\mu\text{F}$  capacitor across it. Replace this capacitor with the best type you can buy—one rated at 600 volts, rather than one rated at 400 volts. Then follow the specific man-

ufacturer's instructions for phase and frequency adjustments.

**RAGGED PICTURE; CIRCLES HAVE WAVY, COG-WHEEL, OR PIE-CRUST APPEARANCE** An open capacitor or resistor (C425 and R448 in Fig. 18) can allow the corrective voltages from the horizontal a.f.c. circuit to overcontrol the horizontal oscillator and to shift the frequency above and below the correct frequency as the oscillator tends to seek the proper operating point. These two components make up an antihunt network to stabilize the correction voltage from the a.f.c. circuit long enough to keep the oscillator from wandering back and forth.

**HORIZONTAL WHITE LINE** The trouble here is no vertical sweep, as shown in Fig. 19. The line is excessively bright because the energy normally distributed over the more than 400 lines of visible picture is now concentrated into one line. Turn down the brightness control to prevent damage to the CRT. (A persistent "attack" of this type on the phosphors can permanently "burn" a visible line into the face of the CRT.) If the replacements of the vertical oscillator and vertical output tubes do not correct the trouble, try rocking the vertical hold, height, and linearity controls. A bad spot on any of the controls is a typical fault.

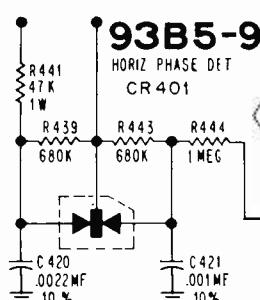
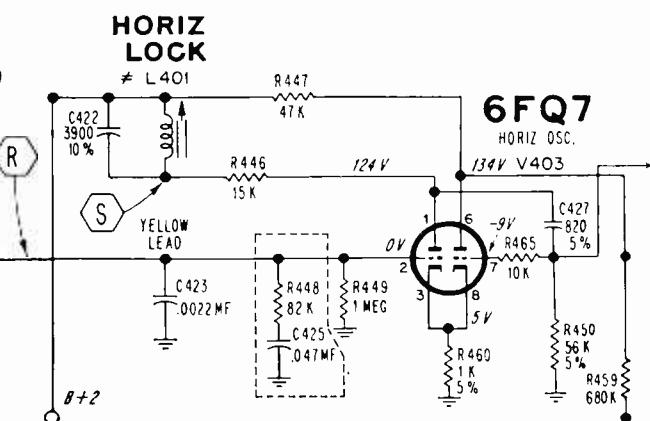


Fig. 18. A cogwheel TV picture is the result of an over-controlled horizontal oscillator. Look for defective components in the antihunt network, C425 and R448, in this typical black-and-white circuit diagram.



Sometimes a control cleaner will help and sometimes a slightly different position of the control will restore the picture. The correct thing to do, however, is to replace the control. Loss of vertical sweep can be due to a defect anywhere in the chain of circuits between the vertical oscillator and the yoke.

You can virtually cut the vertical-circuit chain in half by injecting a 60-hertz a.c. signal into the grid of the vertical output tube. If the picture opens up vertically, about halfway or more, you can assume the trouble is in the circuits leading up to this grid. If the picture doesn't open up, the trouble lies beyond this point. You can obtain a 6.3-volt, 60-Hz a.c. signal from the filament string. Use a capacitor-jumper probe (a  $0.01\text{-}\mu\text{F}$  capacitor in series with a jumper wire) to couple the voltage. Since linear sweep depends upon a sawtooth waveform, the sine-wave filament voltage will tend to compress and fold over the top and bottom of the picture, but you can disregard it. (However, should you encounter this symptom, because of trouble in the set, you could correctly anticipate a B+ filtering problem or some other sine-wave ripple voltage being present in the vertical deflection circuit.)

Actually, you can work your way forward right up to the vertical yoke windings if you can find a signal source of sufficient amplitude. The closer you get to the yoke, the bigger your test signal has to be. In sets equipped with a power transformer having a 300- or 400-volt secondary, you can couple this voltage directly into the vertical yoke windings with the capacitor coupling probe.

**NONLINEAR VERTICAL PICTURE, POSSIBLY ACCOMPANIED BY BRIGHT TOP OR BOTTOM EDGE OR OTHER FORM OF PICTURE FOLDOVER** When performers' heads become pointy and their legs stumpy, when circles become egg-shaped or when the picture folds over on top or bottom as shown in Figs. 20, 21, and 22, there is an upset in vertical linearity. The vertical height control, the vertical linearity control and, on some sets, the vertical peaking control are de-

signed to compensate for variations in line voltage, tube gain, and component values. But there is a limit to the effective range of these controls and their tracking ability. They interact with each other as well as with the vertical hold control. If you readjust one, you usually have to adjust another.

If adjusting controls does not correct the trouble, try replacing tubes in the vertical section and then adjust again. As a general rule, the linearity control affects the top of the picture and the size control affects the bottom. These effects can, to a great extent, give you a clue to the location of leaky capacitors and other defective components in the vertical circuit. If, for example, the picture is folded over at the top or excessively stretched at the top, examine the components located in the same general area, circuit-wise, as the linearity control. If the picture is distorted at the bottom, look in that portion of the circuit where the height control is located.

Should you lose vertical sync while adjusting the height and linearity controls, readjust the hold control to lock in the picture. If you run out of range of the hold control, reset the height and linearity controls until the picture locks in and then try to find the cause of nonlinearity. However, do not rule out the possibility that there may be nothing wrong with linearity and that the frequency-determining components in the oscillator may have changed in value or have become unusable, and that the adjustment of height and linearity controls has been compromised to make up for the drift in the oscillator.

A certain amount of nonlinearity exists in most sets. If it isn't excessive, forget it. You can even hide a little foldover by stretching the picture a bit. Don't be fooled; once components start to change value and foldover sets in, it is only a matter of time before the picture gets worse.

**PICTURE ROLLING VERTICALLY** If the vertical hold control can vary the speed of rolling and can almost stop the picture from rolling even momentarily, you can assume that the vertical oscillator is functioning

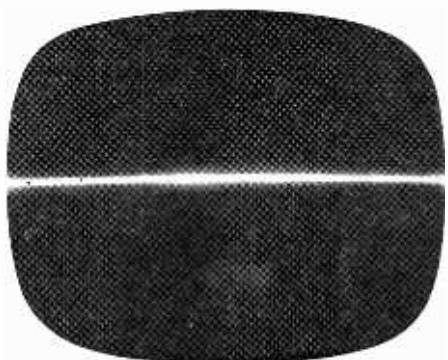


Fig. 19. The complete loss of all vertical sweep causes the electron beam in the CRT to race back and forth horizontally in the center of the screen. When you see this happen, turn down the brightness to prevent damage to the phosphors.

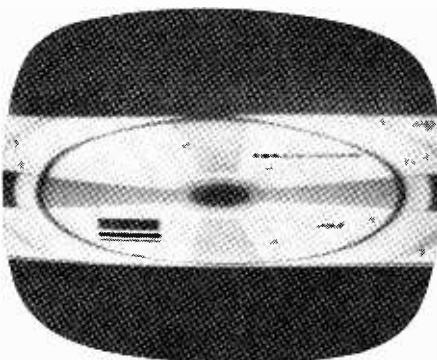


Fig. 20. Insufficient vertical sweep. Vertical oscillator, apparently in good order, could also be at fault in that insufficient drive voltage is developed. However, most likely trouble is in the vertical amplifier circuit, or low B+.

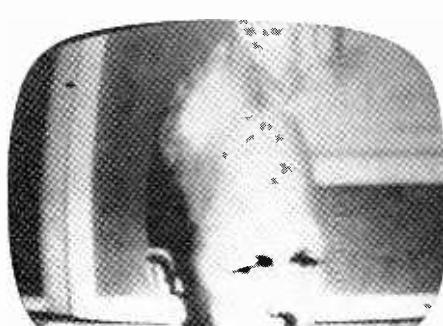


Fig. 21. Foldover on bottom, stretched on top. Some vertical height and linearity controls may have sufficient range to correct this nonlinear condition, but it is only a matter of time before additional drift will mean parts replacement.

properly but that the vertical sync pulse is not reaching the oscillator.

Check the sync and a.g.c. tubes. If the picture appears to be weak and contains a lot of "snow," check the r.f. amplifier tube on the tuner. A defective antenna or a weak signal can cause what seems to be a vertical sync problem. If you can obtain sync on some channels and not on others, look into the signal and a.g.c. circuits. An opposite condition, that of too strong a signal, or upset in a.g.c. that causes the circuits to overload and the sync pulses to become clipped or suppressed, is shown in Figs. 23 and 24. Note the tendency to pull out horizontally.

If the picture can't be stopped by adjusting the vertical hold control, the oscillator may be too far off frequency for the sync pulse to do its work, or some upset in the sync circuit is pulling the oscillator beyond the control range of the hold control. A confusing side effect can be caused by the interaction of the vertical height and vertical linearity controls. Check these controls before attempting to troubleshoot the sync circuits. An oscilloscope at the input and output of the sync separator can tell you the nature of the problem. Sometimes the sync separator fails to prevent the video signal from reaching the vertical oscillator and sometimes a poorly filtered B+ supply will set up enough hum to adversely affect the vertical sync and oscillator circuits. A defect in the integrator circuit between the sync tube and the oscillator can kill or unduly attenuate the sync pulse.

**NO PICTURE; NO SOUND; BRIGHTNESS OKAY** A simple case of no signal getting through the set shows up as no snow or no other interference on the raster. The raster appears to be normal and the brightness of the raster can be varied with the brightness control. The TV signal has been cut off in the circuits that are common to both sound and picture, anywhere between the tuner and the sound takeoff point. Check the mixer-oscillator tube in the tuner, and the i.f. tubes. If the sound takeoff point is past one or more video amplifiers, you will have to check

these too. The detector and a.g.c. circuits also affect both sound and picture.

You should also suspect the audio output stage in some sets. Even though it seemingly has nothing to do with video, many TV sets derive plate voltage for the i.f. tubes from the top of a resistor in the cathode of the audio output stage. Loss of B+ on the plate or screen of any of these tubes can completely cut off the signal. A shorted bypass capacitor in any of the screen circuits can draw enough current through a screen resistor to burn it out, or change its value considerably. Many times you can find a trouble of this type just by sight or smell. A shorted tube, if not caught in time, can also be the cause of burned out resistors.

**NO CONTRAST; RASTER OKAY; SOUND OKAY** Contrast can lose its punch in the video amplifier and output circuits. The trick here is to be able to separate CRT troubles from just a case of a weak video signal reaching the picture tube. Use of a capacitor coupling probe to feed in a hum signal from a 6.3-volt filament to the cathode or grid of the CRT, depending upon which element is driven by the video amplifier, can be helpful. If the hum bars come in clear, you can rule out the CRT, especially if you can vary the contrast of the bars with the contrast control.

Loss of contrast can also be due to an increased value of screen resistance in the video output tube circuit.

**EXCESSIVE CONTRAST; RASTER OKAY; SOUND OKAY** Black elements in the picture are black and most of the grays are also black. Assuming that the brightness level from the CRT is adequate, the problem is simply a case of too much signal. If the excess in signal exists before the sync takeoff point, the sync circuits will also be upset. If sync appears to be normal, confine your search to the video output circuit. A shorted cathode bypass capacitor, if present, can upset the bias on the video amplifier, as can a defect in the contrast control.

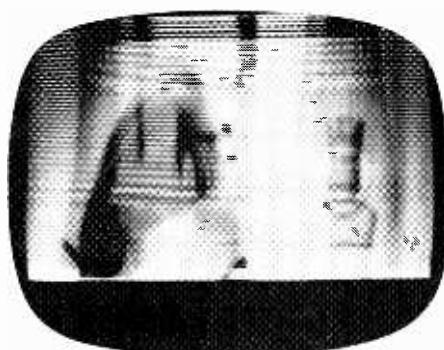


Fig. 22. Extreme case of vertical fold-over. In many instances it is difficult to tell if the picture is out of sync or if it is folded over. Try adjusting the set for a smaller vertical picture in order to pinpoint and identify symptom.

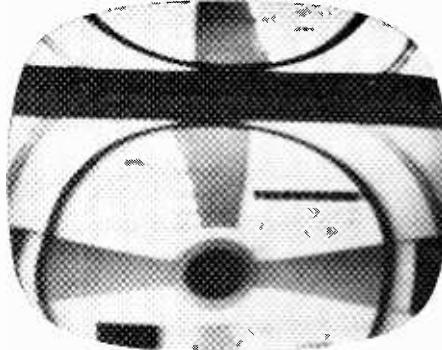


Fig. 23. A continuously rolling picture is indicative of a loss of vertical sync. If the vertical hold control can make the picture stand still (even momentarily), you can be sure only a weak sync pulse gets to the vertical oscillator.



Fig. 24. This picture is pulling and has excessive contrast. These are typical symptoms of overloaded circuits and a.g.c. problems. Some stage in the TV receiver is being driven into saturation and is clipping the sync pulse.

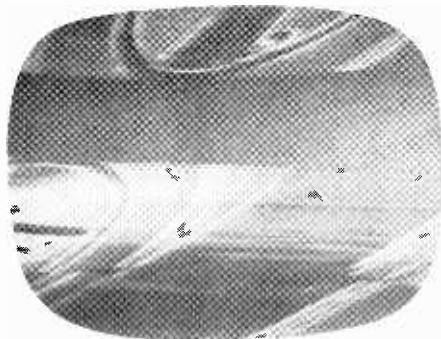


Fig. 25. A badly distorted or negative picture is generally due to defective a.g.c. circuits, defective or overloaded video detector.

Quite often a picture will appear to have excessive contrast when the brightness control is turned too far down or for some other reason the raster is too dark. Don't overlook the possibility of a defect in the a.g.c., i.f.'s, and video detector stages, as well as in the video amplifier circuits.

**PICTURE SMEARS; RASTER OKAY; SOUND OKAY** Since the beam of light in the CRT has to switch on and off quite rapidly as it goes from dark to light areas in the picture, it is essential that conditions in the picture tube and the external circuitry permit good response to rapid changes.

A gassy picture tube loses its "hardness" and can't respond to the rapid changes in signal. A similar defect in the video amplifier tube will also cause this type of trouble. Loss of frequency response in the video amplifier circuits also causes smearing, and can often be traced to a bad peaking coil or capacitor in the video detector and amplifier circuit.

**NEGATIVE PICTURE (MAY BE ACCOMPANIED BY LOSS OF SYNC); RASTER OKAY; SOUND MAY BE NORMAL OR MIXED WITH BUZZ** When the whites are black, and the blacks are white on your TV screen and the sync is upset, as shown in Fig. 25, the trouble is usually due to an overloaded or defective detector. Overload can be caused by an upset in the a.g.c. circuits, by too strong a signal, or by a defect in any of the circuits from the tuner through the detector right up to the signal takeoff point for the a.g.c. amplifier. Loss of the keying pulse from the horizontal output circuit to the a.g.c. tube will knock out the

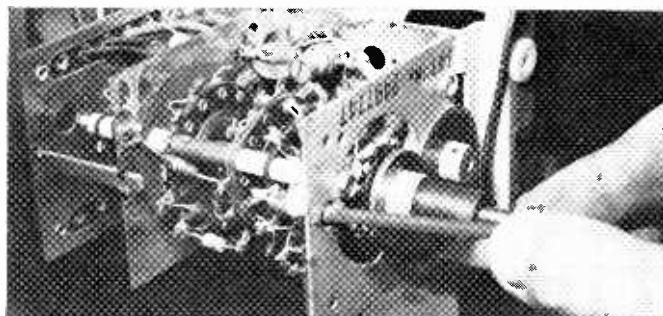


Fig. 26. Most wafer switch tuners have a series of tuned coils which are progressively switched into the circuit as you go from channel 13 to channel 2. Oscillator adjustments should be made on the highest channels first. Keep the fine tuning control centered. Some tuners have only two adjustments, one for the high band channels and another for the low band channels.

a.g.c. and allow both the r.f. and i.f. amplifiers to run wide open, at maximum gain.

In order for white areas to appear as white, and black areas to appear as black on the face of a picture tube, it is necessary for the signal to be going in the negative direction if it is fed into the grid of the CRT and to be going in the positive direction if it is fed into the cathode. As the signal passes from stage to stage, it reverses its polarity. Should there be a defective stage where the signal manages to get through without a reversal, the video signal will arrive at the CRT out-of-phase and result in a negative picture.

However, this is only true for those stages past the detector. The signal in the r.f. and i.f. circuits can change phase without causing a negative picture because there is essentially the same information on either side of the i.f. signal's zero reference line. Once the signal gets past the detector, either the top half or the bottom half is stripped and signal polarity becomes a significant factor.

Armed with this information, you can usually localize the trouble as being either before the detector or after the detector. You can sometimes determine if the trouble is in the picture tube or if it is in the video amplifier by turning down the brightness control and observing the picture. You may have to do this in a darkened room. If the picture becomes positive or if it tends to go positive at low brightness levels, chances are that the CRT is bad.

Should the picture remain negative at all brightness levels, you can look for trouble in the video circuits. If you remove a diode detector, observe polarity when replacing it. If the detector is put in backwards, you will get a negative picture.

**NO PICTURE; SOUND OKAY; RASTER OKAY** Look for trouble between the sound takeoff point and the CRT. If there is no snow on the screen, you can anticipate a clean break in the video signal path provided that the CRT is not defective. Many sets have the sound takeoff point at the plate of the video output tube. This narrows down the possible trouble area considerably.

Don't overlook the coupling capacitor to the CRT. An open capacitor will block the video signal; a leaky or shorted capacitor will drive the CRT to excessive brightness or cutoff depending on the hookup.

**SOUND AND PICTURE ON SOME CHANNELS; PICTURE BUT NO SOUND ON SOME CHANNELS; ANY COMBINATION OF SAME** Should the local oscillator in the tuner drift, either due to a change in the value of some of its components or because of the aging of the oscillator tubes, it is quite likely that sound or picture, or both, can shift beyond the range of the fine-tuning control. Ideally, all channels should come in when the fine-tuning control is set to its mid-position. If only one or two channels are affected, you can try adjusting the oscillator slugs to bring in the missing sound or picture. Sometimes the oscillator in the

tuner will shift only the upper channels, or only the lower channels, or all the channels, so that some or none of them can be received. A new oscillator tube should be installed.

You can work with an off-the-air signal; no special equipment is needed to align the oscillator, except a nonmetallic screwdriver (an alignment tool). On some types of tuners it doesn't make any difference which channel you work on first but on other tuners you must start on the highest channel you are going to adjust and work your way down. Generally, tuners equipped with wafer switches (Fig. 26) require that you start at the top, while turret-type tuners (Fig. 27) have independent coil arrangements. If in doubt, start at the highest channel and work your way down. Center the fine-tuning control and set the channel selector to the channel you are about to tune in. Adjust the oscillator screw or slug until you have both sound and picture and see sound bars in the picture. (This is a form of interference that varies in step with the sound.) Then back off the adjustment screw until the sound bars just disappear. Try rocking the fine-tuning control to see that you have obtained the best possible adjustment. Re-center the fine-tuning control and go on to the next channel. If possible, detune unused channels to eliminate confusion caused by the same channel appearing in two different tuner positions.

Some wafer-switch type tuners have only one adjustment for the high band and only one for the low band. Remote-controlled tuners usually have independent oscillator adjustments for each channel. Each channel can be tuned by the fine-tuner control as the channel selector is switched from channel to channel. *Don't adjust any other tuned circuit on the tuner without proper test equipment.*

**GHOSTS; TUNABLE GHOSTS** The cause of ghosts can be quickly related either to the antenna or to the set by operating the fine-tuning control. If the ghost doesn't change when the control is rotated, the ghost is getting into your set through the antenna. Should the ghost shift as you rotate the fine-tuning control, the trouble is usually due to one or more misaligned or defective i.f. stages. Sometimes new tubes will help and sometimes a.g.c. adjustment will improve things, but in most instances the trouble is due to misaligned i.f. amplifiers. If a single i.f. stage has

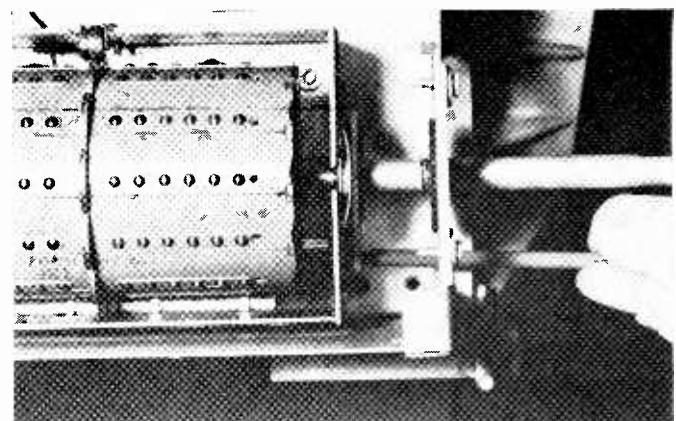


Fig. 27. Turret-type tuner has a separate oscillator coil for each channel. Any channel can be tuned independent of others.

been repaired, or for some other reason that you know its resonant frequency has shifted, only that stage need be adjusted. Unless you are properly equipped and are familiar with the set manufacturer's specific alignment instructions, do not attempt an overall alignment procedure. Ghosts can be leading or lagging, or both, as shown in Fig. 28. Check the antenna to see that it is intact and properly oriented. Antenna lead-in wire goes through many changes as it ages and is exposed to the elements. Deterioration and contamination of insulating materials can set up standing waves, cause ghosts, attenuate or abnormally boost signals, and produce a host of undesirable effects, including loss of vertical sync.

**SNOW ON SCREEN; SOUND OKAY; SYNC OKAY TO VERY WEAK** Snow in the picture or raster, as shown in Fig. 29, is a form of "noise" that you normally see on unused TV channels. It is usually due to the r.f. amplifier in the tuner running wide open. A weak signal, a defective antenna, a defective r.f. amplifier, a breakdown in the a.g.c. circuit, or a combination of any of these conditions can cause these annoying specks on the screen.

The r.f. amplifier tube on many sets has a tendency to break down frequently because of a high cathode-to-filament potential. Check B+ voltage in the r.f. stage with the tube in place. Because of the small space inside most tuners, the physical size of the plate-load resistor may not be as large as it should be, and may not have a large enough heat dissipation

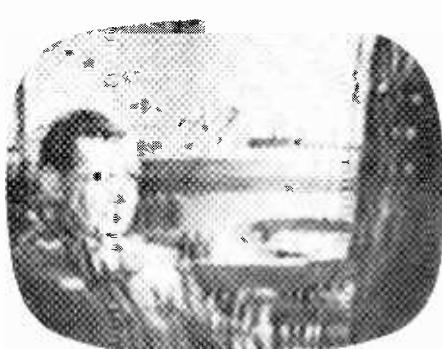


Fig. 28. Ghosts (left) may be due to a variety of defects. Particularly check for poor antenna orientation and multipath TV signal reception. The i.f. amplifier could also be badly out of alignment.

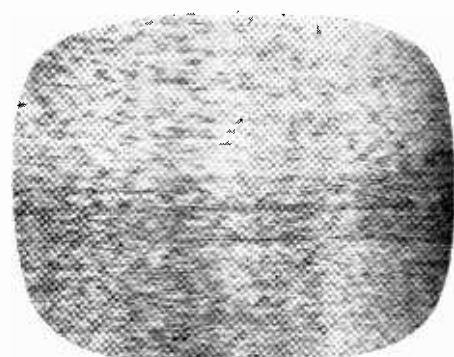


Fig. 29. In the absence of a signal (right), the r.f. amplifier is at full gain and the picture is full of "snow." But the same effect could be created by a defective r.f. stage, or a g.c. trouble.

factor. Such resistors tend to change value and sometimes burn out completely. In the event this resistor keeps breaking down, you can try mounting a higher wattage unit outside the tuner.

**NO VERTICAL SYNC; NO HORIZONTAL SYNC; PICTURE OKAY; SOUND OKAY** While it is always possible that there are two troubles, one in the horizontal circuit and one in the vertical circuit, it is more likely that only one trouble exists in a circuit that is common to both the horizontal and vertical sync sections. The sync separator or sync amplifier "strips" the sync pulses out of the video signal, and under normal circumstances delivers essentially "clean" pulses to the vertical integrator and horizontal a.f.c. circuits. Operating voltages and the relative amplitude of the sync pulse in the composite signal are important. Should any video signal get past the sync separator, the sync circuits will become "confused," and anything from no sync, to false sync, to hardly noticeable symptoms can prevail. When relative amplitudes of sync pulses and video signals are marginally correct, variations in picture stability can be usually seen on different channels. Therefore, it is essential that the signal and signal circuits including a.g.c. be in good order.

An oscilloscope can help you track down missing sync pulses or tell you if there is some foreign matter, video, noise, etc., getting into the sync circuits.

**NO SOUND; GOOD PICTURE** Put your ear close to the speaker and listen carefully. If there is any hum, buzz, or background noise coming out of the speaker, chances are that the trouble is not in the speaker. It is a common mistake to condemn the speaker right away. While speakers do go bad, their life usually exceeds the life of the set.

Troubleshooting the sound section in a TV set is essentially the same as it is in an FM radio, except that the i.f. frequency is 4.5 MHz instead of 10.7 MHz. Be sure that the fine tuning and local oscillator are properly set to allow the sound to get through. If there is any doubt, adjust the fine tuning control to the point where sound bars appear in the picture.

You can virtually cut the sound circuit in half and determine which half has the trouble just by touching the "top" terminal of the volume control with your finger to inject a little hum into the audio amplifier. If you hear the hum you are injecting, the trouble is in the circuits before the control; if you don't hear it, the trouble is somewhere between your finger and the speaker.

**WEAK OR DISTORTED SOUND (MAY CONTAIN HUM, BUZZ, OR OTHER NOISE)** Weak tubes and a drop in B- $\perp$  are typical reasons for insufficient sound levels and distortion. Improper alignment or excessively strong or weak signals account for much of the buzz and noise that creep into the sound section. Hum can come from cathode-to-heater leakage, improperly filtered B- $\perp$ , poor lead dress or ground connections.

Some sets will start to buzz when the picture is too contrasty. You can try turning the contrast control down to see if it affects the loudness of the buzz. If it does, try adjusting the a.g.c. control; it might be set too high for the stronger channels.

If the set has a buzz control or any kind of audio controls on the front or rear panels, try adjusting these for cleanest sound, usually on the weakest channels. Unlike the composite signal i.f. strip, you can peak and adjust the tuned circuits in the sound section without any instruments. All adjustments can be made with off-the-air signals for maximum volume and minimum distortion.

One very important precaution: do not adjust a sound trap or any other trap without a properly calibrated signal generator. Another thing to remember when making instrumentless adjustments is to return the adjusting screw or slug to the original position if in making the adjustment a desired effect or improvement is not achieved.

**THE COLOR RECEIVER** Servicing procedures for a color-TV receiver are essentially the same as for a black-and-white set. Before attempting to troubleshoot color picture problems, it is important to first establish a good black-and-white picture, good sound, and good sync. The color picture tube must be properly converged and in good working order to give a good black-and-white picture. Each TV set manufacturer has a specific set of instructions for proper setup and installation. Picture tube convergence should not be attempted without a dot and bar generator. Horizontal sync, a.g.c., and high-voltage regulation are more critical in a color set. High voltage is higher and should be handled with a greater sense of caution.

Antenna characteristics and signal quality are of greater significance. Hardly noticeable ghosts on black-and-white sets can cause an undesirable change in colors and color fringing.

Color picture tube troubles such as low emission, shorts, opens, and gas can be recognized and treated as you would treat a black-and-white tube. However, a color tube does have a number of critical configurations not found in black-and-white tubes, such as electron gun alignment and balance, shadow-mask alignment, etc. To simplify checking a color CRT, test each gun, one at a time. A CRT tester can do a good job for you and will help you make certain types of repairs and corrections.

Unlike the procedure with black-and-white sets, in the event of a shrunken picture, do not attempt to adjust vertical height, width and linearity controls without first trying new tubes in the appropriate circuits. Adjustment of any of these controls will in most cases misconverge the set. See discussion of Vertical Height Control on page 55.

Unless otherwise indicated, in the discussion of symptoms and cures that follows it is assumed that a color-TV signal is on the air or that a color signal

# Compare Color Generators

*look at the rest... and you'll buy the best, new B&K model 1245*

The all solid-state B&K Model 1245 Color Generator duplicates the waveforms transmitted by a color TV station.

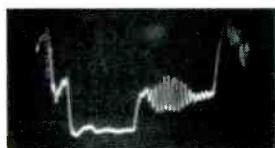
Adherence to these waveforms makes it easy to converge the color tube, check sync and make other raster adjustments . . . and the color generator with station quality signal will be able to sync next year's sets. Generators with compromise waveforms do not give you this obsolescence protection.

Here are oscilloscope photographs from the outputs of two typical competitive color generators, one transistorized and one tube type, and the B&K Model 1245. The detailed analysis with each photograph shows a few of the reasons why you'll save time and effort with B&K.

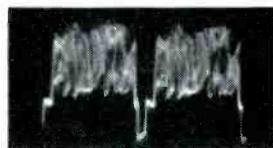
COLOR

CROSSHATCH

STANDARD STATION SIGNAL

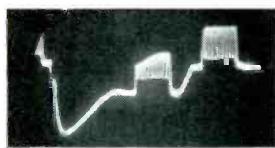


One horizontal sync pulse with its color burst.

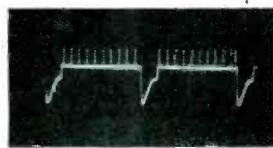


Two lines showing horizontal sync pulse with black and white TV signal.

TRANSISTORIZED B&K MODEL 1245

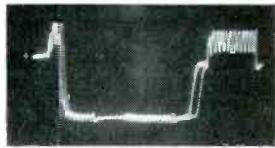


Good duplication of station signal including back porch. If the set won't sync, the set is defective.

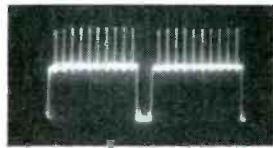


Well defined back porch on horizontal sync pulse permits accurately setting color killer and almost eliminates need to adjust brightness and contrast.

TRANSISTORIZED GENERATOR A



No back porch causes unstable color sync. Burst amplitude compression may permit sync on wrong color bar.



Square wave horizontal sync pulse with no back porch and poor dc coupling forces adjustments of brightness, contrast & fine tuning to obtain usable pattern.

GENERATOR B



No back porch; color information on top of sync-pulse makes sync difficult on some sets.



Complete absence of any back porch necessitates readjustment of brightness, contrast and fine tuning to obtain a usable pattern.

See your B&K Distributor for a demonstration or write for Catalog AP22.



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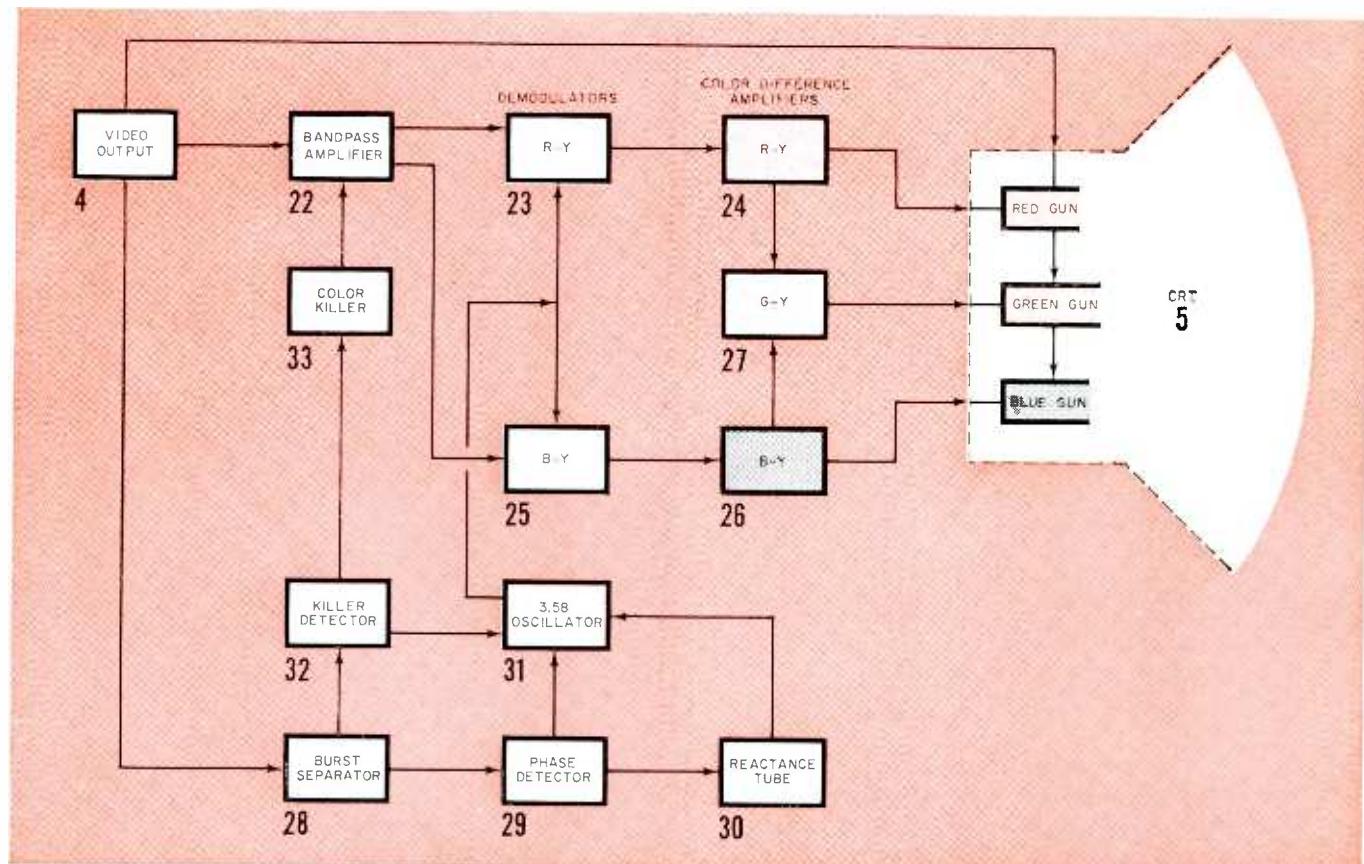


Fig. 30. These are the additional stages in a color TV receiver. The same numbering system applies here as on page 26 and for all means and purposes, block **4** here is the same as block **4** in the black-and-white TV diagram. The color signals ride through the video amplifier centered around 3.58 MHz and are fed to the bandpass amplifier **22** and burst separator **28**. Signals from the burst separator are fed to the 3.58-MHz os-

generator is in use when the color-TV set is being serviced.

Use the block diagram (Fig. 30) as a quick guide to signal flow and sequence of functions. As for black-and-white TV sets, the Function Ladder (Fig. 31) is designed to get you to the troubled circuits in the most direct manner.

**NO COLOR; GOOD BLACK-AND-WHITE** If you can get a good black-and-white picture but not the color out of a color program and if the color level control has no effect, the defect can be in the color killer, the bandpass amplifier, or the 3.58-MHz. oscillator. A negative voltage on the grid of the oscillator indicates that the oscillator is working. If grounding the output of the color killer restores color, look for trouble in the color killer and the killer detector.

To adjust the color-killer control properly, select an unused channel and turn the color-killer control down until the snow starts to turn to all colors (confetti). Then turn the control up until the confetti just disappears. Then check reception of a color signal to be certain that the control is not advanced too far.

COLOR MISSING FROM SOME CHANNELS While some antennas may not pick up weak color signals,

cillator 31 through the frequency-controlling circuits 29 and 30 and to the color detector 32 and color killer 33. In the presence of color signals, the bandpass amplifier 22 also feeds information to the R-Y 23 and B-Y 25 demodulators. The color difference amplifiers 24 and 26 pass signals to the appropriate CRT guns. A portion of the R-Y and B-Y signals is fed into the G-Y amplifier 27 to obtain a green signal

check the r.f. amplifier in the tuner and the a.g.c. action. Also check the fine-tuning control and the setting of the local oscillator in the tuner. If the fine-tuning control is not properly set, trouble will range from complete loss of color to a beat-note type of interference. The proper setting is at the point where the interference just disappears.

Weak signal conditions, if present, may not show up on black-and-white signals. Color reception requires more signal strength than black-and-white reception, particularly to make up for losses and other response characteristics of the antenna.

**"BARBER POLE" EFFECT** When the picture holds still but the colors ripple or change vertically like a moving rainbow, there is a loss of color sync. You can use a bias box to vary the control voltage on the 3.58-MHz oscillator, and if you can restore color sync even momentarily, the oscillator can be given a clean bill of health. The two most likely areas to check are the phase detector and reactance tube. If varying the control voltage has no effect on the oscillator, check the oscillator.

COLOR BLOOMING Even a small amount of blooming becomes objectionable on a color-TV set. The

high-voltage regulator tube is usually the cause of this trouble. High-voltage regulation cannot be achieved unless there is sufficient high voltage to begin with, and the same things that cause a decline in high voltage in a black-and-white set can cause a loss in a color set.

**ONE OR MORE COLORS WEAK, DESATURATED, OR MISSING; GOOD BLACK-AND-WHITE RECEPTION** Loss or deterioration of one or more colors is usually due to an upset in the color signal arriving at the control grid of one or more guns in the CRT. Since the black-and-white picture signal (Y signal) is fed into the cathode of each gun, it is possible to get a good black-and-white picture if the CRT is operating properly and each gun is properly biased (balanced). Therefore, if a color appears to be missing or very weak, the trouble is usually due to a weak or missing signal from one or more of the difference amplifiers (R-Y, G-Y, B-Y). The difference amplifiers may not be putting out a proper signal because of a defect in one of the related demodulators.

If only the G-Y signal is missing or incorrect, the trouble can be isolated to the G-Y amplifier. Loss of the R-Y signal also affects G-Y signal, as does the loss of the B-Y signal. Check tubes, adjustments, and components in the appropriate demodulator and difference amplifier, but don't waste any time in the G-Y amplifier looking for the missing green until you are satisfied that the R-Y and B-Y signals are coming through in good order.

Loss of the R-Y signal causes the color to lean towards blue and its complementary color, cyan. While there is no complete loss of output from the red gun, the picture will appear to be missing the reds. By the same token, loss of the B-Y signal appears to shift the color towards the red-cyan axis and away from the blues and yellows, and loss of the G-Y signal will effectively kill green and magenta.

**WRONG COLORS** When the faces of performers are green or purple rather than flesh colored and the tint control won't restore the proper tint, the color oscillator is running at the wrong frequency. As long as the colors are holding still, the color sync is okay. However, it is a good practice to be certain that all the

colors are coming through before you attempt to adjust the color oscillator transformer. To do this, set the tint control to the center of its range, tune in a live color show, preferably one having a close-up of a performer, then set the color level control at the normal color viewing level. Now touch up the oscillator transformer until a good flesh tone is obtained.

Actually, any alignment adjustments should be done with the proper test equipment and complete adherence to the TV set manufacturer's instructions.

**HUM BARS IN COLOR; BLACK-AND-WHITE RECEPTION OKAY** Hum bars that appear only on color programs are most likely coming from the bandpass amplifier, as this section of the TV set is on only in the presence of a color signal, and cut off during black-and-white transmissions. However, hum originating in the demodulators and color-difference amplifiers will also show up on black-and-white transmissions.

The solution here is the same as for the black-and-white receivers. Start at the first stage and work your way towards the CRT, temporarily removing one tube at a time. Observe the picture as you go. If the tube you pull doesn't eliminate the hum bar, put it back and go on to the next one. When the hum bar disappears, you have located the tube or circuit generating the hum.

**BLUISH BACKGROUND ON COLOR TRANSMISSION** Bluish background is usually due to a lack of retrace blanking.

**POWER SUPPLY** Of all the circuits in the TV set, the power supply is the only one that affects every other circuit, and is the one circuit that attracts the most attention when trouble sets in. It therefore warrants additional consideration to enable you to troubleshoot the TV set with greater authority.

Some defects in set performance caused by the power supply are quite obvious, but are of such a subtle nature that a lot of time is wasted looking for the trouble elsewhere in the set. On the other hand, while the power supply does have a whole family of typical types of troubles, it is often mistakenly blamed for a fault in another circuit, or for a fault caused by

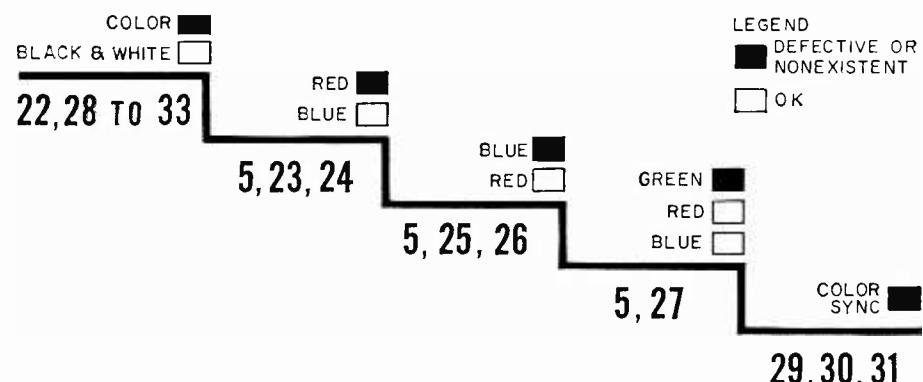


Fig. 31. This Function Ladder is similar to that shown on page 28. You must have a good black-and-white picture before looking for trouble in the color section. Work from the top down and be sure the CRT has been converged and fine tuning is set to permit reception of color signal.

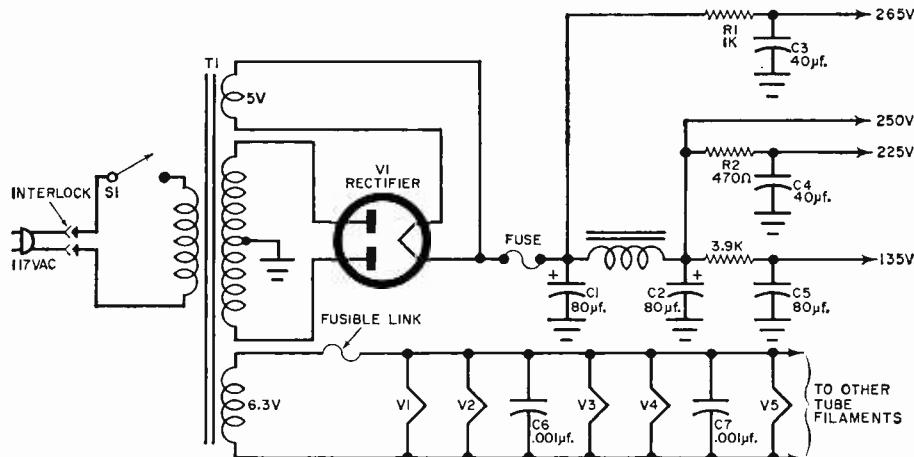


Fig. 32. This typical transformer-type power supply develops several d.c. voltages and provides a.c. voltage for the tube filaments. Highest voltage obtained depends on the transformer design. Full-wave rectification and adequate filtering smoothes the pulsating d.c. to ripples.

an abnormal loading condition. And, of course, there are such external things as too low or too high a line voltage to make the power supply look as if it were at fault.

The power supply converts the 117-volt a.c. house power to usable a.c. and d.c. voltages within the TV set to operate all circuits. A low a.c. voltage is needed to light up the tubes while high d.c. voltages ( $B_+$ ) are used to power the circuits. There are essentially two types of power supplies, those with transformers, as shown schematically in Fig. 32, and those without, as shown in Figs. 33 and 34.

**TRANSFORMER SETS** A transformer-equipped set usually relies upon transformer action to step up the 117-volt a.c. house power to about 300 to 400 volts a.c. and a rectifier to convert the a.c. to a pulsating d.c. voltage. A filter, consisting of a choke and one or more electrolytic capacitors, is used to smooth out these pulsations to obtain a purer d.c. voltage. The same transformer usually provides one or more filament windings, on the order of 6.3 volts, to light up the tubes in parallel. Most service technicians prefer this type of filament hookup because it enables them to quickly spot a tube with an open filament since only the defective tube remains cold.

A dual-diode type tube or a pair of solid-state silicon diodes employed as rectifiers usually provides full-wave rectification. Some sets equipped with a transformer power supply rely upon a pair of diodes in a half-wave voltage-doubler circuit, as in the transformerless sets, to step up the voltage. But the transformer serves to isolate the set from the line and permits the tube filaments to be wired in parallel.

Another advantage of a parallel hookup when servicing the TV set is the ability to pull a tube out of the set to observe the way the set works with and without the tube. Removal of a tube in a series string would disable the entire string. However, do not sell the series-string sets short; the reliability factors and economies achieved with these sets make them highly desirable.

**TRANSFORMERLESS SETS** These sets usually have all tube filaments connected in series and rely upon proper distribution of a part of the 117-volt a.c. line across each tube in the filament string. The strings are designed so that each tube has just the right amount of voltage impressed across its filament. A special breed of tubes having controlled warm-up filaments (heaters) are generally used in these strings. They are designed to withstand current surge and to maintain fairly good stability for long periods of time.

In a transformerless set, a pair of silicon diodes (some sets use selenium) is hooked up as a half-wave voltage doubler to provide a maximum of about 280 volts  $B_+$ . Here again the rectified voltage is fed through a filter network to the various circuits in the TV set. Some sets are made to work on about 140 volts and use only one diode in the power supply.

Because these sets are usually connected to one side of the a.c. power line, adequate safeguards must be taken to prevent shock hazard. It is good practice to use an isolation transformer when servicing them. If a set has a metal cabinet, extra precautions must be taken to maintain insulation between cabinet and chassis and not to compromise the insulation installed by the manufacturer.

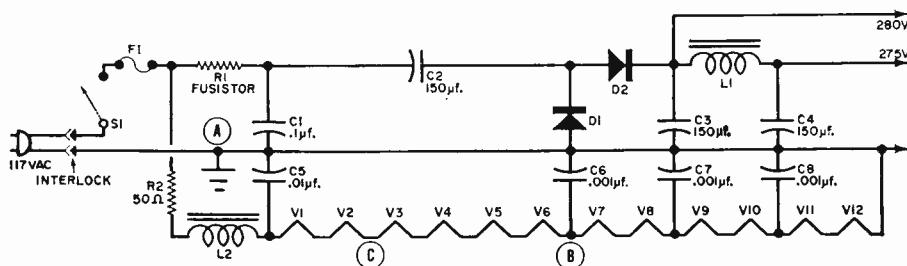


Fig. 33. The d.c. output of this half-wave voltage doubler is harder to smooth out than that of the full-wave power supply, but the circuit is quite common. Some TV receivers use an isolation transformer that also provides all of the filament voltages for a parallel hookup.

**LOW LINE VOLTAGE** An isolation transformer is a handy piece of equipment to have even if you are servicing a transformer-equipped set. The adjustable types can also be used to simulate high and low line voltages. Low line voltage can lead to many different types of complaints ranging from a shrunken picture to a dead set.

Should the local oscillator in the tuner stop oscillating, no signal would get through the tuner. You will have a raster but no audio or video in this case. In some sets you will also lose the raster. Of course, a new oscillator tube in the tuner might work even under low line voltage conditions, but in a very short time the new tube would begin to act like the old one. By observing the set's behavior when you purposely reduce the line voltage, you will know how the set acts and be able to determine what is happening and what to do in the event of a persistent or recurring trouble.

In the absence of suitable equipment to simulate a low line voltage condition, you can load down the a.c. power line with an electric iron, broiler, or other high-current appliance. Observe the action of the TV set while you switch the load on and off. Should you get a seemingly weird complaint that the set works okay in the daytime, but not at night, chances are the house wiring is inadequate and the extra current drawn at night drops the voltage enough to cause trouble in the TV set.

If there is more than one a.c. circuit in the house, you can try another outlet, or you can install a line-voltage regulator. Most regulators, happily, serve a dual purpose in that they also correct for high line voltage.

**SERIES-FILAMENT STRING** On the surface, it seems as though a set having a series-filament string is the most difficult type to service, because all the tubes go out when only one tube fails. However, there is no need to test or substitute each tube until you discover the defective one. While you can do this, it is time-consuming. But if you work with an ohmmeter, a voltmeter, or even a neon-lamp indicator, you can usually find the trouble in a few minutes.

One word of caution: don't rely on those \$3.95 tube testers that are essentially nothing but a continuity tester with a neon lamp indicator. They can mislead you; for example, a tube with an open heater, but with a cathode-to-heater short, will give you, in many instances, a normal reading. These checkers will also give you a normal reading when the tube has a shorted heater or a heater whose resistance has changed enough to cause trouble. On the other hand, a fifty-cent neon-lamp tester can be used instead of a voltmeter to track down a break in a filament string.

The quickest way to troubleshoot a series string is to use an "island-hopping" technique. You can pull a tube from almost any convenient place, in about the center of the string, such as V7 in Fig. 33, and, with a voltmeter, look for 117 volts a.c. between points A and B. Since the chassis is "grounded," you can

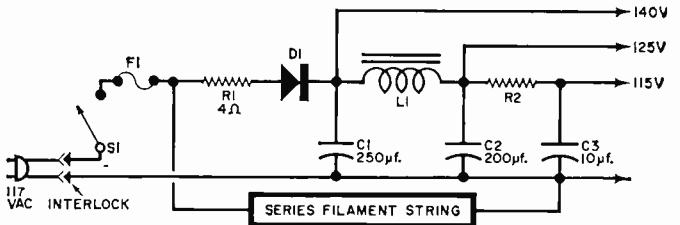


Fig. 34. Half-wave rectifier and series filament string supply is essentially the same as the half-wave voltage doubler, except for the amount of B+ voltage; ripple frequency is 60 Hz.

select any convenient point on the chassis as point A. This test is made with the TV set turned on and plugged into an a.c. outlet.

If all is well between points A and B, through V1 to V6, the full line voltage will appear because there is no voltage drop across any of the components in the filament string when the string is open. (When there is no current flow, there is no voltage drop.) Absence of a voltage reading between points A and B tells you that the trouble lies somewhere between the line cord plug and V6. The presence of voltage indicates that this half of the string is okay, and that the break is probably in the other half of the string between V7 through V12 and point A.

If the break appears to be before V6, re-insert V7 and pull V3. Now look for voltage between points A and C. This same reasoning will tell you if the break is between A and C, or between C and B. You can readily see that this technique helps you spot the trouble in only three or four tries—not bad considering that the string has 12 tubes, a choke, a resistor, a fuse, a switch, plus many connecting wires, and any one or more of these things could be at fault. You can also perform the same check with the a.c. power disconnected, using an ohmmeter to verify continuity between check points. Keep in mind, though, that a series string normally has a resistance of about 200 to 300 ohms.

**CIRCUIT BREAKERS** Fuses, circuit breakers, fusible links, and other overload and current-surge protectors are designed to break the circuit before any major trouble can develop. Sometimes these devices open up by themselves just from fatigue as well as because there is trouble in the string. Don't just replace a fuse or reset a circuit breaker without checking the circuit or at least considering the possibility that there may be other trouble. A shorted capacitor, such as C6 and C7, can cause some of the tubes not to light and some of the tubes to glow more brightly, and—hopefully—to blow out the fuse before a tube, transformer, or coil lets go.

**PARALLEL - FILAMENT STRING** Should a parallel-wired string open up, look for trouble in the vicinity of the transformer. Many sets have one side of the filament in each tube and one side of the transformer filament winding connected to the chassis. A defective connection between the chassis and the trans-

former filament winding can cause some strange effects. A high-resistance connection could keep the tubes from being adequately heated and prevent them from working properly . . . loss of gain and upset of a.g.c. circuits are quite common with this condition. Sometimes the tube filaments will glow normally, then dim, while at other times an intermittent on and off condition may be noted. The simple answer to this problem is to make a good soldered ground connection for the transformer filament winding. Some sets use a rivet as the ground connection. Don't overlook this rivet since it often develops a high resistance to ground and is usually the cause of a blinking filament string.

**B+ TROUBLES** If all the tube filaments are lit and the set is dead, chances are that B+ is defective. It can be the cause of a loss of brightness, shrunken picture, and distorted sound. Other troubles include dim picture, poor focus, and blooming. While it is possible for a power transformer to break down, troubles are more likely to develop in the rectifiers, filter capacitors, and even in the other circuits of the TV set. A short or other abnormally high current drain anywhere in the set will load down the power supply and eventually break down some of its components. You can quickly determine if this is the case just by disconnecting the leads, one at a time, going to the other circuits. If the power supply's ability to deliver proper voltage has not been affected by the abnormally high drain, B+ will jump back to normal when the defective circuit is disconnected.

If the B+ does not come back to normal after you have "unloaded" external defects, you can check the a.c. voltage before it gets to the rectifier. Shorted rectifiers or leaky electrolytics can pull down the a.c. voltage, and you may have to disconnect these components. Where a rectifier tube is used, all you have to do is pull the tube. By observing polarity of the capacitors and diodes, and bridging them with similar components you can very often find a defect. If two diodes are used, bridge both of them; if the B+ voltage then increases more than 10% you should replace the diodes. A good electrolytic capacitor placed across a defective one will decrease hum and increase B+. Remember, shorted or leaky components have to be disconnected from the circuit before you try a new part.

Hum bars on the TV screen and hum in the audio circuits can usually be traced back to a poorly filtered power supply. Look for faulty electrolytic capacitors and chokes, such as C3, L1, and C4 in Fig. 33, and C1, L1, and C2 in Fig. 34. This type of trouble could also come from a cathode-to-filament short in one of the tubes. The trick, then, is to be able to predict where the trouble is coming from. There are several ways to isolate the cause. In a full-wave rectifier type of power supply, the ripple voltage occurs at 120 hertz. This will cause two fairly large black horizontal bars to appear on the raster, with or without the presence of video. A 60-Hz ripple shows up as only one black horizontal bar. Since the filaments operate on 60-Hz a.c., a shorted or leaky tube is a likely cause of this symptom. But watch out for the half-wave voltage-doubler type power supplies; they also have a 60-Hz ripple component in the B+ voltage. However, hum caused by the power supply, both half-wave and full-wave types, generally affects sound, picture, and raster. The volume control, under these circumstances, usually has little or no effect on the level of hum coming from the speaker.

A shorted tube before the sound take-off point will affect the sound and the picture, but will not appear on the raster when the video is removed. If the defective tube is located before the detector, the hum will not be heard when the incoming signal is removed, by disconnecting the antenna and shorting the antenna input terminals, for example. If the hum is introduced by a defect in a circuit before the volume control, the hum level can be increased or decreased by adjusting the control. Hum in the sound alone or picture alone would normally be due to a defect in either the audio or video circuits, respectively, after the sound take-off point.

Hum in the sync circuits can create a false sync condition in the vertical sync section and cause the picture to lock in (vertically) with the vertical blanking bar exposed. Effects of hum in the horizontal sync circuits are more subtle and difficult to pinpoint, but it does cause some instability which can show up as ripples, weaving or pulling.

There are other apparent sources of B+ voltage in the TV set, from the boost voltage developed by the damper in the high-voltage section, for example, and in some sets from the voltage divider action of the audio output tube and its cathode resistor. Regard-

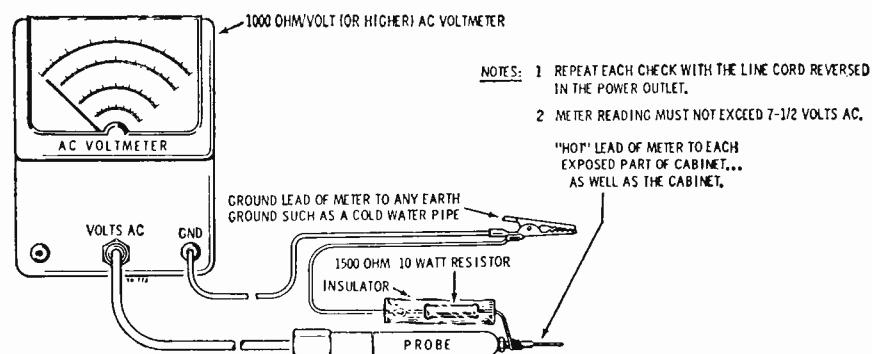
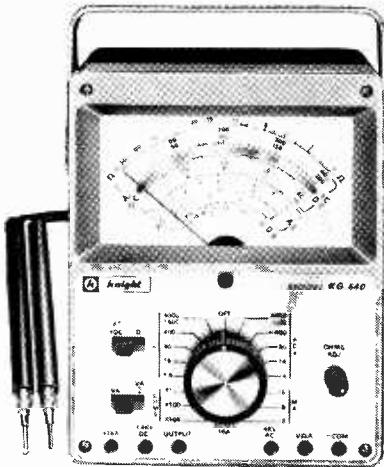


Fig. 35. This circuit should be used to determine a.c. leakage between a metal TV cabinet and ground. Check all of the exposed metal parts including knobs. A reading in excess of 7½ volts indicates a potentially dangerous path.

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CIRCLE NO. 9 ON READER SERVICE CARD

less of the voltage source, each usually is accompanied by its own set of filters and each can be isolated and tested. The trick here is simply one of knowing which circuits are affected by which power source. Unfortunately this information cannot be obtained without an examination of the schematic. Few service manuals treat this subject separately.

**SAFETY TEST** The receiver should be safety-tested after servicing to insure protection against electrical shocks. Do not use a line isolating transformer when testing for potential shock hazard.

According to Motorola, in addition to practicing the basic and fundamental electrical safety rules, the following test, which is related to the minimum safety requirements of the Underwriters Laboratories, should be carefully performed.

Referring to Fig. 35, a 1000-ohms-per-volt a.c. voltmeter is prepared by shunting it with a 1500-ohm, 10-watt resistor. The safety test is made by contact-

ing one meter probe to any portion of the receiver exposed to the operator, such as the cabinet trim, hardware, controls, knobs, etc., while the other probe is held in contact with a good "earth" ground such as a known grounded cold water pipe.

The a.c. voltage indicated by the meter should not exceed 7½ volts. A reading exceeding 7½ volts indicates that a potentially dangerous leakage path exists between the exposed portion of the receiver and ground. Such a receiver represents a potentially serious shock hazard.

This test should now be repeated with the receiver's power plug reversed. When making the safety test on a receiver equipped with external connections (remote controls and motorized tuners or any special accessories including indoor antennas), be sure all units are connected and functioning at the time of test. Make the test on all sets, including both transformer and transformerless types.

## COLOR TV INSTALLATION

A bandwidth of less than 3 MHz may be adequate for black-and-white TV, but for color reception, it is not broad enough to pass the 3.58-MHz color-burst signal. Positioning the signal within the passband can best be appreciated when you consider that the maximum total bandwidth allowed for video signals is 4 MHz. When you combine this very narrow margin with the tendency of colors to change quite easily because of signal conditions, antenna conditions and conditions in the set, you can begin to see why it is necessary for the set to be properly adjusted for color. Still other adjustments are important in order to receive a good black-and-white picture on a color TV set.

In an effort, on the part of the TV set manufacturers, to simplify adjustments and to enhance reliability, new controls, new circuits, and new components have been introduced. Even the simple ON-OFF SWITCH has been modified. At the risk of oversimplification, the following text material starts with an explanation of all of the controls; but before the material runs out, you should know exactly how to go about installing and adjusting a color TV set. And the more you know about color sets, the more you know about TV in general.

**CLASSES OF CONTROLS** There are three general classes of controls: the primary controls in the front of the set, normally adjusted by the customer; the secondary controls normally on the back of the set, and normally adjusted by the serviceman during installation; and the alignment controls, which are not usually adjusted, except at the factory and during major repair work in the service shop.

It cannot be stressed too strongly that non-customer type controls should not be touched unless you are thoroughly familiar with their action. Proper setting



FRONT PANEL controls of a color set can be adjusted by a child; but once the convergence control board is unlocked, keep the children away. Up-front controls do away with mirrors. This Heathkit GR295 also has a built-in dot generator.

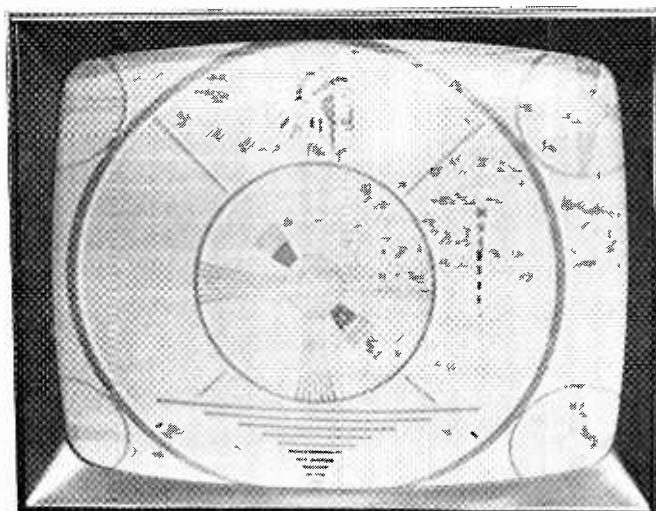
of most of the secondary and alignment controls requires the use of appropriate test equipment. However, certain minimum touch-up adjustments can be made without test equipment, to correct for aging and variations of signal conditions. Before you make such touch-up adjustments, mark the position of the controls so that you can reposition them to their original settings if the adjustments fail to do what you want them to do.

Keep in mind that certain types of adjustments (for convergence, purity, gray scale, etc.) must follow a specific order, and that this order may be different for different sets. The order in which the explanation of these controls is presented here is not necessarily the order in which they should be adjusted, but rather the order which will help you to understand them more readily.

Also note that not all secondary controls are in the back of the set; some of them have been put on the front, to enable you to see the screen directly while making an adjustment.

ON-OFF SWITCH, as always, is located on the volume control, but in most modern receivers a push-off, pull-on switch is used. Some receivers have a switch that turns the set on with one push and turns it off with the next push, and other receivers still use the conventional rotary on-off switch which requires resetting of the volume control each time the receiver is turned on. It should be noted that the sound in color receivers starts with about the same delay as in a black-and-white set. The picture takes a bit longer to start—in many cases about one minute is normal. Volume and tone controls are conventional.

BRIGHTNESS CONTROL is conventional—its setting adjusts the average light output of the CRT. Changes in room lighting, such as between day and evening, require resetting of this control. Control adjustment for a color picture is the same as for a black-and-



LOW CONTRAST can make the overall picture appear to be too bright and washed out; both blacks and whites are gray.

white picture, since color does not add to the brightness level. In color receivers the maximum brightness level is a function of the initial adjustments of gray scale tracking and adjustment of the high voltage. Optimum brightness control settings can more easily be achieved when the contrast control is also adjusted.

CONTRAST CONTROL adjusts the contrast ratio or range of the picture. Contrast can be defined as the difference or spread of light between the brightest white and the darkest black. Excessive contrast makes the light grays white and dark grays black, and causes a loss of subtle shadings. Insufficient contrast causes both the whites and the blacks to be gray, which gives the picture a washed-out appearance. It is important to have a correct contrast setting for color reception, since most observers find misadjusted contrast more objectionable for color than for black and white.

Correct contrast adjustment can best be performed with a bright black-and-white scene. Wait for a high contrast picture such as a well-lit studio, or outdoor shot. If the contrast adjustment is made for a night scene or other low-contrast picture, a normal scene will have excessive contrast. Adjust the brightness control for a pleasing brightness level, and then advance the contrast control from a low setting until the picture just becomes black in the dark areas and does not cause a defocusing or blooming of the highlights.

When the brightness and contrast levels are correctly set, the points of "just black" and "just not blooming" occur at the same time. If blooming is reached and no real blacks are present, the brightness level must be lowered. If excessive blacks appear before blooming occurs, the brightness level should be increased.

COLOR FIDELITY CONTROL (not found on all receivers) adjusts the whites of the picture to a pleasing shade, ranging from a sepia color (reddish-brown), through a normal white, to a cyan color (sky blue, or greenish-blue). This control caters to individual taste and permits correction for slight color shifts caused by normal aging of the tubes and other components in the TV set.

Because room lighting affects the shade of white that is most pleasing, adjustments should be made under normal lighting conditions and for a black-and-white picture. This setting also affects the appearance of the colors and if the control is adjusted for a color picture, it can cause confusion with the settings of the other color controls.

COLOR CONTROL (sometimes called CHROMA, or COLOR INTENSITY CONTROL) varies the amount of color saturation. Low settings result in a pastel-like appearance or weak-color picture. Excessive color settings cause blooming, streakiness, and an almost iridescent picture. Proper setting of this control varies from channel to channel and also depends upon

accurate adjustment of fine-tuning and other controls.

As a general rule, it is better to have less color than excessive color. On some receivers (Zenith, for example) a switch is built into the control which completely disables color when pulled out. In cases of no color, check this switch before looking for trouble elsewhere in the set.

**TINT CONTROL** (also called HUE, or COLOR SHADING CONTROL) adjusts the color received to the same shade as the color transmitted. Skin color is used as a reference since we normally have a good idea of what it should look like. Therefore, adjust the control to obtain the most pleasing skin color. When another known color is transmitted, it can also be used as a reference to set the tint control. This applies particularly to well known shades of red, such as that on a familiar cigarette package.

Red is a good reference color because slight differences in shading show up readily. Misadjustment of this control in one direction causes the color to shift to purple (magenta), and in the other direction to orange. Proper setting of this control may vary from channel to channel and from one type of program material to another; taped shows, live programs, commercials, etc., may call for a readjustment of the tint control to obtain optimum color reproduction.

**CHANNEL SELECTOR** is essentially the same as in a black-and-white receiver. Some receivers employ a two-speed continuous drive for UHF channel selection.

**FINE TUNER CONTROL** in a color set is much more important than in a black-and-white receiver. While an incorrectly tuned black-and-white signal may only suffer from picture smear and lack of detail, the same misadjusted fine tuner setting for a color signal can cause a complete loss of color. Correct procedure for fine tuning is the same for black and white as it is for color. Turn the control until sound interference ap-

pears in the picture, then back it off to the point where the interference just disappears.

Interference is much more noticeable on a color set. Actually, color intensity is generally much greater at the interference point, but the correct setting, nevertheless, is when the interfering herringbone pattern just disappears. Most modern receivers have an individual fine tuning adjustment for each channel which can be preset. On these sets, adjustment of the control on one particular channel has no effect on the other channels. When there is no color on a color transmission, check the fine tuner control setting.

**VERTICAL HOLD CONTROL** requires setting when the picture rolls vertically, just as in a black-and-white set. The adjustment is most critical for weak signals. A "hard" lock can be achieved by rotating the control until the picture rolls downward, then backing slowly off until the picture just locks in. Check the setting on all channels.

If there is a lot of noise present, such as ignition noise from trucks and cars, adjust this control to minimize picture jumping. Once the control is adjusted, it should not require any more attention, except for receiver aging, excessive variation in line voltage, or accidental misadjustment.

**HORIZONTAL HOLD CONTROL** is used to restore the picture if it is broken up horizontally—diagonal lines, etc. The horizontal section supplies keying pulses to other sections in the receiver, including automatic gain control (a.g.c.), and color burst separator. If the horizontal hold control is misadjusted, the picture may be overloaded (improper a.g.c. action) and no color present (loss of color burst kills color).

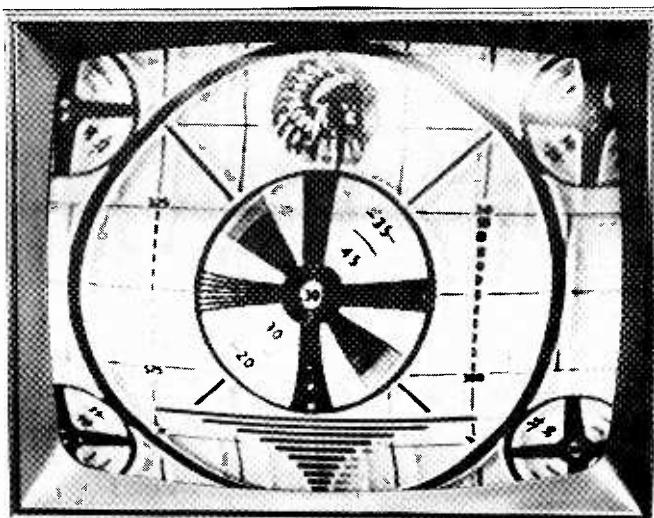
For proper adjustment, rotate the control in the direction that reduces the number of diagonal bars until the picture locks in. Switch channels momentarily to see if the picture locks in again (this is known as consecutive sync). If diagonal bars appear when channels are changed, the control is not correctly set. Readjust until the picture remains locked in.

Some receivers normally have a certain amount of thermal drift. Let these receivers warm up for about 5 to 10 minutes before performing any adjustments.

**CIRCUIT BREAKER** is used in most color receivers to disconnect the power supply from the other circuits in a receiver in the event of an overload. Power-line surges, accidental arcing in the receiver, and other trouble in the set will "trip" the breaker. When the breaker opens, further damage is prevented, but there will be no picture and no sound.

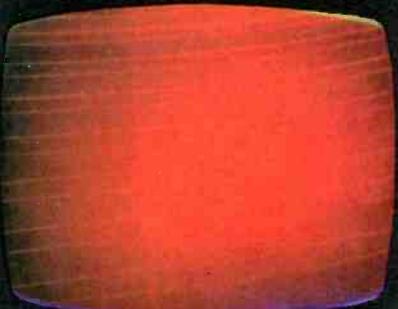
Allow about one minute after the set is turned on for the picture and sound to appear—if it doesn't, try resetting the breaker. This is accomplished by pushing the red button in and then releasing the button. It is impossible to hold the breaker closed; the circuit is completed only after the reset button is released. If

(Continued on page 54)



OVERLOAD is usually caused by misadjusted a.g.c. circuit, shows up as excessive contrast and unstable horizontal sync.

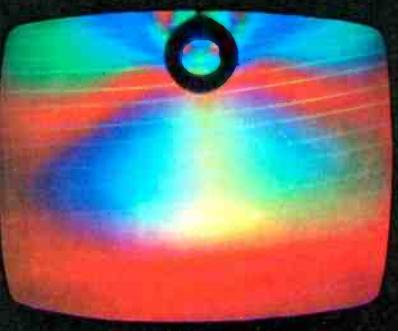
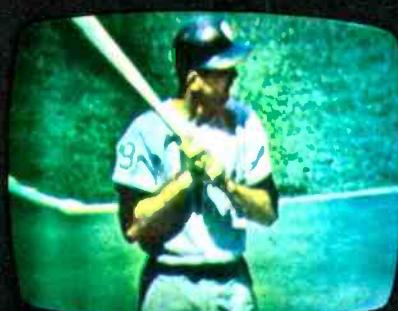
# COLOR • TINT • CONFETTI • PURITY



**COLOR CONTROL** Color intensity should be variable from no color, to washed out color (top, left), to normal (left), to excessive color (above). A little less color is often more pleasing to the viewer than saturated colors.



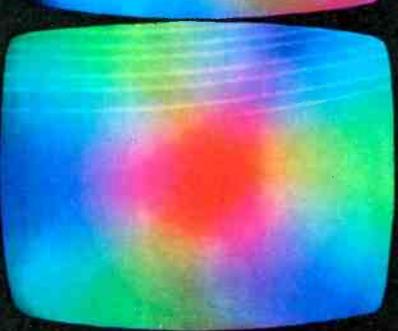
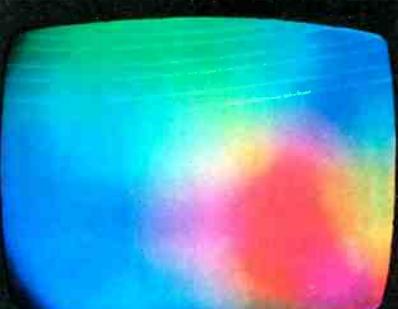
**COLOR SPLASH** Extreme corners of screen discolored due to secondary emission is of no great disturbance.



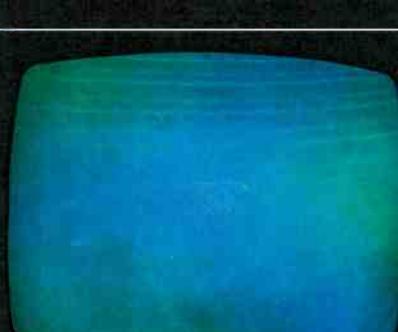
**WEIRD COLORS** Distortion caused by magnet held close to screen. Use degaussing coil to demagnetize tube and set before adjusting convergence.



**TINT CONTROL** Always adjust for best skin color, or best red. Control range should extend from excessive green (top, left), through normal (left) to excessive purples or blues (above). Effects vary with content of program.



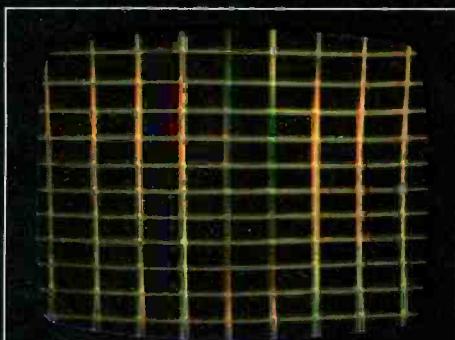
**CONFETTI** Snow turns to colored confetti in color TV set when control for the color killer circuit is misadjusted.



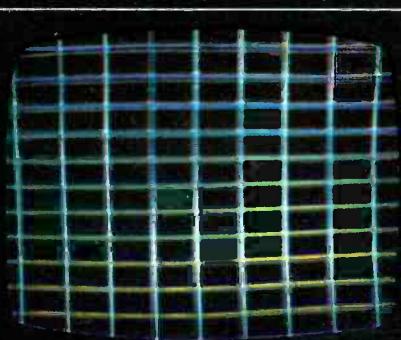
**RED FIELD PURITY** Set up screen for purity adjustments while operating red gun only with yoke pulled back. Off-centered red spot (top), is centered (above) by adjusting red purity magnet.

**POOR FIELD UNIFORMITY** With only the blue gun operating, discolorations due to poor purity adjustments show.

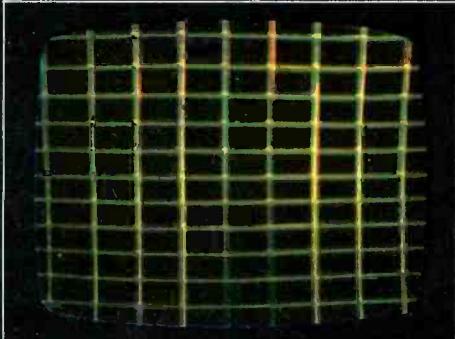
# CONVERGENCE • HUE • DEMODULATION



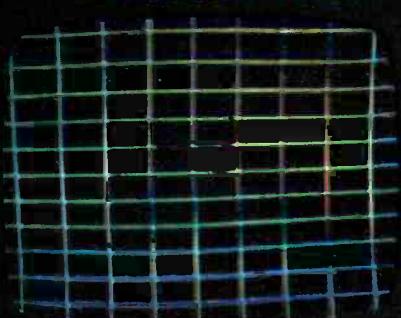
**MASTER AMPLITUDE CONTROL**  
Converge bottom red and green vertical lines. Red and green become yellow.



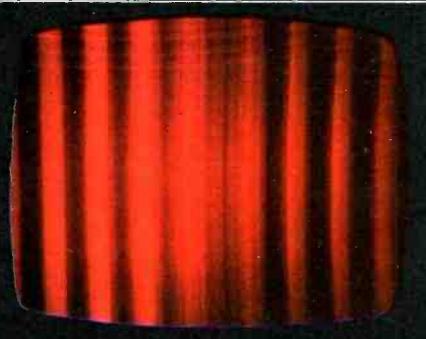
**COLOR BAR PATTERN** Normal display is indication of proper operation of phase, matrix, and other circuits.



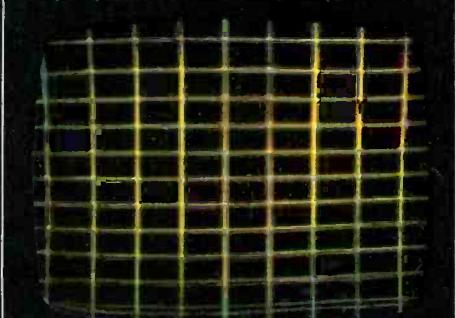
**MASTER TILT CONTROL** Converge red and green vertical lines in top area of screen. Recheck static convergence.



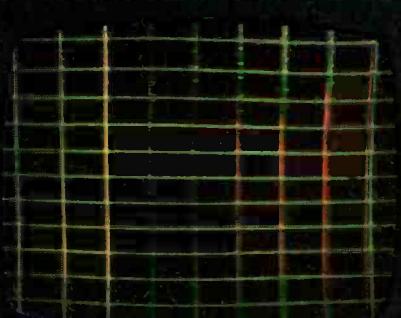
**BLUE VERTICAL AMPLITUDE & TILT**  
Shift the top and bottom blue horizontal lines up or down to converge with the yellow (red and green) lines to form white lines. Misconvergence is present in both photos. Lower photo shows top lines almost converged.



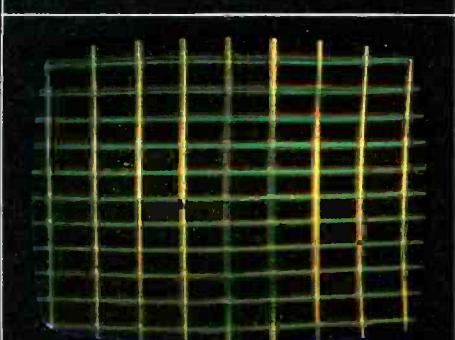
**HUE CONTROL** Proper setting blends sixth bar into background. Kill green and blue guns to obtain this display.



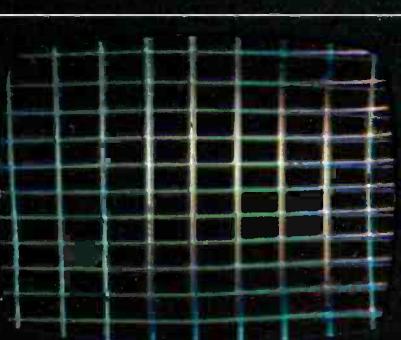
**DIFFERENTIAL AMPLITUDE CONTROL**  
Converge horizontal red and green lines in lower portion of the screen.



**RED AND GREEN VERTICAL LINES**  
Converge vertical red and green lines on right side. Optimize central area.



**DIFFERENTIAL TILT CONTROL** Converge horizontal red and green lines at top of screen. Optimize central area.



**BLUE HORIZONTAL LINES** Straighten the blue horizontal center lines to correct droop and misconvergence.



**DEMODULATORS INCORRECTIVE** Defective Z (or B-Y) demodulator shows up mostly as loss of blues (top); predominant loss of reds (above) can be traced to troublesome X (or R-Y) demodulator. Absence of red or blue also causes loss of green.

# AREAS OF IMMEDIATE INTEREST FOR DYNAMIC CONVERGENCE

## ⑤ Static (Center) Convergence

### VERTICAL GROUP

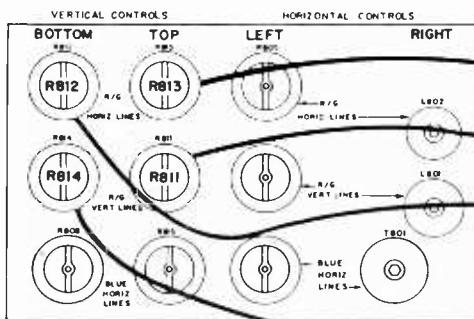
- ① To Converge Red & Green Vertical Lines Top, Adjust Red & Green Master Tilt (R811); To Converge Red & Green Horizontal Lines Top, Adjust Red & Green Differential Tilt (R813); To Converge Blue Horizontal Lines Top, Adjust Blue Tilt (R815)
- ② To Converge Red & Green Vertical Lines Bottom, Adjust Master Amplitude (R814); To Converge Red & Green Horizontal Lines Bottom, Adjust Differential Amplitude (R812); To Converge Blue Horizontal Lines Bottom, Adjust Blue Amplitude (R808)

### HORIZONTAL GROUP

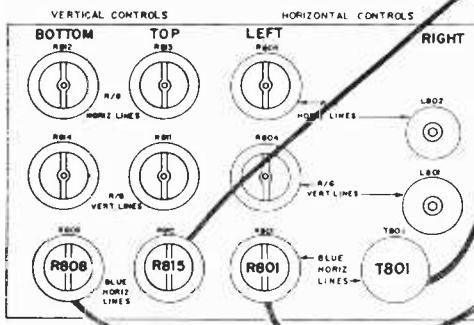
- ③ Converge Red & Green Vertical Lines Left (R804) (R-G 3); Converge Red & Green Horizontal Lines Left (R805) (R-G 4); Converge Blue Horizontal Lines Left (R801) (B 1)
- ④ Converge Red & Green Vertical Lines Right (L801) (R-G 1); Converge Red & Green Horizontal Lines Right (L802) (R-G 2); Converge Blue Horizontal Lines Right (T801) (B 2)

## CONVERGENCE

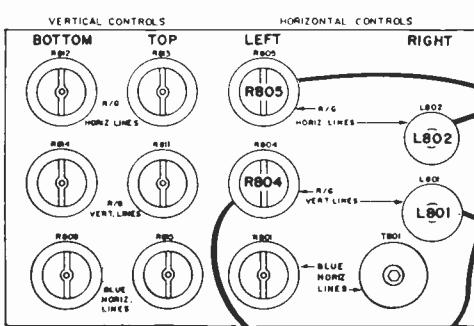
1. Use either crosshatch or dot pattern for center converge.
2. Converge center of screen with red, green, and blue magnets and the blue lateral magnet.
3. Adjust R811 and R814 for convergence (parallelism) of R/G vertical center line.
4. Readjust center convergence if necessary.
5. Adjust R812 to converge bottom R/G horizontal lines and R813 to converge top R/G horizontal lines at center line of screen.
6. Adjust R801 and T801 for straight horizontal blue center line.
7. Adjust R808 and R815 for uniform displacement of blue horizontal lines along center vertical lines.
8. Converge blue horizontal lines with R/G horizontal lines by adjusting the blue convergence magnet. Adjust red and green magnets if necessary.
9. Repeat steps 6 through 8 if necessary.



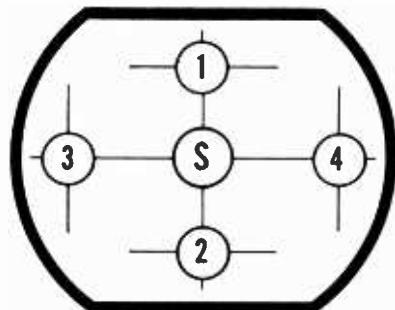
STEPS 3 AND 5 ADJUSTMENTS



STEPS 6 AND 7 ADJUSTMENTS



STEPS 10 AND 11 ADJUSTMENTS



EE41076

the picture appears for a moment and then disappears, turn the receiver off, wait two minutes, reset the breaker and turn the set on again. Should the breaker trip again, look for a defect in the receiver.

**FOCUS ADJUSTMENT CONTROL** varies picture sharpness. Adjust for best focus on a good-contrast black-and-white picture with a normal-to-high brightness setting. Brightness level should not be high enough to cause blooming. In a black-and-white set, this adjustment is usually performed while examining the raster lines. Dot structure and antiglare treatment of most color picture tubes tend to obscure these lines. You can observe printed matter or other fine details to obtain best focus.

As the control is varied, the picture should go from blurred to sharp and to blurred again. Color picture tubes arc internally on occasion; if such arc occurs, the picture may momentarily go out of focus. Allow a few minutes for the receiver to recover from the arcing before attempting any readjustments.

**VIDEO PEAKING CONTROL** (or **SWITCH**, also called a **CRISPENING CONTROL**) adjusts the response of the video amplifier. Its action on the picture can be compared to that of an audio tone control. Before checking this control, it is important that the fine tuning and contrast controls be adjusted for best picture. View a normal scene from a normal viewing distance and pay particular attention to sharp edges, such as on lettering, and other fine detail.

A picture with excessive peaking shows a white outline at the edges and may have an excessively "busy" appearance. Insufficient peaking causes a loss of detail and blurred edges; the picture seems to have a soft, or dull appearance. Viewing distance is important. A sharp and crisp picture at the proper viewing distance appears to be too "busy" when you are sitting too close to the set.

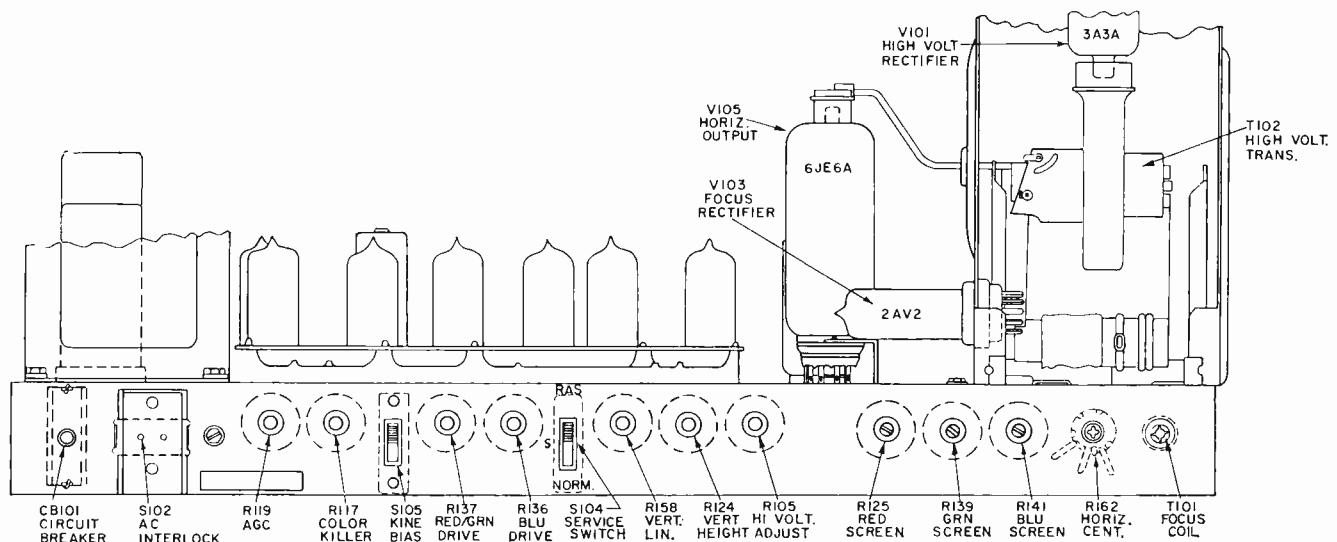
Different channels transmit pictures of different sharpness and the adjustment should either be made for the channel watched most frequently, or for a compromise setting which makes most channels acceptable.

**AUTOMATIC GAIN CONTROL** adjustment is not the same for all receivers. Service notes or operating instructions should be consulted for the proper procedure. In the absence of specific instructions, the following procedure can be effective in nearly all cases.

Tune the receiver to the strongest signal in your area, turn the a.g.c. control slowly to cause an increase in contrast until signs of overload appear (usually a bending or twisting of vertical lines in the picture), then back off the control to the point where the bending disappears and continue turning for approximately another 15 degrees. Check this setting on all channels. The control must be backed off still further if any of the channels show signs of overload or delay in coming on when switching channels. The horizontal hold control should be set to the center of its hold-in range before you adjust or check the a.g.c. action.

**NOISE GATE CONTROL** (also called **THRESHOLD** or **OPTIMIZER CONTROL**) is designed to minimize the adverse effects of pulse-type noise generated by cars, trucks and machinery, and is adjusted in much the same manner as the a.g.c. control. Advance the control until the picture twists or bends and then back it off slightly past the point where the twisting disappears. (Note: unlike the a.g.c. control, the noise gate control does not affect contrast.)

If all channels show effects of noise, the control should be adjusted to minimize jumping and tearing of the picture, but if some channels come in clear and relatively noise-free, the adjustment should be made to favor the strong channels. It is better to get a



BACK OF SET controls on RCA CTC20 Series chassis are conveniently situated to simplify installation and service. A considerable amount of interaction of control functions is normal for all color sets. Adjustments should not be made without test equipment and full knowledge of control action. It's a good idea to mark the original setting of the controls.

strong channel as well as possible than to get a poor one a little less poor.

COLOR KILLER CONTRCL (also called KILLER THRESHOLD CONTROL) adjusts the point at which the color circuits cut out for a black-and-white transmission, and cut in for a color program. If the color killer control is adjusted too far in one direction, no color will be seen on a color picture, and if too far in the other direction, color fringing will appear on black-and-white pictures.

The best way to adjust this control is to set the channel selector to an unused channel and rotate the killer control until the snow turns into confetti, back off on the control until the confetti just turns into snow, then tune in a color program to see if the color is coming through. If the killer control is correctly adjusted, it will not change the intensity (saturation) of the colors.

A quick check can be made by rotating the killer adjustment back towards the point where confetti was seen and watching for any change in color intensity. If such a change is noticed, the control was advanced too far; if no change is found, return the adjustment to the point where the confetti disappeared. If a compromise setting is indicated, good color reception should be favored; after all, this is a color receiver.

**CONVERGENCE ADJUSTMENTS** If you consider each triad of red, green and blue dots as one spot on the screen, the purpose of convergence adjustments is to have the three guns in the picture tube act in unison so that all the guns "hit" whatever spot is being scanned at the same time. The color of the spot can be anything within the spectrum of TV color, including black and white, depending upon the intensity of the three electron beams and their effect on the phosphors within the spot.

Static convergence is the process by which the three guns are made to hit the center of the screen; dynamic convergence corrects for "errors" on the rest of the screen. These adjustments interact with each other and a certain amount of going back and forth among the adjustments is necessary. It's a process of gradually obtaining the best set of adjustments.

Specific recommendations for convergence adjustment procedures, and the exact sequence of things to do and adjustments to make, vary a bit from manufacturer to manufacturer, and from servicemen to serviceman, but generally you should: (1) degauss; (2) size, shape and center picture; (3) adjust static convergence; (4) adjust purity; (5) adjust gray scale and check white field uniformity; (6) readjust static convergence; (7) adjust dynamic convergence (8) recheck and touch up purity, static convergence and gray scale.

DEGAUSSING is simply a process of sweeping an a.c. field past a magnetized substance to demagnetize it. External magnetic fields affect color purity and rea-



DEGAUSSING COIL held in close proximity to the set is moved in a circular manner across the entire front, top, and sides to neutralize unwanted magnetized areas. Keep the coil away from the back of the set to avoid weakening any of the purity and convergence permanent magnets. After you have "wiped" the set clean, keep moving the coil, and back away from the set as far as you can before switching off the coil.

sonable attention to locating the set away from motors, transformers, etc., is desirable. Most modern receivers have built-in manual or automatic degaussers to demagnetize the picture tube. (Sets manufactured prior to 1964 were not so equipped.) In any case, an external degaussing cannot harm the receiver; but, it can help.

To degauss a set with an external degaussing coil, turn on the coil, stand close to the set and move the coil as though you were washing a window, in a moderately slow circular manner, covering the entire area around the front, sides, top, and bottom. (Keep the coil away from the rear of the set to prevent demagnetizing or weakening any of the permanent magnets.) Dancing colored patterns and distortion of raster shape in step with the rotating coil will be noticed if the set is left on; this is normal. Keep rotating the coil while you back away from the set slowly, until you are about five or six feet beyond the point where no more noticeable effects appear on the screen, then shut off the coil.

Automatic degaussers go to work before the picture appears on the screen, each time the receiver is turned on. To operate a built-in manual degausser, push the switch, and hold it in for about a minute or so, then release it. Degaussing is required whenever the set's location is changed, particularly if it is made to face in a different direction. Degaussing, preferably with an external degausser, should be performed before adjusting purity or convergence.

**VERTICAL SIZE CONTROL** (also known as VERTICAL HEIGHT CONTROL) adjusts the vertical size of the picture. In most receivers this control affects the bottom of the picture more than the top. Vertical size and linearity adjustments in a color receiver should not be changed unless it is absolutely necessary. Besides interacting with vertical hold and vertical linearity

adjustments, the vertical size control affects convergence. Size adjustments should be made before convergence adjustments are made, and not after.

Size adjustments can be made with the aid of an on-the-air test pattern, or preferably with a crosshatch pattern from a color bar generator. When you are working with a station test pattern, the circle in the pattern should be made as round as possible. Unfortunately, circle roundness is sometimes lost in transmission, and the test pattern may not be on the air when you want it. Your best bet is to work with a pattern from your own signal generator.

If the crosshatch pattern contains 4 vertical lines for every 3 horizontal lines, you can strive to adjust the controls for equal-sized square boxes. However, you can work with a horizontal line pattern only and adjust the vertical size control for equal spacing between lines. The number of lines in the pattern is not critical but should be enough to provide no more than about an inch of space between them. (A service shortcut used by many TV technicians calls for a slight upset of the vertical hold control—just enough to cause a slow vertical roll—and observation of the size of the vertical blanking bar: good linearity is indicated when the width of bar remains constant as it travels across the screen.)

A certain amount of nonlinearity can be tolerated, and if the variation in spacing between lines is not more than about  $1\frac{1}{2}$  times smaller, or larger, at the top than at the bottom, and if the picture is normal in other respects, it is best not to make an adjustment. On the other hand, a picture that is too small shows up as a black bar or space on the top or bottom of the picture and is more noticeable, and more objectionable, than nonlinearity. Even so it may be possible to adjust the vertical centering control to shift the black space off the screen, or divide it so that some of it is on the top, and some of it is on the bottom of the picture. If you can sufficiently temporize a shrunken pic-

ture situation in this manner, you will be able to defer a convergence procedure. Centering controls do not upset convergence the way size controls do.

However, do not make any adjustments without first trying tube replacement. In all cases the vertical oscillator and output tubes (in some receivers one dual-purpose tube serves both functions) should be replaced with known good tubes before readjusting the size and linearity controls. Some more tips: for an initial set-up, try to get about  $\frac{1}{2}$ -inch overscan at the top and bottom of the screen, and with good linearity; for touch-up and other minor corrections, make a mental note of the position of the controls before turning them, to enable you to return them to their original position in case they don't do what you want them to do and you have to troubleshoot the set further.

**VERTICAL LINEARITY CONTROL**, much like the vertical size control, affects the overall size of the picture vertically, but mostly near the top. Convergence is also affected. This control should be adjusted in conjunction with the vertical size control for best overall linearity and size—before convergence, not after.

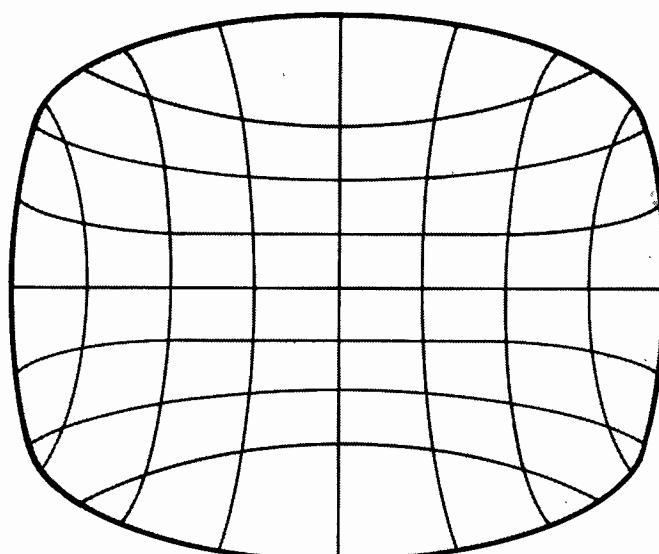
**VERTICAL CENTERING CONTROL** changes the vertical position of the entire picture. A small adjustment has almost no side effects on linearity or convergence and should be tried first if a black margin appears either at the top or bottom of the picture.

**HIGH VOLTAGE** regulation stabilizes the brightness level and minimizes blooming with changes of the brightness control. If the picture shrinks at low brightness and expands at high brightness, the high voltage regulator control is not properly adjusted.

Most manufacturers have a pair of test points in the regulator circuit (usually a 1000-ohm resistor) where you measure voltage drop. Find these points and follow the manufacturer's recommendations.

**HORIZONTAL CENTERING CONTROL** moves the entire picture right or left. It should be adjusted if a black margin is visible on either the right or left side of the screen, or if the picture appears to be poorly centered horizontally. If the black margin cannot be eliminated, the horizontal output tube should be replaced with a known good tube. The damper tube and horizontal oscillator tube should also be tried. And don't overlook possible low-line voltage conditions or power supply deficiencies.

**HORIZONTAL LINEARITY CONTROL** (sometimes called **EFFICIENCY** or **OPTIMIZER CONTROL**) is best adjusted with a meter. Misadjustment will shorten the life of the horizontal output tube. To make this adjustment, insert a milliammeter (500 mA) in the cathode circuit of the horizontal output tube and adjust the coil for minimum current reading; normal readings range from 190 mA to 250 mA, depending upon make and model of receiver.



PINCUSHION effects show up even when the lines are straight, because of screen curvature. Adjust the set while another person observes from a normal viewing angle; a mirror won't do.

In the absence of a meter an approximate adjustment can be performed, if absolutely necessary, by observing a test pattern or crosshatch pattern. Look for the settings that change horizontal linearity the most. The correct adjustment occurs in the center of the range of most rapid change.

It must be stressed that this adjustment is critical and should not be attempted unless a number of output tubes have failed, or it is not possible to achieve good linearity even after a number of output tubes have been tried. It should be considered as a service shop adjustment and is listed here only because the coil is accessible from the rear of some receivers.

PINCUSHION AMPLITUDE CONTROL corrects pincushion distortion inherent in large-deflection-angle picture tubes. Straight lines near the top and bottom of the picture as well as on both sides either appear to be, or actually are, bellied towards the center of the screen. Electrical circuitry is provided to correct this type of distortion.

Normal viewing angle is an important consideration when adjusting for pincushion distortion. The spherical face of the picture tube and the level of the viewer above or below the set affect the apparent pincushion error. When looking down on a receiver, even straight lines on the top appear to be bent—pincushioned top lines appear to be worse than they actually are, and at the same time, pincushioned bottom lines appear to be partially corrected. The reverse is true if the viewer is looking up at the set.

When making this adjustment, it is best to have a person observe the screen from a normal viewing position, and have him tell you when the lines appear to be straight. A mirror cannot be used conveniently—it is almost impossible to simulate a correct viewing angle with a mirror.

Advance the amplitude control until the horizontal lines near the top (preferably on a crosshatch pattern) and bottom appear to be as straight as the lines in the center. (Note: This adjustment is for horizontal lines. Most modern receivers have a fixed amount of correction for vertical lines and do not have any provisions for adjustment. If side pincushion controls are available, it is a simple matter to adjust them, if necessary, to obtain straight vertical lines.) If an increase in adjustment has no effect, or causes a hump that is not centered on the horizontal lines, check the pincushion phase adjustment.

PINCUSHION PHASE adjustment (usually requiring an adjustment tool) need not be made unless the pincushion phase coil has been accidentally misadjusted. Advance the pincushion amplitude control to its maximum setting, and adjust the pincushion phase coil. As the coil is adjusted, a "bump" will be seen to move horizontally across the screen. The setting is correct when the bump is exactly in the center. Once the phase is set, reduce the pincushion amplitude control setting until the lines are straight.

STATIC CONVERGENCE adjustments are made by properly positioning the three radial magnets mounted in the convergence yoke assembly. Location and shape of magnets may vary slightly on different sets, but their effects are the same in all cases.

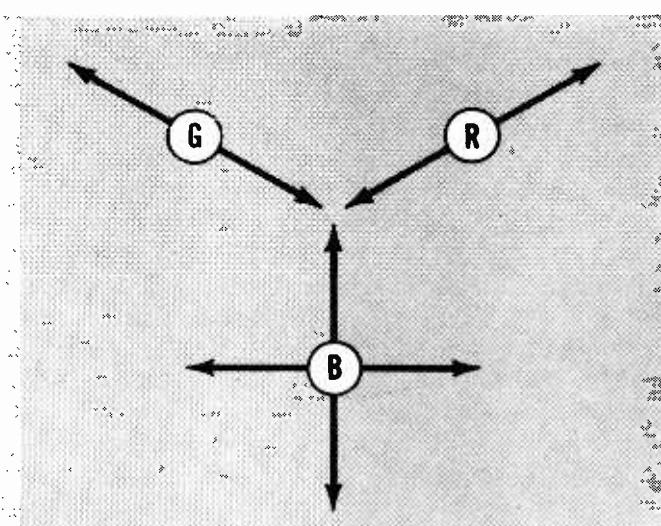
The Red Static Convergence Adjustment moves the red dot in the center of the picture diagonally from lower left to upper right. Adjustment range is on the order of one inch of movement.

The Green Static Convergence Adjustment moves the green dot in the center of the picture diagonally from lower right to upper left. A projection of the red and green dot movements would look like an "x." Adjust the red and green magnets until both the red and green dots are exactly at the same position, to form a yellow spot. An error in gray scale adjustment, or in focus, can result in unequal dot sizes. Accurate adjustment of convergence depends upon proper gray scale and focus. If at all possible, work with a dot pattern from a color bar generator to make these adjustments.

The Blue Radial Adjustment moves the blue dot in the center of the picture vertically straight up or straight down. After the red and green dots have been correctly superimposed, move the blue dot until it is in the same position or in the same horizontal line as the yellow spot. Normally, the blue dot will land on one side or the other of the yellow spot.

The Blue Lateral Magnet moves the blue dot horizontally. This magnet also has a slight effect on the red and green dots and it may be necessary to repeat the red and green adjustments if the lateral magnet is adjusted.

In the early stages of static convergence adjustment procedure, slight errors are permissible, since dynamic convergence adjustments cause a slight shift in static convergence, and it is necessary to retouch the static adjustments. But once purity and dynamic



STATIC CONVERGENCE adjustments merge the three beams in the center of the screen to form a white spot. Positioning a series of magnets moves the beams in the directions shown.

convergence adjustments are close to proper settings, extreme care should be observed to obtain exact static convergence. A viewer's eyes tend to be drawn to the center of the screen—very slight errors in static convergence are objectionable.

PURITY adjustments are made to obtain uniform displays of each of the three colors. Position the set so that it is facing in the normal viewing direction, and degauss it thoroughly. Static convergence must be at least approximately correct before purity adjustments are made. Static convergence interacts with purity and a certain amount of adjustment and readjustment of both are normally required. Inspect a crosshatch pattern on the screen—if the area in the center is not white, follow the procedure for static convergence before you look for purity.

After checking and adjusting static convergence, set up a red field (kill green and blue guns) to check for purity. Remove video signals, either by switching to the Purity position, if there is one on the Service-Normal switch, or by positioning the channel selector between channels, or by removing the third i.f. amplifier tube from the set. Next, loosen the yoke mounting screws and slide the yoke back until it stops against the convergence assembly; a red spot, about three inches in diameter, surrounded by various other colors, will appear. Adjust the purity magnet to center the red spot on the face of the picture tube.

Actually, there are two magnets. Most of these magnets have tabs on them to facilitate adjustment. If only one magnet is moved (tab spread changed), the red spot will move toward or away from the center in a radial manner. If both magnets are moved together, the red spot will move around the center in a circular manner. When corresponding tabs on each of the magnets are together and the two magnets are moved as a pair, the spot will not move appreciably; but when the tabs are far apart, and the magnets are moved as a pair, spot motion will be significantly greater. You can move the magnets separately or together until the red spot is correctly positioned in the center of the screen.

Once the spot is centered, position the deflection yoke by pushing it slowly forward, while observing the face of the picture tube in a mirror, until the entire screen is a uniform red color. The yoke should be loose enough in its mounting to permit smooth motion, yet tight enough to prevent it from slipping out of its position when released. Readjust the purity magnets to get rid of any impurities that might be present after the yoke has been placed in its best position. The end result should be a perfect red field, except for a small amount of "splash" on the outermost half inch of the screen in some picture tubes.

After the best red field has been established by alternately adjusting the purity magnet and the yoke position, check the green field and blue field separately. In most cases a pure green field and blue field will be found. If either of these fields is not pure, but

the red field is, recheck static convergence. If necessary, readjust static convergence. If good purity cannot be obtained on the green or blue field in spite of good red purity and center convergence, then readjust the yoke and purity magnets to obtain satisfactory green or blue fields. Work with either the green or the blue field, whichever is most critical, but do not compromise the red field.

After good purity has been obtained on all fields, rotate the yoke—if necessary—to set the picture horizontally and vertically straight. Do not move the yoke backwards or forwards, accidentally or otherwise, while you are rotating the yoke. The easiest way to check for a straight picture is to have an observer critically look at what is supposed to be a horizontal line on the center of the screen, from a distance, and to have him tell you when it is horizontal. Then, gently tighten the yoke mounting screws.

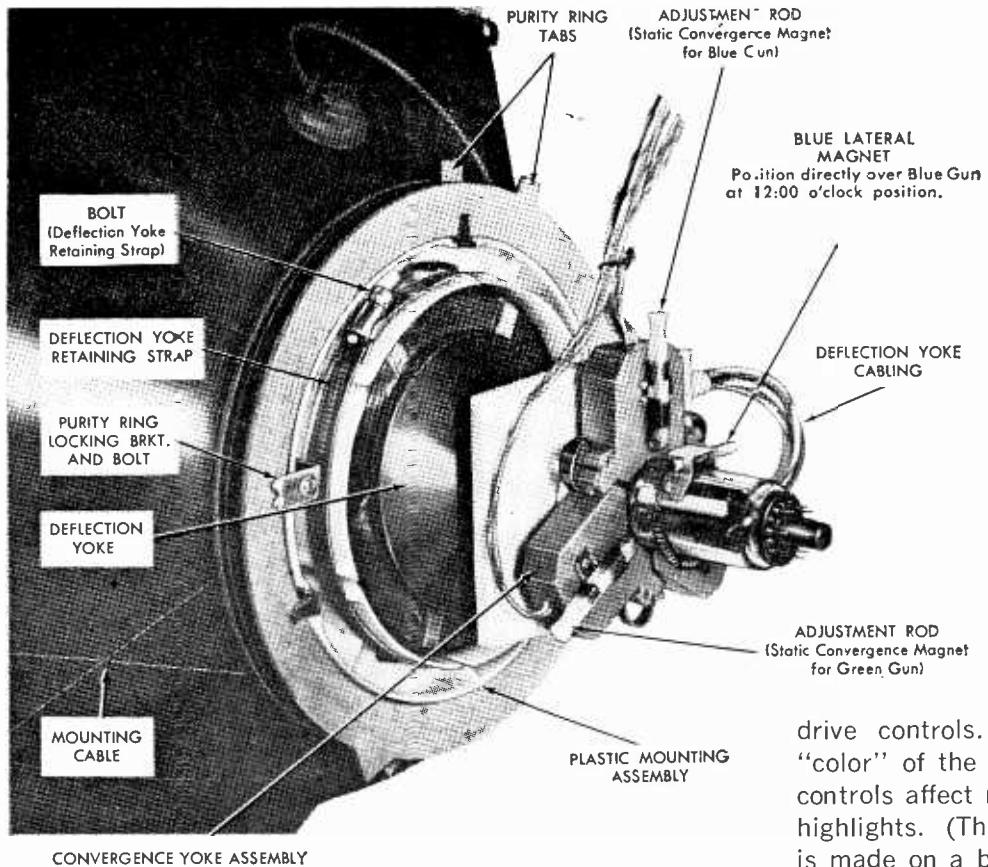
Just as static convergence affects purity, so do large changes in dynamic convergence adjustment. It is advisable to recheck each field for purity after all other adjustments are completed.

WHITE UNIFORMITY (uniform "color" of the entire screen) can be checked by killing the video and examining the raster for uniform brightness. If the Service-Normal switch has a purity position, you can set the switch in that position, or you can rotate the channel selector to a position between channels. If any portion of the screen has an objectionable discoloration, try degaussing the set before you decide to make any purity adjustments. Slight discolorations are often the best possible compromise, and the receiver should be left in this condition, especially if overall color reception is satisfactory. If the outermost half inch of the picture is off-color because of secondary emission in the picture tube, forget it. This is a commercially acceptable, and not too objectionable, condition which cannot be corrected, at least not at this stage of the art.

If the white field is not uniform, each color field should be reexamined individually for uniform displays, just as is done when purity adjustments are made. A few picture tubes may show up with a slight amount of nonuniformity even though the individual fields are pure; this condition is also considered acceptable. An experienced serviceman may be able to readjust purity slightly for a better compromise between pure fields and white uniformity, but the beginner is more likely to make matters worse.

KINE BIAS SWITCH (some receivers have a control rather than a switch), sometimes referred to as the master G-1 control, should be considered before proceeding with gray scale adjustments. Proper position of this control is the minimum setting (top position for RCA models) at which tracking adjustments can be made. Start with this control at minimum and proceed with gray scale adjustments.

If, in the process of adjusting gray scale, it is not



CONVERGENCE YOKE ASSEMBLY

possible to produce a visible line from each of the three guns, even when the screen control for the "blacked-out" gun is at maximum, it is necessary to advance the bias control. For example, if the blue gun doesn't produce a blue line, advance the Blue Screen Control to maximum and then advance the bias control until the line appears. However, do not attempt adjustment of kine bias without following the gray scale adjusting procedure.

**GRAY SCALE** (black-and-white-tracking) adjustments are made to provide a full range of grays from the lowlights to the highlights, without any apparent color "bleed." Five potentiometers and one switch are used in modern receivers to obtain a desired gray scale, and to maintain (track) that scale at all brightness control settings.

A Normal-Service switch allows the receiver to operate normally, or to operate in a suitable manner to permit gray scale adjustments. In the Service position, the switch disconnects the video signal from the picture tube, pegs the brightness at a low level, and kills the vertical sweep—a "single" horizontal line appears in the center of the screen. (Should you ever run into a complaint of no vertical sweep, check the position of this switch before looking for trouble in the set. For a viewable picture, the switch must be in the Normal position.) In some sets, these switches have a third position (Purity) which restores the raster, but not the video, to facilitate purity adjustments.

The five potentiometers individually serve as red, green and blue screen controls, and green and blue

PURITY adjustments are made to obtain uniform fields of color. Most often recommended procedure calls for adjustment of the red field initially, and then a check and retouch adjustment of the blue and green fields. Pull the yoke back as far as it will go, disable the blue and green guns, rotate the purity ring magnets to center the "blob" of red color, and then push the yoke forward until there is a uniform field of red over the entire screen. Secure the yoke, and check the blue and green fields. Size and location of purity ring in this Zenith set differ somewhat in other models, but adjustments are performed in a similar manner.

drive controls. Screen controls affect mostly the "color" of the grays in the lowlight areas; the drive controls affect mostly the "color" of the grays in the highlights. (There shouldn't be any color; this check is made on a black-and-white picture.)

Action of the screen and drive controls can be likened to the way a pentode type tube operates. Brightness varies directly with plate current; the more current the greater the brightness, and the smaller the current the less brightness. Plate current decreases as the tube approaches cutoff, and at cutoff the screen is blacked out. The control grid has more effect on plate current than the screen when plate current is high and thus has more effect on the bright areas. However, the screen has more effect on plate current than the control grid when the tube is operating near the cutoff point, which accounts for its effects on the lowlight areas.

It's true that both the lowlights and the highlights are affected by the grid drive controls alone, and by the screen controls alone. In this respect they are no different from the way the brightness control and the contrast control affect the picture; either control can make an area lighter or darker, but there is a tremendous difference between a full-contrast, low-brightness picture, and a low-contrast, high-brightness picture.

In order to achieve optimum gray scale tracking, the three screen controls are set to cut off all the beams at the same time, and the two drive controls are set to obtain the same shade of "white" at high brightness levels. With both ends of the brightness range accounted for, response in the intermediate levels will be satisfactory.

Screen and drive controls behave in a logical manner, and affect the colors just as you would expect. A high setting of a screen or drive control emphasizes its primary color on the screen, and a low setting brings out the complementary color. For example: an

excessive blue control setting makes the blues stand out, and an insufficient blue control setting drops the blues and seemingly pulls up the yellows; excessive red brings on the reds, and insufficient red reduces the reds and emphasizes cyans (greenish blue or sky blue); excessive green ups the greens, and insufficient green down the greens and brings out the magentas (bluish red and purple).

The color control should not change the gray scale. If it does, the color killer is not correctly adjusted. (Do not confuse the color fidelity control with the color control.)

Need for occasional gray scale readjustment is not an indication of trouble. Receiver aging, occasional picture tube arcing, and accidental control turning can cause a change in gray scale. However, if good grays cannot be achieved with proper adjusting procedure, the trouble can be in the picture tube, or in the receiver. When making adjustments, follow the sequence of adjustments step by step, in the order indicated by the manufacturer, but make adjustments only when needed. Mark the position of the controls. If a control doesn't perform the way it should, return it to its original marked position before making further adjustments or troubleshooting any part of the circuit.

Remember that room lighting conditions affect the appearance of the gray scale; and some mirrors do not reflect all colors with equal efficiency. Therefore, place the set in its normal viewing position, adjust the room lights for average lighting conditions, and position yourself to view the screen directly when making adjustments for gray scale, or get another person to help you.

To adjust the set for gray scale, tune in a good-contrast black-and-white picture, position the brightness, contrast and color fidelity controls in the center of their range, set the color control screen controls and kine bias switch at minimum, and put the Service-Normal switch in the Service position. Slowly advance the red screen control until the red line appears, and then back the control down until the line is just barely visible; then follow the same procedure with the green and blue screen control. If it is impossible to see any one of the colors, change the setting of the kine bias switch (or control) to make the line visible, and repeat the procedure.

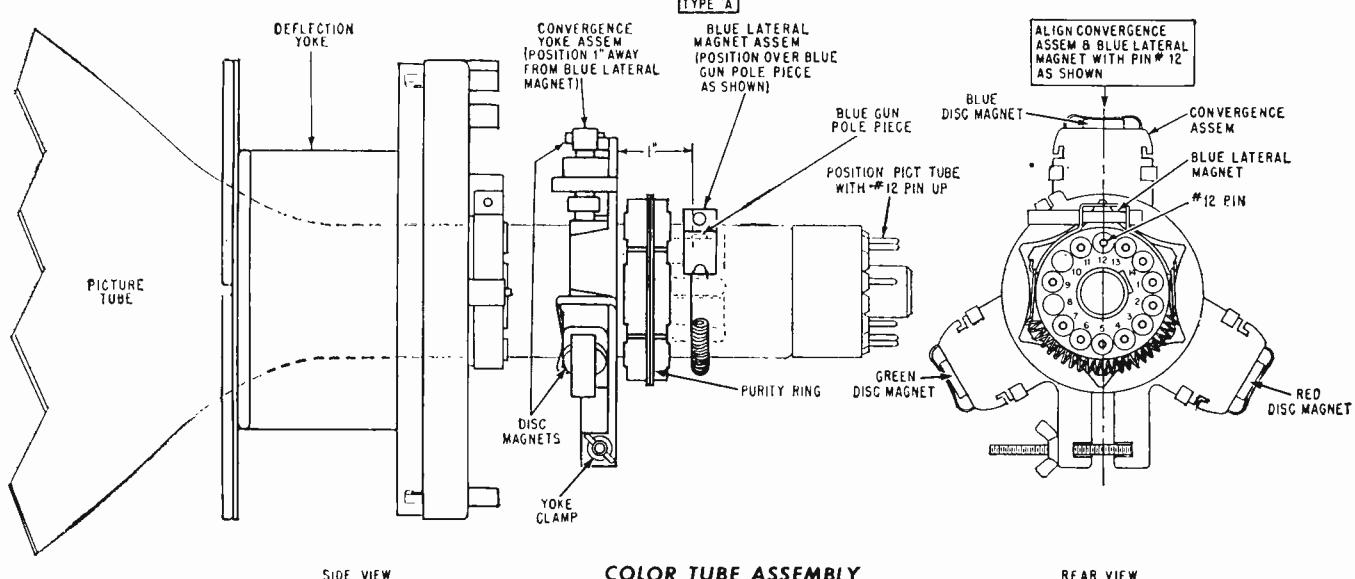
The end result of these adjustments should be a dim horizontal white line across the picture. When all three guns are adjusted for the same light output, the blend of the three colors will appear to be white. Don't be too concerned if the three lines do not coincide exactly to form

a white line; absence of vertical sweep may permit a slight displacement. Return the Service-Normal switch to the Normal position.

Examine the black-and-white picture at normal brightness level. First, look at the shade of gray in lowlight areas of the picture. If an undesired color shows through this gray, very slowly readjust the appropriate screen control: red control down for red, up for cyan; blue control down for blue, up for yellow; and green control down for green, up for magenta.

Next, examine the grays in the highlights and compare the "color" with the grays in the dark area. If the highlights appear to be greenish, for example, reduce the setting of the green drive control; if magenta, increase the green drive control; for shades of blue, decrease the blue drive control, and for yellow increase it. For shades of cyan, decrease both the green and blue drive controls, since there is no red drive control; similarly, for red shades, increase the settings of both the green and blue drive controls.

In some receivers, the picture tube grid leads can be interchanged to permit switching the drive controls to other grids. In these sets, it is possible to have the green drive control actually connected to the red or blue grid; adjustments



DEFLECTION YOKE, convergence yoke assembly, purity ring, and blue lateral magnet assembly are precisely positioned on the neck of the picture tube. The tube itself must not be rotated from its correct position; in most sets, the blue gun is on top.

should be performed by interpreting the effect of the adjustment on the screen rather than by the label on the control.

As a final check, after both drive and screen controls have been adjusted to obtain good grays and proper tracking, vary the setting of the brightness control. As the control is turned up from a very dark picture to a very bright one, the "color" of the grays should not change. If a slight change is noticed, the screen controls can be slightly touched up. Any attempt to make more than very slight adjustments may result in having to perform the entire procedure over again.

DYNAMIC CONVERGENCE adjustments are designed to overcome the distortions introduced by the curvature of the picture tube's screen and the constantly varying deflection angles of each beam. Unlike the relatively simple adjustments of magnets for convergence in the center of the screen, dynamic convergence requires setting up nine potentiometers, two coils and one transformer. With a little patience, knowledge and experience, you can make the three guns track each other over most of the screen surface.

On a crosshatch pattern, a group of six potentiometers is used to make the beams converge along the center vertical line, as well as the central portion of most of the top and bottom horizontal lines crossing the center vertical line. Three other potentiometers and three slug adjustments are used to converge the center horizontal line and the central portion of the vertical lines crossing both ends of the center horizontal line. There are no dynamic type adjustments available for the corner areas of the picture tube. A good yoke on a good tube will give satisfactory corner convergence when the center vertical and center horizontal areas are correctly converged.

A good test of adequate convergence is to observe a black-and-white picture from a distance of about six feet from the tube. If no

# 3 more features —all new



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objectionable color fringing is noticed, convergence is good. The center area should show no fringing from a distance of four feet.

Dynamic convergence cannot be performed without the use of a crosshatch—or a dot—pattern. Even experienced operators can make dynamic convergence worse if they attempt to perform the adjustments on a picture. It is better to accept a slightly misconverged picture than to waste a lot of time in an attempt to improve it without proper equipment.

Note the position of the controls before adjusting them, just in case you happened to grab the wrong one, or in case you can't get the expected response—you may wish to reset them to their original position. Let the receiver warm up for about 10 minutes before making any adjustments to allow for physical expansion of picture tube and other parts, as well as for thermal drift in some of the circuits. Sets adjusted when cold will go out of adjustment when hot.

CONVERGENCE ERRORS may arise that cannot be corrected due to characteristics of a given tube-yoke combination. There is no correction for the horizontal position of the blue dot except at the center. (One exception: some Motorola receivers have a dynamic blue lateral adjustment.) On rectangular tubes the blue line on the outermost inch of the horizontal line will droop slightly below the converged red-

green line. On 21" tubes the last inch should be ignored. An attempt to correct it may result in a more noticeable and more objectionable error nearer the center of the picture. If the brightness control is turned up too high, some colored lines may appear in the background. These are retrace lines—they cannot be converged. Readjust brightness and contrast if necessary to eliminate them.

Fortunately, the number of dynamic convergence controls has been reduced and there is a good deal of similarity of control function and arrangement in modern sets. Adjustment procedures have been simplified by combining some of the functions that were individually controlled in early model TV sets. Red and green beam convergence is accomplished with one set of controls, but another batch of controls is used to merge the blue beam with the red and green. In older receivers the cross-connections between the red and green controls did not exist. Only after the red and green beams have been brought together is the blue beam positioned. As a matter of convenience, the blue beam can be killed while the red and green beams are adjusted.

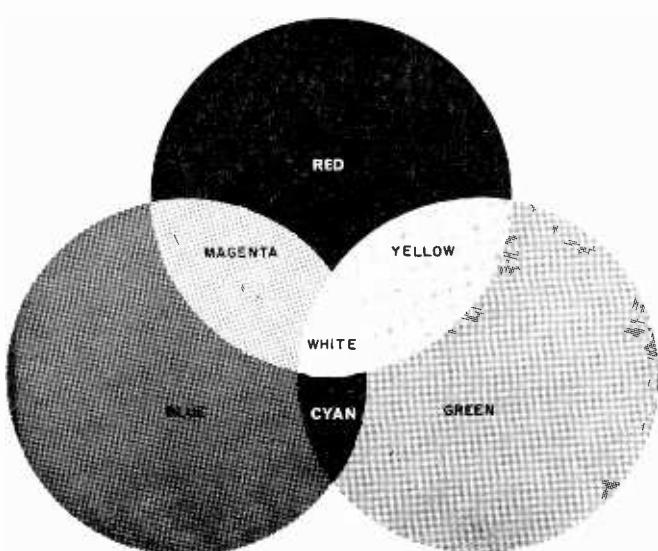
Just as height and linearity controls affect different parts of the screen, so do the convergence amplitude and tilt controls; amplitude controls affect the bottom of the screen, tilt controls affect the top. These controls are further classified

as master and differential controls; the master controls affect the vertical lines, and the differential controls affect the horizontal lines.

The controls on the dynamic convergence board are divided into two groups according to the portion of the screen affected—vertical convergence controls, and horizontal convergence controls. Vertical convergence controls are adjusted before the horizontal convergence controls.

Vertical convergence controls are adjusted for optimum conditions along the vertical line in the center of the screen, usually in the following order: converge the red and green vertical center lines at the top and bottom with the master tilt and master amplitude controls, respectively; converge the central portion of top and bottom red and green horizontal lines using the differential tilt and differential amplitude controls; converge the top and bottom blue lines with the red and green (yellow) lines to form white lines using the blue tilt and blue amplitude controls.

Horizontal convergence controls set up proper working conditions on the right and left sides of the screen along the center horizontal line. There are three slug adjustments and three potentiometers. The slug adjustments affect the right side and the potentiometers the left, but there is a good deal of interaction between these controls, and it is necessary to go back and forth, adjusting and readjusting them, until you have achieved the desired results. Adjust the left and right blue horizontal controls (B1 and B2) to obtain straight horizontal blue lines across the center of the screen; converge the central portion of the red and green vertical lines at the right and left side of the screen (R-G 1 and R-G 3); converge both ends of the center red and green horizontal lines using the R-G 2 and R-G 4 controls. (Note that the adjustments are made to satisfy conditions essentially along a vertical and a horizontal center line, and not in the corners.) Retrace your steps and retouch static and other convergence adjustments.



ALL COLORS, as well as white, can be developed by adding red, green, and blue in proper proportion. Large circles represent primary colors. The complementary color of a primary is made up of a mixture of the other two primaries. For example: cyan, which is the complementary color of red, is a mixture of blue and green, and when mixed with red becomes white.

# STRAIGHT TALK ON SERVICING AM/FM RADIOS

By JOHN D. DRUMMOND

## TACKLING TUBE-TYPE AM RECEIVERS

Tracking Down the Trouble  
Don't Jump—Walk!  
Test Equipment You'll Need  
Signal Tracing  
Point-To-Point Checks  
Receiver Alignment

## HERE COMES THE TRANSISTOR AM RADIO

Transistor Biasing  
Troubleshooting the Receiver

## TACKLING THE FM RECEIVER

Watch Out for Drifts  
FM Alignment

## SERVICING HINTS

This chapter deals with some of the more common problems that you—the repairman, whether rank amateur or professional—are likely to encounter as you go about the business of radio receivers for pleasure or profit. It discusses the servicing approach used by the pros rather than let you rely on the hit-or-miss buckshot "technique" employed by so many "basement" operators.

For, let's face it: anyone could conceivably fix a radio receiver by systematically replacing each and every component in the set until the fault is corrected, although the time and material costs could be astronomical. But this is not really radio servicing. If you develop a logical and systematic test procedure and have a basic understanding of how a radio works, you'll be able to track down and correct the most troublesome fault in the shortest time possible. Since—as with any skill or profession—time is of the essence, the more experienced you become, the more money that you will make and the more time that you will save.

From a purely practical standpoint, we cannot cover in this chapter every conceivable situation that you are likely to encounter. But we'll attempt to provide you with enough background information to enable you to adapt the principles discussed to any repair problem and come up with a logical solution—regardless of the type and make of radio receiver. Therefore, while no particular emphasis is placed on the repair of short-wave receivers or automobile radios, you should still be able to repair any one of these sets by following the general procedures outlined. Finally, FM radios should be no more difficult to troubleshoot than AM radios—once you understand the principles involved.

## TACKLING TUBE-TYPE AM RECEIVERS

The following paragraphs discuss the repair of tube-type radio receivers—there are still millions of them around—before going on to their transistor counterparts. This will give most of you old-timers an opportunity to bone up on some long forgotten principles, before you are dragged kicking and screaming into the era of solid-state circuitry.

**TRACKING DOWN THE TROUBLE** Most receiver troubles can be grouped into one of three broad categories: (1) the dead receiver that doesn't play, (*no reception*); (2) the receiver that plays with a weak, noisy, or distorted sound (*poor reception*); and (3) the receiver that plays for a while, and then konks out suddenly, without warning (*intermittent reception*).

Now, let's take a close look at some of these troubles and, with the help of the appropriate family-tree troubleshooting diagrams (Fig. 1, 2, or 3), try to come up with the cause of failure and prescribe a remedy for the ailment.

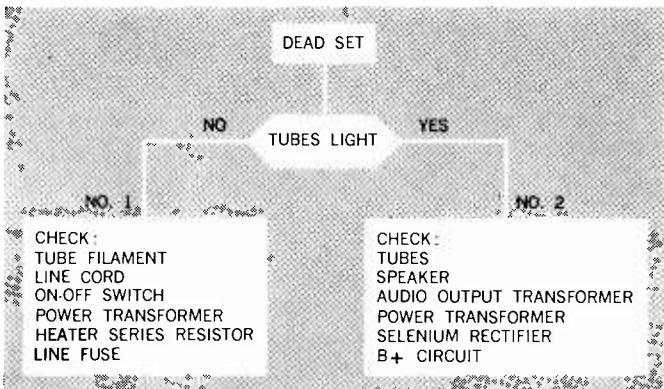


Fig. 1. The most common problem with a tube-type AM radio is the set that is "dead." If you follow a logical check and test procedure, you will eliminate the alternatives shown here.

**NO RECEPTION** When there is no reception at all (in contrast to poor reception or intermittent reception), you'll first try to determine the specific nature of the ailment and the category into which it falls. For example, if the set is completely dead and the tubes don't light, then the trouble falls into category No. 1 (Fig. 1). You should check tube filaments, line cord, on-off switch, power transformer (in transformer-type sets), heater series resistor, and line fuse. If you have a dead set, but the tubes light, the trouble falls into category No. 2. In this case, you should check the tubes, speaker, audio output transformer, power transformer or selenium rectifier (if used), and the B+ circuit as a whole.

If you get no reception at all, but do get a slight variable hum, or hiss, from the speaker (see Fig. 2), you have trouble No. 3; this means that the power is probably good and that the trouble is to be found in the converter, i.f. amplifier, detector, audio amplifier, or output stage. For this type of symptom, the quickest way to localize the trouble, after routine examination, is to use signal tracing or signal injection procedures (to be described later).

Trouble No. 4 is indicated if the radio receiver is blowing out fuses or dimming the house lights. Here you have a short circuit on your hands, and it must be cleared before the receiver is plugged in again. Specific short location techniques will also be discussed later.

**POOR RECEPTION** If your trouble is poor reception (Fig. 3) or loud background hum, the first thing to do is see if the receiver hum level can be varied with the volume control. If the hum cannot be varied, there could be a heater-to-cathode short in one of the output tubes, a defective filter capacitor, an open grid resistor, or even an open volume control.

When the volume control is able to vary the hum, you have trouble in the circuits ahead of the control. This could mean an open grid resistor, an open r.f. or i.f. winding in one of the coils or transformer, or an open a.v.c. or screen bypass capacitor. (See Fig. 2.)

If you hear *birdies* or motorboating (trouble No. 7), there may be oscillation in one of the stages. You can more or less determine the malfunctioning stage by the elimination process—by simply trying your volume control again. If you cannot vary the loudness on the symptom noise, the condition is in one of the audio stages. If the volume control varies the pitch of oscillation, but not the loudness, you probably have trouble in the first audio stage. If, on the other hand, the volume control does cut off the sound completely when it is varied, check all the stages preceding the audio.

For trouble No. 8, you have the noisy receiver that snaps, crackles, and pops due to arcing in the line cord, a tube, or other component. The technique you must use here is to look for sparks. Tap the tubes and i.f. cans and check for poor solder connections, especially in the power supply. Charred or badly tarnished resistors, especially those that are "bloated" or cracked, could be the cause of your troubles.

Trouble No. 9 is evidenced when you get distorted or garbled sound. To isolate the trouble, check the tubes and the speaker—especially look for a torn or frozen voice coil. Also, do not overlook the possibility of a leaky grid coupling capacitor (Fig. 4) or open a.v.c. bypass capacitor, or an open resistor.

Trouble No. 10, weak audio with high background noise, can usually be traced to a defective tube or open antenna coil. If the audio level picks up as you place your hand near the radio, the trouble is probably in the r.f. stage. To eliminate the audio amplifier as a source of trouble, touch the control grid of the first audio amplifier tube with your finger (this is usually the center tap of the volume control). If you get a loud click from the speaker, the audio amplifier can be presumed to be good. You can then concentrate on the antenna, r.f. coil, or some other component in the r.f. circuit.

If stations will not track correctly, or are tuned in at wrong spots on the dial (trouble No. 11), the receiver front-end should be aligned before you go any further.

**INTERMITTENT RECEPTION** The intermittent receiver falls into category No. 12. It does not appear on our chart because this type of trouble assumes no predictable pattern and can be the most difficult trouble to track down.

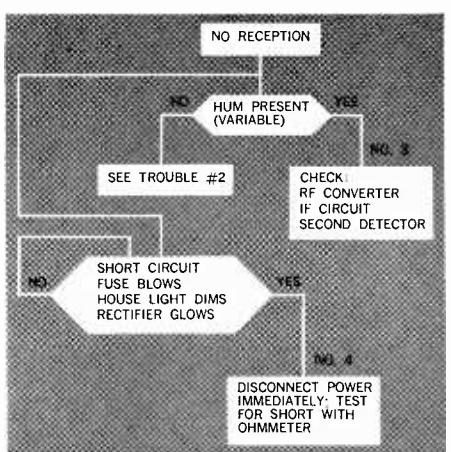


Fig. 2. If the AM receiver is "dead" except for a hiss from the speaker, you would normally follow the steps outlined in this flow diagram. In any event, test all the tubes before getting too far involved. Then proceed as shown in the diagram on the facing page.

For example, the set suddenly stops playing; you pick it up to troubleshoot it, and it starts playing again and stays on. You tap it gently, stomp it, or even kick it, but it stays on. You can put it down and a few minutes later it goes off again. Then it will go on and play for a day, a week, or longer; then, suddenly and without any warning, pfft!

This kind of trouble is most often attributable to an intermittent tube, a cold solder joint, or a loose connection.

**DON'T JUMP—WALK!** Ever stand by and watch a professional radio repairman operate—especially when he's not trying to impress you? He doesn't start ripping the radio apart the way some hams do. He probably checks the line cord, looks to see if the tubes light, removes the back cover and takes a sniff or two to detect possibly a burnt transformer or electrolytic. If everything seems okay at this point, he might check the tubes—unless the trouble symptoms clearly eliminate the possibility of a bad tube. If the trouble has not yet been determined, he would then proceed to remove the chassis from its cabinet for a more detailed visual inspection before calling on his instruments for help. Of course, the alert serviceman tries to get as much information as possible from the customer about the nature of the trouble and case history of the set. This often saves him many of the preliminary steps described. For example, if he has been told that the set started smoking, he would refrain

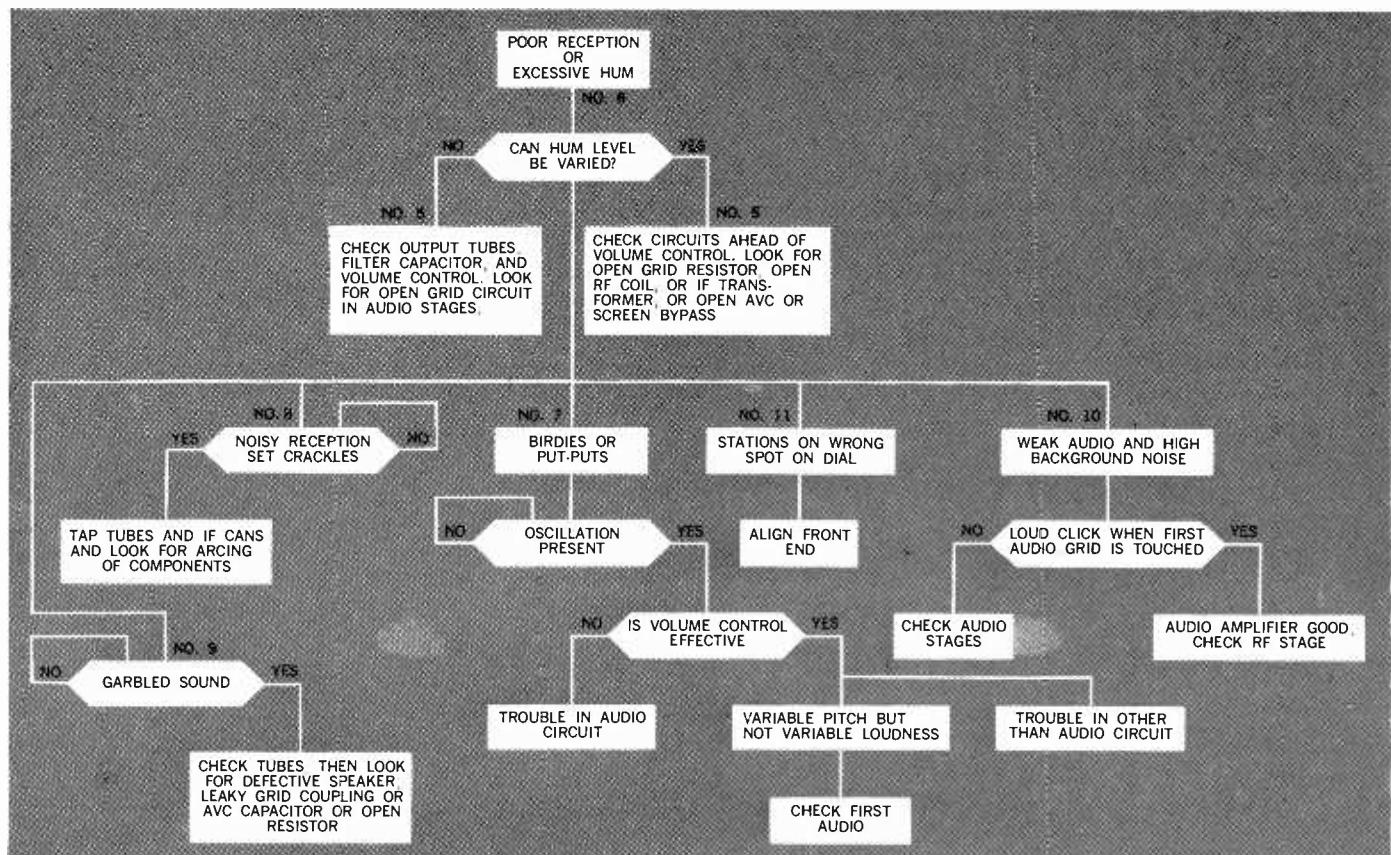
from plugging it in until he has located and removed a possible short circuit.

Because most of the troubles you will encounter are directly attributable to bad tubes, you should, as a routine matter, test all the tubes—preferably by direct substitution. A word of caution; don't put too much faith in your tube checker unless it is a fairly good one. Also, watch out for rigged tube checkers such as are found in some drugstores and small radio shops—if you do not have one of your own. If you suspect a particular circuit, replace the tube in that circuit with one known to be good. This is the surest test and, in the long run, the most economical.

There are some cases where both a tube and some other part are bad. Then, when you locate and replace the faulty component, the radio still won't work. This can cause you a lot of extra work and some frustration, until you decide to check the tubes again by direct replacement.

When you are troubleshooting a set for poor reception, it is a good idea to examine the antenna visually for breaks at the solder connections. You can speed up the analysis by putting your finger on the volume control center terminal (turn the control all the way up), and listening for a hum. The presence or absence of a hum, as well as the hum level, can tell you a great deal about the condition of the receiver. Naturally, you'll have to have a little practice and patience to be able to interpret the symptoms properly. Where you have an intermittent condition,

Fig. 3. This diagram provides a detailed breakdown of most of the trouble conditions frequently encountered in radio receiver servicing, and lists corrective action for each condition or symptom described. Symptoms not listed here appear in Figs. 1 and 2.



try tapping the tubes, jarring the set, or otherwise moving the parts around. You might just stumble on an open circuit or a loose connection.

When the set is blowing fuses, the first thing to look for is metallic objects such as a pin, a piece of wire, or some loose solder that somehow might have gotten into the radio and is now causing the short condition. But the rectifier tube is usually the worst offender here.

If you get no results from preliminary procedure, it is best to take the radio chassis out of the case (if you have not already done so). As a matter of fact,

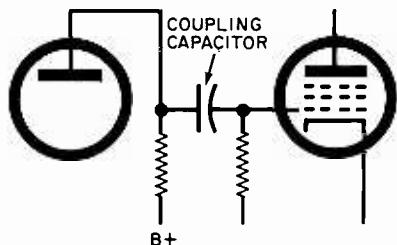


Fig. 4. A leaky grid coupling capacitor usually produces distorted or garbled sound.

it is a good idea to pull the chassis, even to test the tubes, if the area inside the cabinet is cramped. After all, there are only a few screws to remove and a couple of knobs to take off. Remember, you could break the tubes or damage antenna wires if you don't have enough room to work in, to say nothing of burning yourself on hot components.

Once you have the radio on the bench, give it a close inspection. Look for loose wires, wires with insulation burned off, charred or broken resistors, filter capacitors having a white, powdery mold around the terminals or bulging around the middle, soldering connections that are greenish or otherwise corroded. Watch out for bare wires that might be touching each other to form a short circuit. You may need a soldering iron during this phase of repair, but be careful—the iron is not only capable of performing repairs but also of causing great damage. If you find it necessary to replace a part, make a sketch to show all related wire connections before you remove the part. Better yet, tape and identify each lead you disconnect to facilitate re-connection. If you connect wires or components on the wrong terminals, you may be in for some real trouble. Remember the technician's adage: check twice, solder once.

Except when you have a short circuit, you will usually be doing your troubleshooting with the set turned on. This requires the use of a VOM or VTVM, except when you're just probing. Most radio shops keep a supply of standard parts on hand which can be quickly substituted in the circuit to check out a suspected component. These spare parts can be real time-savers

Fig. 5. On many occasions it is handy to have a few assorted replacement parts on your workbench so that they may be substituted for suspected bad components. Alligator clips with insulated sleeves can be soldered to the capacitor wire leads.



and be as useful as any test equipment in the shop. For a start, you can get a 20- $\mu$ F, 200-volt electrolytic capacitor, a 0.05- $\mu$ F tubular capacitor, and a 2000-ohm, high-wattage (about 10 watts) resistor. Solder alligator clips to the leads (see Fig. 5). A good precaution is to put rubber insulators over the clips to keep them from accidentally touching and shorting out other components.

When you are getting a steady hum that you can't get rid of by turning down the volume control, it might be an indication of a bad filter capacitor. You can usually check this out by clipping your replacement filter capacitor alternately across each of the filter capacitors in the receiver. A good practice is to first clip the hot lead from the filter capacitor to take it out of the circuit (you needn't remove the common lead). Remember that not all filter capacitors have their negative terminals going directly to ground. A good many radio receivers use the so-called *floating* ground, so you should not indiscriminately clip your test capacitor common lead to the receiver chassis. If the set's filter capacitor common terminal is connected to one side of the power line but is not chassis grounded, the set has a *floating* ground.

If the trouble clears up during this substitution test, be sure to put the right value capacitor in the circuit. Remember, the correct capacity is not the only criterion to go by when you're replacing a capacitor in a circuit. You must have the proper working voltage rating, or pfft! While we're on the subject of replacement parts, it is advisable never to substitute a part which has a lower voltage or power rating. If the set calls for a 10-watt resistor, don't assume that a 5-watter will do. It may not.

**TEST EQUIPMENT YOU'LL NEED** Some oldtimers will tell you that all they ever used to repair a radio was a screwdriver, a pair of pliers, and a soldering iron. Maybe so. But we suggest that you do not rely on the seat of your pants to do radio servicing, but instead go out and buy the equipment you need. A recent visit to a number of old, reliable radio/TV repair shops in the New York area revealed a strict reliance on good test equipment. All shops visited had at least one of the following instruments: VOM, VTVM, signal generator, signal tracer, tube tester, capacity tester, transistor tester, and oscilloscope. One shop even had a lamp with a built-in magnifying glass for working with transistor radios.

If you are a newcomer and are still debating about the kind of equipment to buy, consider the following: a good VOM, rated at 20,000 ohms per volt or better; or a VTVM having an accuracy of at least  $\pm 5\%$  on a.c. and d.c., and as many different ranges as you can get; an r.f. signal generator (practically any one will do as long as it covers both AM and FM frequencies); a signal tracer; an in-circuit capacitor tester; and, above all, a good tube tester.

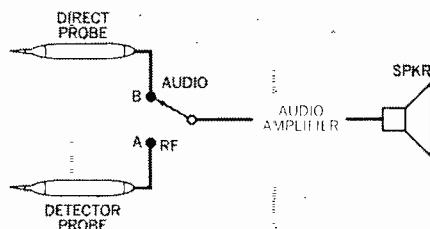
If you do transistor work, you should also have a low-impedance battery eliminator. If you use a high-

impedance type, it can introduce the same troubles as weak batteries, even though the voltage may be correct. If you do not know the impedance of the battery eliminator, you can make up and use an impedance-matching box similar to the one shown on p. 69. The box may also include a milliammeter so that current drain can be measured directly. If batteries are used to check the circuit, they should be fresh batteries.

**SIGNAL TRACING** Signal tracing can best be explained as a way of sampling the signal as it passes through the receiver or amplifier from stage to stage. In other words, it is a method of isolating the particular malfunctioning stage of a receiver or circuit.

If the signal tracer is to be independent, it must be able to convert part of the sampled signal output from the circuit into sound. To do this there must be a means of extracting the audio envelope from the r.f. carrier at any desired point in the receiver. Of course, the radio already has a circuit that performs this function—the detector. But if samples are to be taken at

Fig. 6. A signal tracer is simply a low power audio amplifier fitted to two different type test probes.



points preceding the detector, the signal tracer must be equipped with its own detector.

Manufacturers of commercial signal tracers usually provide complete instructions for their operation and these may vary slightly from brand to brand. However, here's how the average signal tracer works (see Fig. 6):

Suppose you want to test the audio amplifier stages in a receiver. Since the output of these stages is an audio signal, the detector part of the signal tracer will not be required and can usually be bypassed simply

by flipping the "RF-Audio" switch to position B (Fig. 6). Therefore, any audio signal picked up by the tracer's audio probe will go directly to its audio amplifier and come out through the speaker as intelligible sound.

If it is desired to check the output of a stage carrying an r.f. signal, you simply switch in the detector by flipping the "RF-Audio" switch back to "RF." The detector probe removes the carrier frequency, leaving only the audio components of the signal. Checking an i.f. stage is done in exactly the same way as checking an r.f. stage, since the only real difference between these two signals is the frequency of the carrier.

**USING THE SIGNAL TRACER** Let's assume that Fig. 7 is the block diagram of a receiver you have to repair, and you want to find out which one of the stages is malfunctioning. Of course, you have already gone through all the preliminary troubleshooting steps described earlier, but the trouble still remains.

Start out by applying the signal tracer's r.f. probe to the output of the receiver's r.f. amplifier, as shown in Fig. 7. If this stage is working properly, the r.f. energy will enter the signal tracer's detector probe, be converted into audio, and then come out as sound in the signal tracer. If there is no sound from the signal tracer, or if the sound that comes out is weak or badly distorted, you know that something is wrong with the r.f. amplifier stage. Using this same procedure, you can test each stage of the receiver, working back to the audio. Remember to switch back to "Audio" once you've passed the detector stage.

**USING THE SIGNAL GENERATOR** Experienced technicians usually do their signal tracing with the aid of a signal generator since this instrument is always at hand. You will have to proceed a little differently than you did when using the signal tracer.

Let's look at the block diagram of the receiver again (Fig. 7). To signal-trace with the generator (a better term would be *signal-inject*), start from the audio section of the receiver and work your way toward the front-end. In other words, inject the audio signal (first set the generator to "AF Output") at the input of the audio amplifier. If the audio stage is working, you will hear a tone through the receiver's speaker. If you get a sharp, well-defined tone from the speaker, the receiver's audio section is working okay, and you can go on to test the i.f. circuit. For this test you must set the signal generator for a 455-kHz modulated signal, and inject the signal at the grid of the last i.f. amplifier. If you are still getting a pretty good signal at the speaker, go on to the next i.f. stage. Once your i.f.'s check out, go to the r.f.'s.

Set the signal generator to 700 kHz, and apply this signal at the grid of the converter tube. Incidentally, you will note that the tone gets louder and louder as you approach the front-end of the receiver. Assuming everything is okay here, you can go on to the r.f. am-

(Continued on page 70)

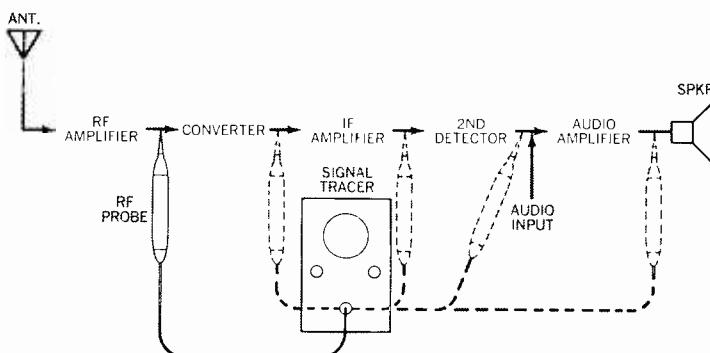


Fig. 7. As the name implies, the signal tracer can be used to check for the presence of a signal from the r.f. stage (if there is one) to the speaker. The r.f. probe is used to check stages before the second detector and the a.f. probe thereafter.

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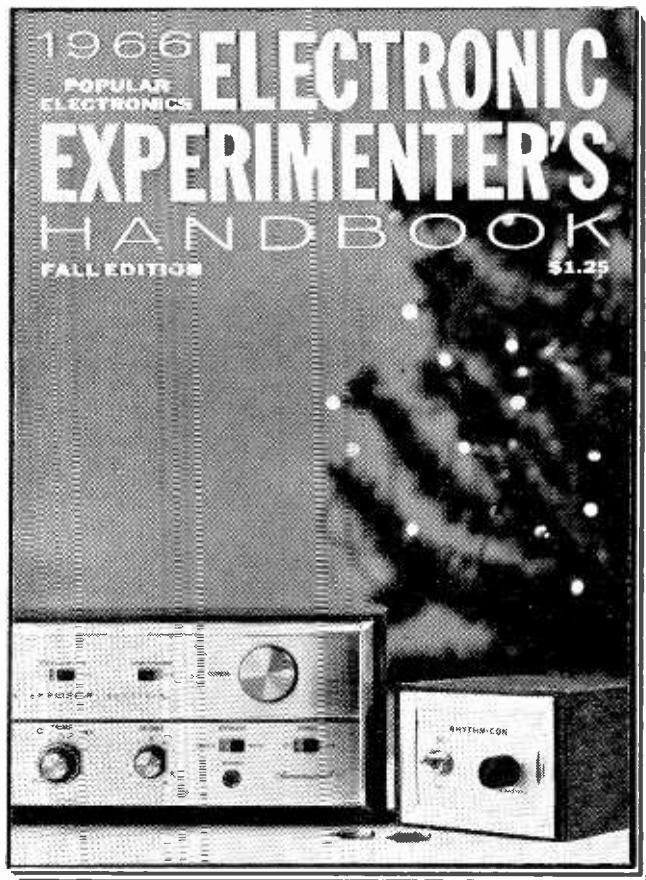
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plifier or the antenna itself; but you must now tune the receiver to the signal generator's frequency to get an output.

Bear in mind that as you signal-inject, you are trying to isolate the malfunction. Once you have gotten it down to a specific circuit, begin a systematic check of the circuit to spot the defective part. The point-to-point checks described in the paragraphs which follow will guide you in the right direction.

Signal injection, as you have just seen, involves an attempt to feed a signal from a source through an energized circuit. The signal should be of the proper frequency and amplitude for meaningful results. For example, if you are testing the audio circuit, set the signal generator to a suitable frequency in the audio range. Some generators have a 400- or 1000-hertz audio output. This is usually designated "AF Output." Set the signal generator to the intermediate frequency i.f. when signal testing in the i.f. circuit. Remember, you must use the modulated output. As a final word, always turn the receiver volume control up, while keeping the signal generator output low enough so that the tone is just audible. Keep readjusting the sound if it gets too loud.

**POINT-TO-POINT CHECKS** Assuming you have isolated the trouble to a particular stage in the receiver, your next step is to locate the precise circuit and then the malfunctioning component. Actually, once you have located the circuit, the trouble will be more or less obvious. But let's go through the motions nonetheless to see how you can systematically arrive at the same conclusion, using the point-to-point checks.

You will need a VOM or VTVM. If you have a VTVM, use it in preference to the VOM, since the

TUBE FUNCTION	TERMINAL	VOLTAGE (with respect to cathode)
R.F. Amplifier	Plate	+80 to +100
	Plate	+30 to +50
	Screen	About same as plate
	Control Grid	-1 to -3 (varies with strength of signal)
Converter	Plate	+80 to +100
	Screen	Same as plate
	Signal Grid	-1 to -3 (varies with strength of signal)
	Oscillator Grid	-3 to -6
I.F. Amplifier	Plate	+80 to +100
	Screen	Same as plate
	Control Grid	-1 to -3 (varies with strength of signal)
Detector-A.V.C.-First Audio	Diode Plates	-2 to -8 (varies with strength of signal)
	Triode Plate	+20 to +40
	Grid	-1
Power Output	Plate	+100 to +120
	Screen	+80 to +100
	Control Grid	-4 to -6
Rectifier	Cathode	+120 (measured with respect to common ground)

Table 1. Average voltages in various stages of the receiver.

VOM will have a loading effect when measuring the grid and other critical circuits.

**MAKING VOLTAGE CHECKS** Luckily, most a.c.-d.c. as well as transformer-equipped radios operate with similar d.c. plate, screen, and grid voltages. Thus, you do not always have to know the exact voltages specified by the manufacturer to determine if the stage is operating. For instance, in most receiver audio output circuits, the plate and screen voltages each measure approximately 100 volts. The plate of the first audio amplifier tube averages about 30 volts, but never exceeds 50 volts. The i.f. amplifier plate and screen will each measure around 100 volts. The converter's plate and screen should also be around 100 volts, while the detector's plate should measure less than -8 volts. The converter's oscillator grid should measure anywhere from -3 to -6 volts, depending on the receiver dial setting.

Bear in mind that all these voltages are nothing more than approximations, and you are going to find some exceptions right across the board. In general, slight voltage variations, on the order of  $\pm 10$  or 20 percent, will usually have little or no effect on the operation of the circuit. Of course, if you want more exact values, you will save a lot of time by having the

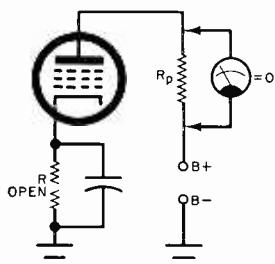


Fig. 8. If the tube is conducting, a voltage drop will be measured across the plate load.

actual schematic to work from. Most manufacturers provide service notes, and they can also be obtained from other sources, such as the Howard W. Sams "Photofacts."

If you fail to get a voltage in the expected range at the plate of a tube (see Fig. 8), you now have a definite clue to go by. Also, should you find the wrong voltage, say higher than 50 volts, on the plate of the first audio amplifier tube, you will have discovered another clue. As a final example, if you don't get the -10 volts or so you expect on the oscillator grid, the tube isn't oscillating. These voltages all point to specific areas where you can look for trouble. But, remember, you must be a little liberal since radio receiver circuits operate satisfactorily within a wide range of voltages.

Table 1 summarizes the approximate voltages that can be expected in the average tube-type table model receiver..

**MAKING RESISTANCE CHECKS** Although the voltages in a radio set are pretty much standardized, the same cannot be said of the resistances. Most manufacturers' service notes list typical resistance

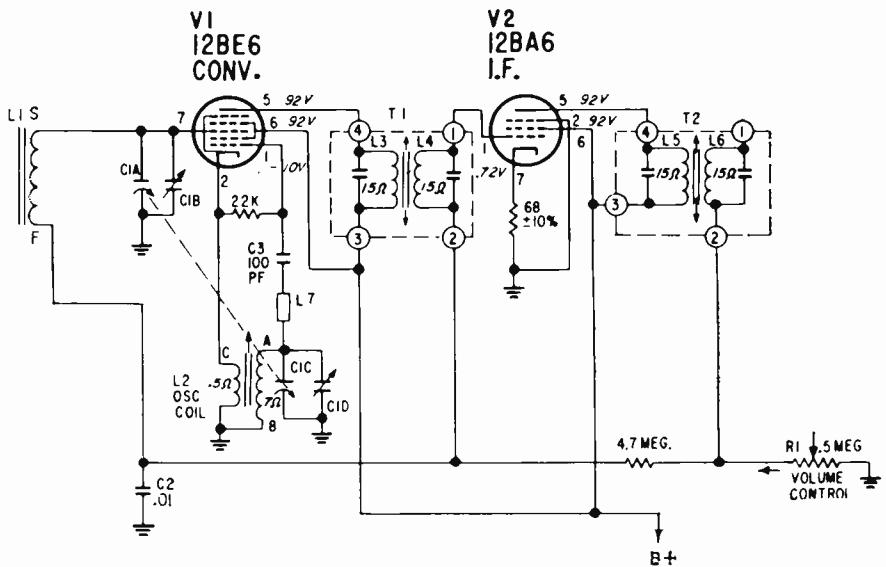


Fig. 9. Resistance values at various points in the receiver can be determined by direct measurement with the aid of a schematic diagram. For example, an ohmmeter placed between the grid and the converter tube (V1) and ground measures coil L1, the volume control, and the 4.7-megohm a.g.c. isolation resistor, all of which are connected in series.

values that should be obtained at the various parts of the receiver, especially at tube terminals. A typical example is shown in Table 2.

In the absence of these notes, you can use the set's schematic diagram to determine resistance between certain given points (see Fig. 9). But you should be careful when making these resistance checks with the schematic, since you can be led astray. For instance, some series-parallel combinations are pretty tricky to figure out, so unless you know what you are doing, play it safe; cut one end of the resistor to be measured out of the circuit and check each resistor separately.

But most of the measurements you'll be making will be to check specific resistance values. For example, a continuity check of the output transformer may show that the reason you have no voltage on the plate of the output tube is an open transformer primary. The primary coil of the i.f. transformer will likewise cause a lack of plate voltage on the i.f. tube if the coil becomes open.

When you are checking the set to track down a short, set your ohmmeter to the  $R \times 1000$ -ohm range and measure the resistance from B+ (locate the power supply filter capacitor) to ground. Resistance should be on the order of 25,000 ohms or higher. If the resistance is considerably less, say 15,000 ohms, you most likely have a high-resistance short. If it is below 1000 ohms, you have practically a dead short. You can locate the actual short using the ohmmeter

as follows: Start at the cathode of the rectifier tube and progressively move the ohmmeter probe along the B+ path. If you are approaching the short, the resistance measurement will be lower; if you are going away from the short, the measurement will be higher. If you come to an intersection where there are many wires, disconnect them, one at a time, and see if the short clears.

If the short clears when a particular wire is removed, follow the path of that wire and continue probing. At some point you will hit upon a very low resistance path leading to a shorted capacitor, shorted choke, or shorted transformer. You may even find a shorted connection. You then remove the short and restore the set to normal operation.

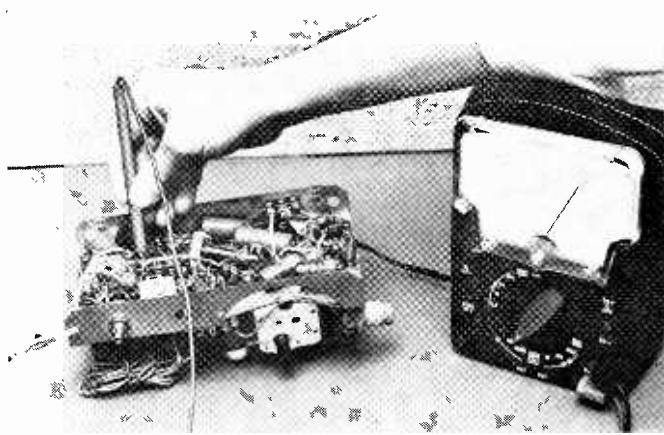
**CHECKING THE CLOCK RADIO CIRCUIT** If you are working on a clock radio and are unable to get a.c. power for the set, you should check the clock radio line circuit and the clock timer switch for continuity. Figure 10 shows the line circuit of a typical clock radio. While there might be some difference in circuit details, basically all clock radio circuits will tend to have the same configuration.

**CHECKING THE A.G.C. CIRCUIT** Trouble in the automatic gain control (a.g.c.) circuit, also referred to as the automatic volume control (a.v.c.) circuit, is usually indicated by an intermittent loss in volume. To check this circuit, disconnect the i.f. transformer

TUBE	PIN NUMBERS							
	1	2	3	4	5	6	7	8
V1 (6BA6)	2.7 meg.	0	0	1.0	inf.	inf.	0	inf.
V2 (6BE6)	47K	1.5	1.0	0	inf.	inf.	2.2 meg.	inf.
V3 (6BA6)	6	0	0	1.0	inf.	inf.	220	2.2 meg.
V4 (6AV6)	10 meg.	82	1.0	0	2.7 meg.	470K	inf.	370K
V5 (6V6)	0	1.0	inf.	inf.	100K	.68	0	260
V6 (6X5)	0	10	386 to CT	inf.	385 to CT	1.0	0	inf.

Measurement conditions: (1) Battery lead removed from set; (2) Ohmmeter common lead to chassis ground; (3) All measurements to be within  $\pm 20\%$ ; (4) Tone and volume control fully clockwise.

Table 2. Some manufacturers provide resistance charts like the one shown at left to help you diagnose the receiver troubles.



VOLT-OHM-MILLIAMMETER can be used to measure a.c. and d.c. voltages, direct current, and resistance. Here is a Triplet VOM being used to measure resistance in a receiver.

secondary from the grid of the i.f. tube as shown in Fig. 11; then ground the grid through a 1-megohm resistor.

Using a signal generator set to 455 kHz, apply a modulated signal to the grid and wait to see if the set loses volume. It may be helpful to raise the line voltage to approximately 130 volts to speed up the process. If this test restores normal volume, then the trouble lies either in the tuned circuit or in the a.g.c. isolation circuit between point 1 and 2.

**RECEIVER ALIGNMENT** Although broadcast-band receiver alignment hardly involves any "tricky" procedures, it nonetheless requires considerable skill and know-how to do a thorough alignment job on any receiver. Thus, the serviceman should always follow the radio manufacturer's service notes on alignment. The alignment procedure given by one manufacturer is reproduced in Table 3. In the absence of specific service information, however, reasonably satisfactory results can be obtained by following this basic procedure.

You'll need a signal generator capable of producing an unmodulated signal at frequencies from at least 455 kHz to 1600 kHz, and a VTVM or 20,000 ohms-per-volt VOM to monitor the signal. The signal can also be monitored audibly through the receiver loudspeaker.

For best results, the receiver circuit should be aligned in a definite order. First adjust the tuned circuits nearest the detector, and then work back toward the antenna (see Fig. 12). The recommended alignment sequence is: (1) the i.f. amplifier circuit; (2) the oscillator circuit; and (3) the r.f. circuit.

When you're tuning the i.f. circuit, the local oscillator and a.v.c. circuit should be made inoperative. You can make them so by short-circuiting the oscillator tuning capacitor as well as the a.v.c. capacitor. Also, connect the a.c. VTVM or VOM leads across the speaker voice coil; set the meter range switch to a low enough range for mid-scale deflection. Start with the 10-volt range and re-adjust downward as necessary.

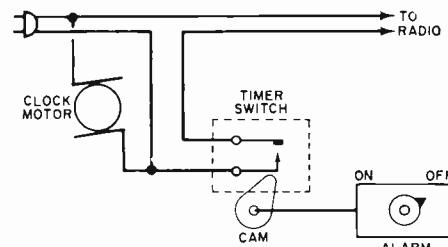


Fig. 10. Partial wiring diagram of a typical clock radio circuit showing timer switch.

Connect the signal generator ground terminal to the receiver ground, and its "hot" terminal to one side of a  $0.005\text{-}\mu\text{F}$  capacitor. The other side of the capacitor now becomes the probe.

To align the i.f. circuit, set the signal generator frequency to 455 kHz and reduce the output to a level that will produce a barely audible signal or a low reading on the output meter. Connect its capacitor-terminated probe to the grid of the last i.f. amplifier.

AM ALIGNMENT					
STEP	TUNING CAPACITOR SETTING	TEST EQUIPMENT HOOKUP	GENERATOR FREQUENCY	ADJUSTMENT POINT	ADJUST FOR
1	Fully closed	AM Signal Generator—Signal to test point (X). Ground lead to chassis. A.C. VTVM—A.C. probe to tie point (S). Ground lead to chassis.	455 kHz 400 hertz 30% Mod.	T16 Bottom T16 Top T14 Bottom T14 Top	Maximum a.c. voltage reading
2	600 kHz	AM Signal Generator—Radiate signal to receiver through a loop of several turns of wire. A.C. VTVM—Same as Step 1	600 kHz 400 hertz 30% Mod.	T18 Osc. coil	Maximum a.c. voltage reading
3	1400 kHz	AM Signal Generator—Same as Step 2 A.C. VTVM—Same as Step 1	1400 kHz 400 hertz 30% Mod.	C15G AM Osc. Trimmer C15E AM Antenna Trimmer	Maximum a.c. voltage reading

Table 3. Sylvania Electric's alignment instructions above are typical of those appearing in manufacturers' service manuals.

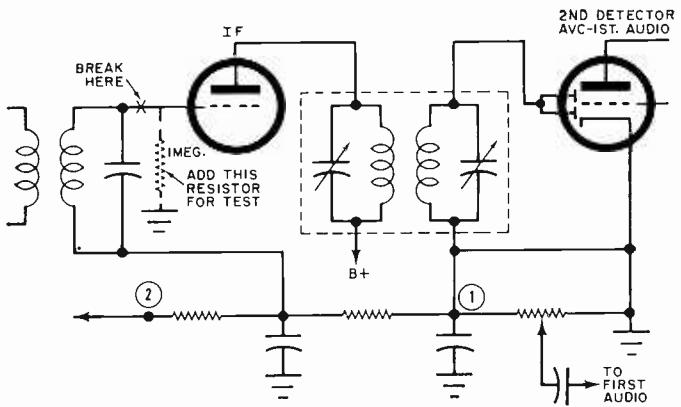


Fig. 11. Typical receiver a.g.c. circuit showing test points.

Then adjust the i.f. output transformer slug (using the appropriate tool) for maximum output (see Fig. 13). If the tone becomes too loud, or if the meter pegs off scale, reduce the generator output. After that, adjust the preceding i.f. stage in the same manner, connecting the signal generator to the grid of the stage before the one being adjusted.

To align the front-end, set the signal generator to 1400 kHz and connect its probe to the signal grid of the oscillator/mixer tube. Tune the receiver to 1400 kHz or until you hear the signal generator tone or get a good meter indication. Adjust the oscillator trimmer for maximum loudness or a.c. meter deflection as may be necessary.

To adjust the r.f. circuit, connect the signal generator across the antenna, without changing its frequency. Now adjust the r.f. trimmer for maximum loudness or maximum meter deflection, while gently rocking the tuning capacitor back and forth to keep the signal tuned in. Do not disturb the trimmers during this adjustment. For best results you should go over the whole alignment procedure to compensate for any interaction which could have detuned any of the circuits.

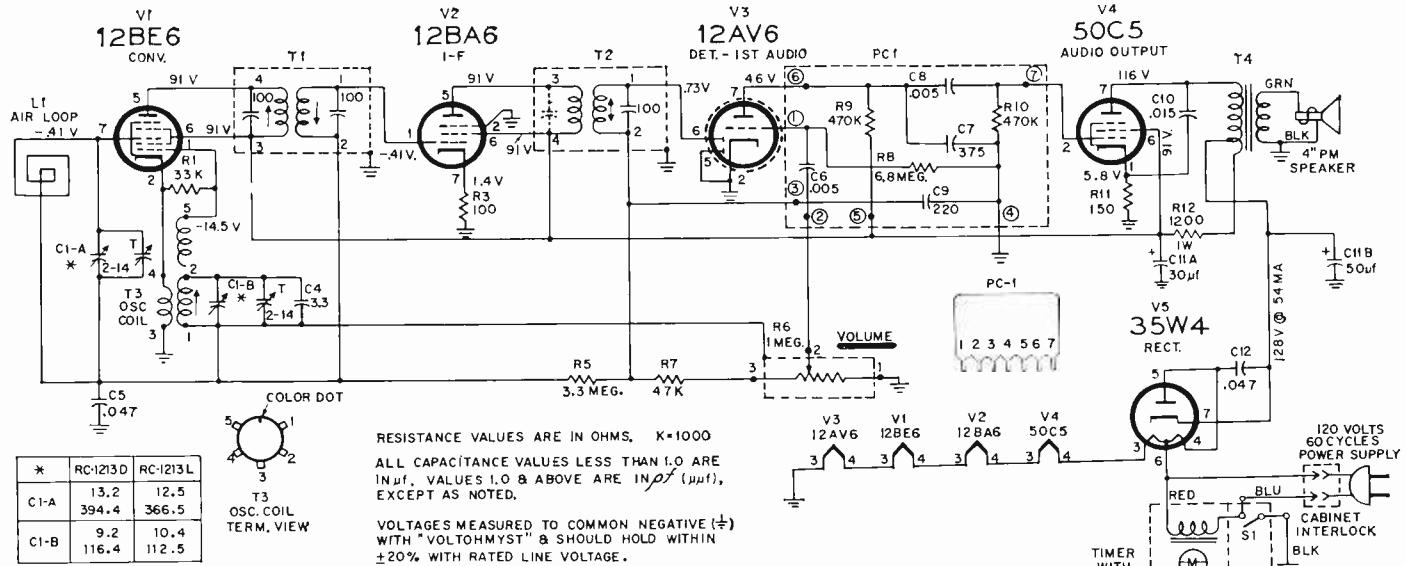
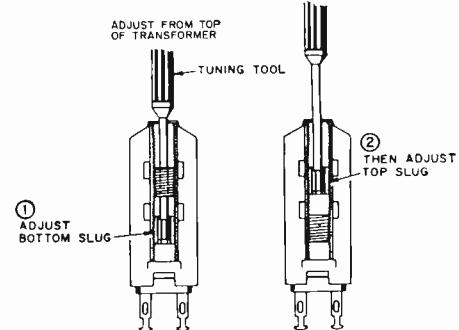


Fig. 12. Schematic of RCA's RC-1213P a.c./d.c. receiver with series-string filaments is typical of standard table radios.

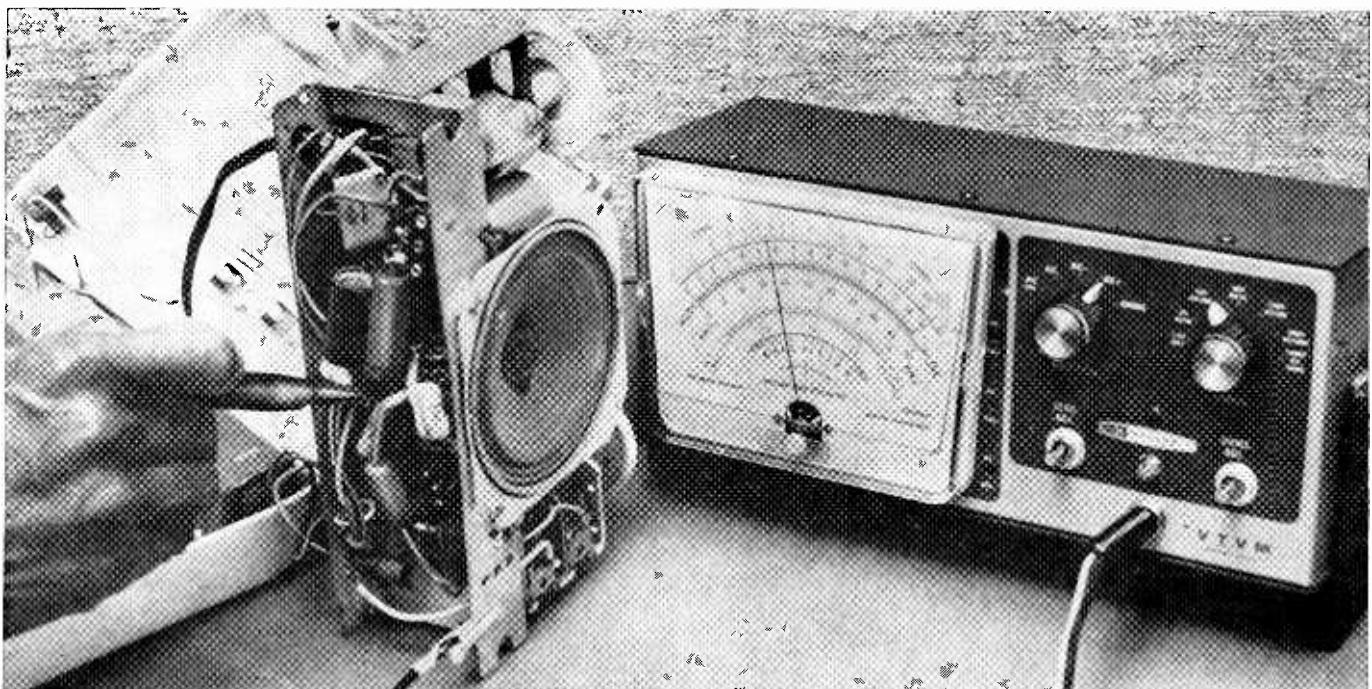
Although general in nature, the alignment procedure described above will produce excellent results. But, where possible, endeavor to obtain the manufacturer's instructions, which usually provide information tailor-made for the particular receiver.



## HERE COMES THE TRANSISTOR AM RADIO

In many respects, the servicing approach for transistor radios is similar to that used for vacuum-tube receivers. Admittedly, some of the trouble symptoms encountered in tube-type radio receivers do not appear in transistor radios. But this does not mean that transistor radios are more difficult to service. It simply means that many of the troubles that bedevil the tube-type receiver do not appear in the transistor radio. For example, open filaments, burned-out resistors, arcing contacts and components, and so on, do not occur in transistor radios.

When servicing tube-type receivers, you first check the tubes, after which you use some method of signal tracing to isolate the trouble to a particular stage. This is followed by voltage or resistance measurements to locate the faulty component. With transistor radios, it is common practice to first check the bat-



ACCURACY AND VERSATILITY make the vacuum-tube voltmeter (VTVM) a standard test instrument in any up-to-date service shop. This Heathkit model, which uses a single ohms/a.c./d.c. probe, is shown measuring a radio receiver oscillator grid voltage.

tary(ies), after which circuit isolation by signal tracing follows. Because of the reliability of transistors, they are not checked on a routine basis. And when transistor failure occurs, it can usually be traced to abuse of the device or improper servicing techniques.

**TRANSISTOR BIASING** In *pnp* transistors, the emitter is connected to a positive supply voltage, usually through a stabilizing resistor (See Fig. 14). In *npn* types, the emitter receives a negative voltage through a resistor. The collector voltage for both types is always opposite in polarity to the emitter voltage, and is usually applied through a load resistor.

The base bias voltage is normally established through a driver network that provides a slight forward bias between the base and emitter. The transistor goes into cutoff as the base voltage approaches the magnitude and polarity of the emitter voltage. Conversely, the transistor is turned on (and conducts heavily) by a voltage opposite to that of the emitter, and draws a sort of idling current even when no signal is applied.

In radio work, it is usually customary to apply the signal between the base and emitter circuits. When limiting resistors are in the base circuit, the signal may be bypassed around them through coupling capacitors to avoid losses that would otherwise be produced by the resistors. The amplified output signal appears at the collector.

**TROUBLESHOOTING THE RECEIVER** A practical understanding of how the transistor works in different circuits, and how it functions under varying conditions of bias will make it relatively easy for a technician to

develop an effective approach to servicing transistor radio circuits.

From Fig. 15 it can be seen that functionally the transistor radio is essentially the same as its tube-type counterpart. However, in practice the transistor circuits are not as easy to define. Therefore, even the most experienced serviceman must rely on the schematic diagram and other service data supplied by the manufacturer once a routine check fails to uncover the cause of malfunction of the receiver. The schematic diagram of a typical transistor receiver is shown in Fig. 16. Let's make a dry run to see how to proceed with troubleshooting.

**PRELIMINARY INSPECTION** Most of the troubles that bedevil the transistor radio result from the radio being dropped or from run-down batteries. And, although there are no tubes to light up, no problem with power supply hum, and no blowing of the house fuse, these radios have been known to develop shorts that drain the life out of the battery. Because batteries are relatively inexpensive, the first thing you should do when you have a transistor radio to repair is to check or change the battery.

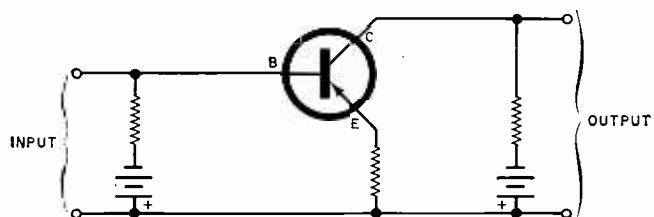


Fig. 14. The emitter of a *pnp* transistor is biased positively with respect to the collector. For *npn*'s, the reverse is true.

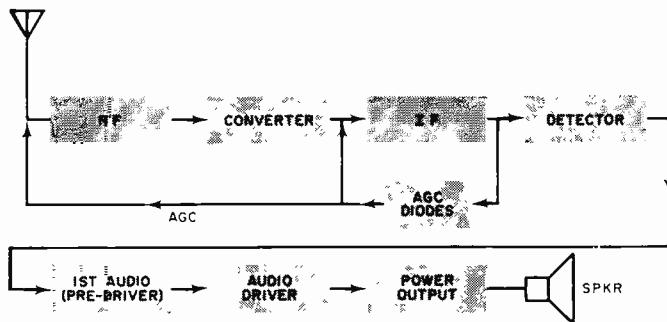


Fig. 15. Functionally, the transistor receiver is no different from its tube-type counterpart, as you can see in the diagram.

There are many instances where batteries become defective in a matter of minutes or hours. Remember that batteries age and depreciate whether you play the radio or not. As a matter of fact, even though they are supposed to be "brand-new" when bought, they may be just "half-new" due to aging on the shelf.

Now let's consider the radio that has been dropped. If it falls into salt water, the best thing to do is to forget it . . . throw it away, for it will never be the same again. If it falls into fresh water, dry it out under a hot lamp, replace the battery, and try it again. If it plays, fine; if it doesn't, you'd better start testing the set, part by part.

Next to the battery, the weakest link in a transistor radio is the etched circuit board, which chips, fractures or breaks when the radio is dropped. If you remove the component board and hold it up against the light, you might be able to see the crack. A good

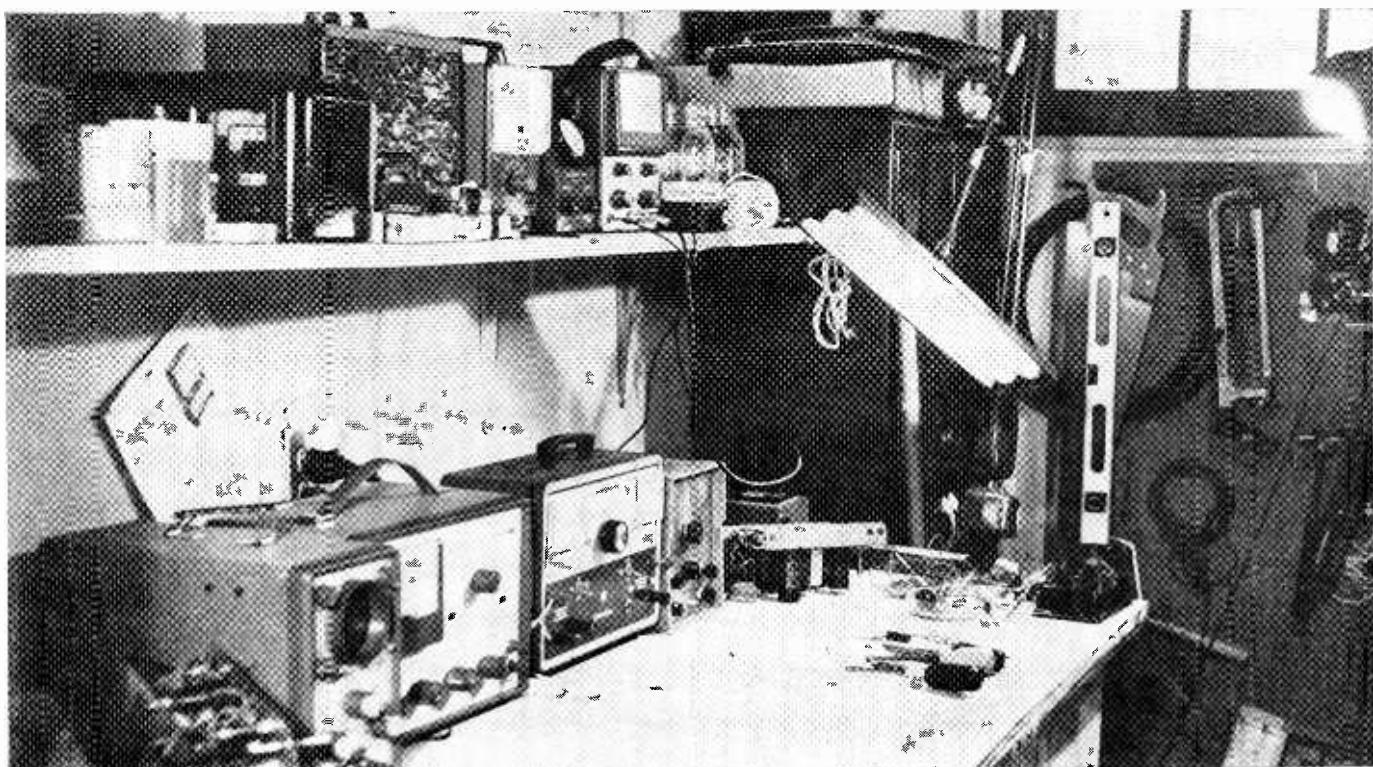
practice is to carefully touch up each connection with a low-wattage soldering iron. But stay away from the transistor terminals. Also, be careful not to allow the solder to run and short out adjacent connections.

If you are about to remove your first component board from its case, you may be frustrated by what appears to be a job of ungluing the component board from the plastic case. Actually, this isn't so . . . it just seems like it. Quite often the antenna, volume control, or even the battery assembly connections are wired right into the case. Try swinging the board clear without removing these components; if the board cannot be removed in this manner, you may have to disconnect the wires first. But be sure to draw a simple sketch showing where each wire goes—before you remove the wires.

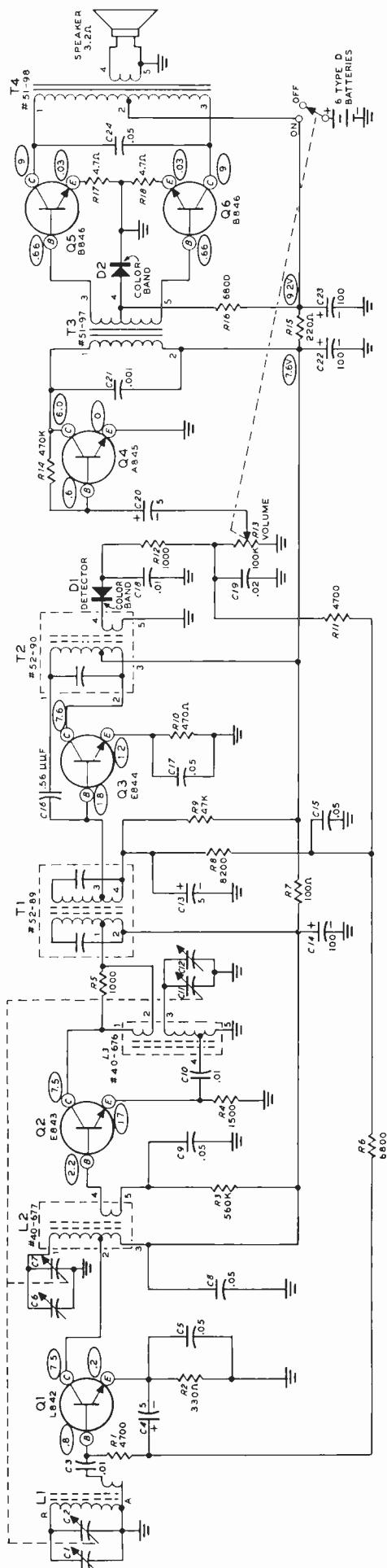
From here on, start testing the circuits or components on the basis of recognizable trouble symptoms.

**STAGE-BY-STAGE TROUBLE ISOLATION** Trouble isolation always begins with the audio stage (see Fig. 17). This stage can be given a quick check by listening for a "click" or a "thump" as the set is turned on. Dead silence—except for the mechanical click of the switch—is an indication that the stage is inoperative. Another method of checking this stage is to look for a voltage drop across the output transistor collector load. A zero indication on the meter denotes an inoperative stage.

Your next step is to check the operation of the i.f., converter, and r.f. stages, in that order. This is best accomplished by measuring the voltage across the

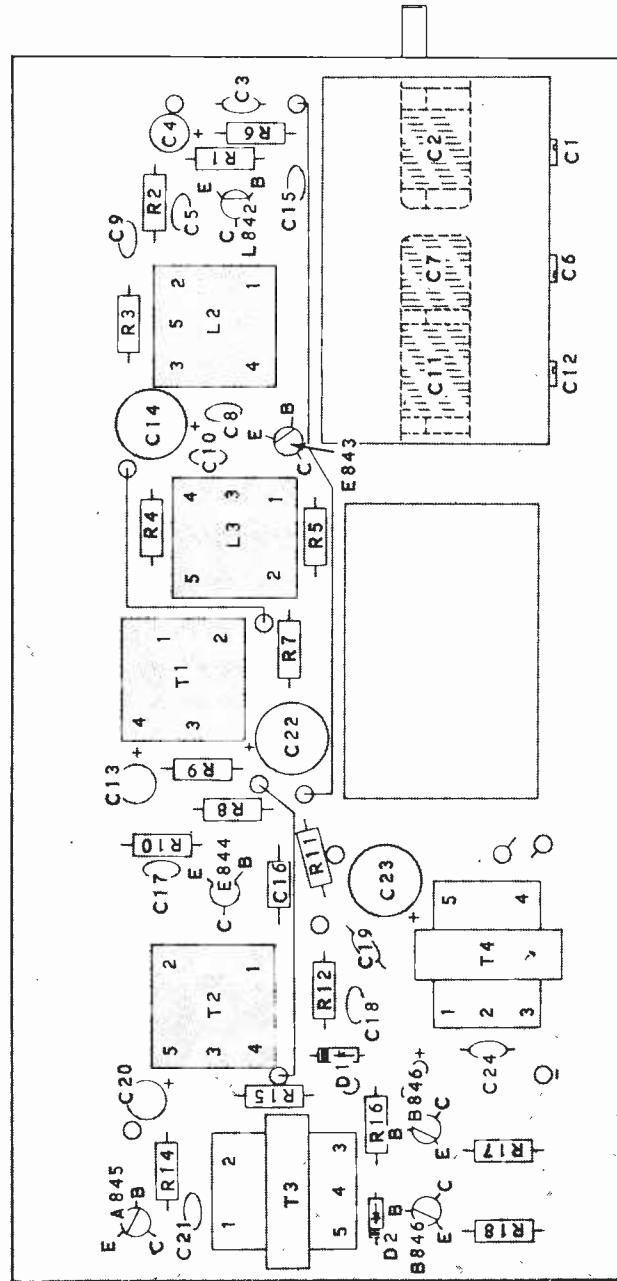


SIMPLE AND UNPRETENTIOUS, this radio repair shop is equipped with all the essential test equipment for the repair and maintenance of both tube-type and transistorized electronic equipment. A wide assortment of tools and an electric drill are included.



**SCHEMATIC OF THE HEATHKIT  
AM PORTABLE RADIO  
MODEL GR-24**

NOTES:  
ALL CAPACITOR VALUES IN  $\mu$ F UNLESS SPECIFIED OTHERWISE.  
ALL RESISTOR VALUES IN OHMS; K=1000.  
ALL RESISTORS ARE 1/2 WATT.  
INDICATES VOLTAGE READINGS.  
VOLTAGES TAKEN WITHIN 11 MECH INPUT VTVM.  
VOLTAGE READINGS ARE OC FROM POINT INDICADED TO CHASSIS GROUND WITH NO SIGNAL.



## CIRCUIT BOARD X-RAY VIEW (VIEWED FROM FOIL SIDE)

Fig. 16. Manufacturers' schematic diagrams usually provide all the servicing information a technician needs to troubleshoot a set. This schematic diagram of the Heathkit Model GR-24 includes operating voltages at various points in the receiver, and a printed circuit board layout shows location of parts and test points.

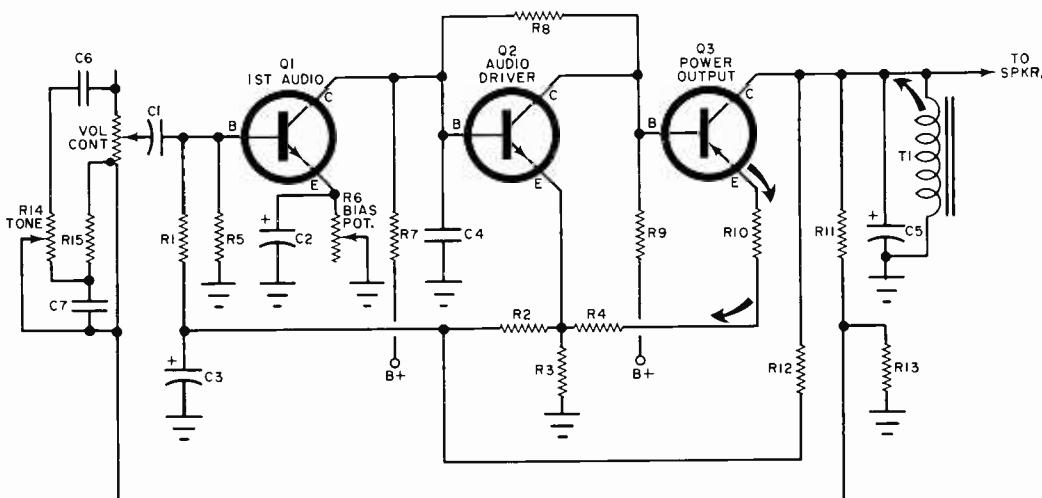


Fig. 17. The audio stage can be checked by listening for a "click" in the speaker as set is turned on, or upon injecting a signal at the volume control.

emitter resistor of the stage under test. If you get an indication, you know that the transistor is conducting. Since current flow in a transistor is controlled by the emitter-to-base forward bias, you cannot assume arbitrarily that you have a defective transistor when there's an indication of poor stage operation.

You can check the forward bias on pnp transistors by connecting the positive voltmeter lead to the emitter, and the negative lead to the base. This allows you to read the bias indication directly on the meter. For npn transistors, reverse the leads. But remember that in converter and oscillator circuits the bias varies with oscillator frequency. The following tabulated data should help you recognize some of the more common conduction and biasing conditions:

Emission	Bias Condition	Probable Fault
Low or non-existent	Good or too high	Open transistor
None	No bias	Defective circuit
Too high	Low or reverse	Leaky transistor

If a transistor appears to be open, you can check it in the circuit as follows: Set your ohmmeter on the Rx100 scale and check each of the two diodes of a transistor as shown in Fig. 18. To check the collector

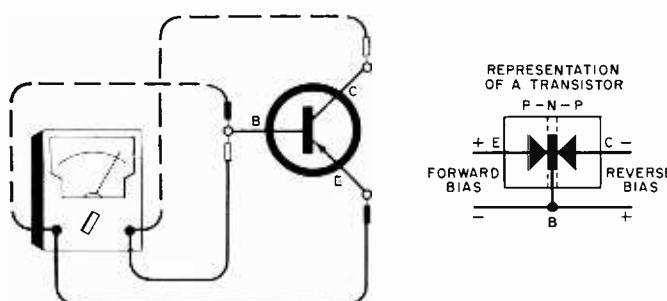


Fig. 18. If a transistor checker is not available, an ohmmeter can be used to provide a quick check of diode elements.

diode, connect the leads to the base and collector and note reading. Reverse leads and note second reading.

The lowest reading should be under 500 ohms for germanium transistors and under 1000 ohms for silicon transistors. The high reading should be at least twice the low reading. Perform the same test on the emitter diode to completely check the transistor.

Make these checks with power removed from the radio. Note that the detector diode and a.g.c. diodes can be checked in the same manner.

You can also use a good transistor checker to measure emission and other operating parameters. These instruments are operated in pretty much the same way as tube checkers, and their reliability is about the same. Remember that some transistors come plugged into a socket like a vacuum tube, and thus can be removed easily. Others are wired in the circuit like any other component and must be cut out or unsoldered. If the leads are long enough to permit easy reconnection, it is better to cut the leads than to apply excessive heat—which could render the transistor useless. If it becomes necessary to unsolder the leads, hold the leads with a pair of pliers while unsoldering to take some of the heat away from the transistor. Do the same when soldering any transistor or diode. The basing diagram of some common transistor types is illustrated in Fig. 19.

**TROUBLESHOOTING THE POWER SUPPLY** Electrically, the commonest source of trouble is the power supply (Fig. 20). The power supply circuit consists of the battery, one or two tiny filter capacitors, and a resistor or two. The filters sometimes go bad, thereby producing motorboating or whistling instead of audio. You can generally recognize the filter capacitors by the polarity marks (+ and -) which they bear. They

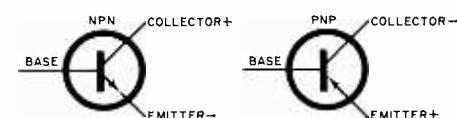
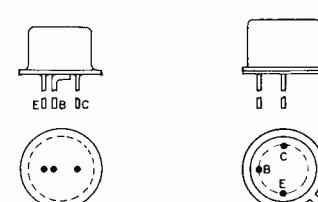


Fig. 19. Basing diagrams of some common npn and pnp transistor types.



will usually have capacities on the order of about 100  $\mu$ F at from 6 to 25 WVDC.

The best way to test the power supply filter capacitor is, of course, to put a substitute in its place after first disconnecting one lead of the capacitor from the circuit. Caution: Short the leads of the test capacitor together to discharge it before putting it in the circuit.

**SIGNAL INJECTION** This type of trouble isolation technique can be used very effectively to localize an inoperative stage in a receiver, as explained in the paragraphs dealing with the troubleshooting of tube-type receivers. As you have probably guessed, you begin by injecting the signal into the audio circuit; the volume control center tap is a good place to start. Then work towards the receiver front-end by going next to the last i.f. amplifier, the first i.f. amplifier, and so on.

Remember one thing: you must keep the signal generator output as low as possible to avoid damaging the transistors and also to keep the receiver a.g.c. from functioning. Naturally, you'll signal-inject at the base of the transistor. Once you have localized the trouble to a particular stage, your best bet is to start checking each component in the stage. To save time, start by testing the transistors.

**MEASURING RESISTANCE** When it comes to making ohmmeter measurements in transistor circuits, you not only have to be careful about damaging the transistor with reverse current, but you also have to be

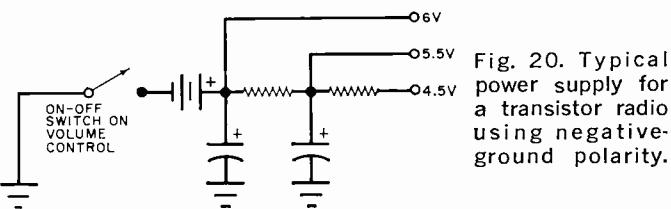
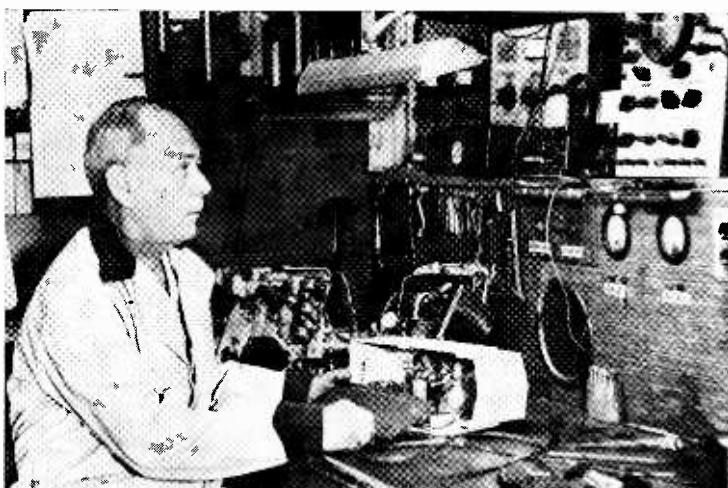


Fig. 20. Typical power supply for a transistor radio using negative-ground polarity.

careful about the accuracy of the readings you get. For example, if the resistance of an audio transformer primary is measured twice, with the meter leads reversed, you will note a considerable difference between the two readings. As shown in Fig. 21, the low reading of 160 ohms is in error since the winding resistance is 200 ohms. The low reading is obtained because of a parallel path through the base-collector diode. When the meter leads are reversed, the base-collector diode is reverse-biased, resulting in the 200-ohm reading. When making resistance checks in any transistor circuit, the ohmmeter leads should always be reversed and the highest reading taken as the value of the component.

## TACKLING THE FM RECEIVER

The general approach to servicing FM receivers is essentially the same as that used for servicing AM receivers. You usually start out by checking the tubes,



MORE THAN 36 YEARS at the same location in a New York City suburb, this old-timer, Adolf J. Wild, still talks about the good old days of the Atwater Kent. He is shown observing response curve of one of the newer AM/FM radios on a scope.

the power supply, and finally the audio, i.f., and r.f. circuits. Remember, don't start ripping things apart when the set fails completely or develops trouble symptoms. Remove the chassis from its cabinet and carefully inspect it for burned parts or other defects that can be easily spotted. After that, probe around in each stage, shorting out the tube grid to ground as you move along. A loud click at the speaker is usually an indication that stages from that point backward in the circuit are in working order. After that you can try a little signal tracing.

You will generally find an r.f. stage before the mixer and FM detector. And, as you already know, the FM frequency range is much higher (88-108 MHz). It is important not to disturb the position or shape of any components in the r.f. circuit. Don't bend, or even re-route, any of the leads in the front-end of an FM receiver.

Since purchasers of FM receivers also want to listen to AM stations, many FM receivers are designed to work on AM as well. The block diagram of a typical AM-FM combination receiver is shown in Fig. 22. The general lineup of stages in such a combination set is, first, an r.f. amplifier for FM alone; then separate converters, one for AM and one for FM; then, one or two

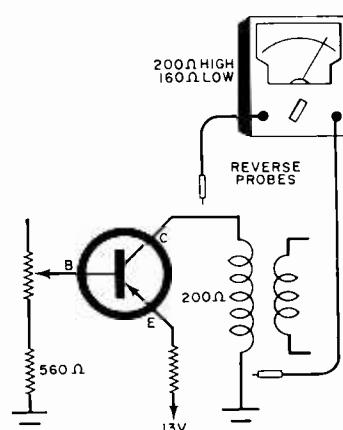


Fig. 21. When making resistance measurements in transistor circuits, always reverse the ohmmeter leads and use the higher of the two readings.

i.f. stages which are sometimes common to both AM and FM; next, separate detectors for the two i.f. signals (455 kHz for AM and 10.7 MHz for FM); and finally a common audio amplifier for both signals.

Generally, the AM-FM combination is not particularly difficult to service. For example, if both the AM and FM sections are inoperable, you would immediately suspect the power supply or the audio amplifier, since these circuits are common to both AM and FM reception. If you can pick up AM stations but cannot hear a thing on FM, you would begin checking the FM r.f. amplifier, mixer, i.f., and detector. If the shoe is on the other foot and you have FM but no AM, you would simply start checking the AM circuits as you did the FM circuits.

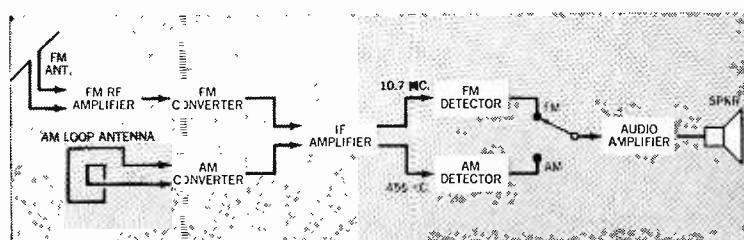


Fig. 22. In this AM/FM combination receiver, the i.f.'s of both the AM and FM portions of the set are brought into the same i.f. amplifier tubes. The 455-kHz and the 10.7-MHz i.f. signals are then demodulated by the respective detector circuits.

Whatever you do, don't attempt to service the receiver blindfolded. You should get a schematic diagram for the set and use it as a guide for servicing. If you don't have the schematic, you may not know, for example, whether the circuit uses the AM converter tube as an FM oscillator.

**WATCH OUT FOR DRIFTS** You tune in to your favorite FM station, flip on the a.f.c. (automatic frequency control) switch, and sit back to enjoy the music. Two minutes later the music becomes garbled and the set sounds a little detuned. You retune it and sit back. The cycle repeats itself over and over and over, until you decide to sit closer to the set so you won't have to be getting up every minute. Old man, your receiver is drifting and must be fixed.

FM drift can usually be traced to a defect in the os-



THIS PHOTOGRAPH was not taken in a factory warehouse, but in the back room of a successful radio service shop.

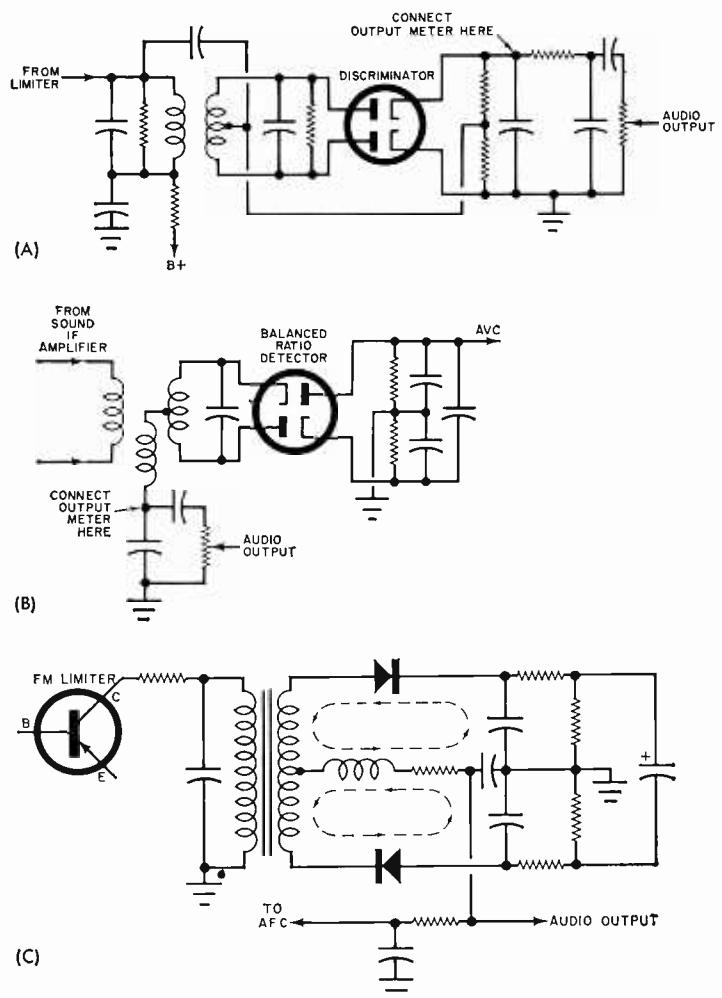


Fig. 23. The FM discriminator shown in (A) above has generally been replaced by the balanced ratio detectors in (B) and (C).

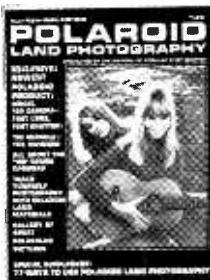
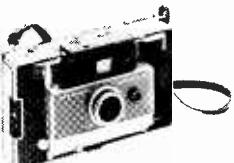
cillator or a.f.c. circuit. Fortunately, in the majority of cases the oscillator tube turns out to be the culprit. It is therefore always a good practice to change this tube first whenever this trouble appears. There would be no point in testing the tube since it would no doubt show up as "good" on a tube tester. You must change the tube for a good one.

If it turns out that the tube is good, get the schematic and start checking the frequency-controlling capacitors in the oscillator circuit. Here, again, your best bet is to substitute new capacitors. When you replace these capacitors, be sure to install units with negative temperature coefficients. If you've been unsuccessful thus far, turn to the a.f.c. circuit. You can give this circuit a quick check as follows:

(1) With the a.f.c. switch in the "off" position, tune in a station as best you can. (If there is no separate a.f.c. switch, tune in just the same.)

(2) Flip the a.f.c. switch to "on" and attempt to detune the set by shifting the tuning dial. If the a.f.c. is operating properly, you will be able to tune over a considerable range (up to a couple of MHz's) before being able to lose the station. If tuning is critical, as is evidenced by sharp tuning of the set, the a.f.c. circuit becomes the prime suspect.

**if you  
snap  
with  
this...**



**it's a  
snap  
with  
this!**

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**FM ALIGNMENT** Before you start tampering with the alignment of your FM receiver, you are advised to lay off unless you are an old pro at the game or unless you are absolutely sure the receiver is out of alignment. Above all, don't try to align the receiver to correct drift; this won't cure it. Another thing: while you can generally touch up the receiver front-end by ear, don't monkey around with the i.f. transformers unless you have a good signal generator and an output meter (VOM or VTVM).

There are two general types of discriminators in present-day FM sets. The first is the *discriminator*, found mostly in older FM sets. The other is the *ratio detector* (see Fig. 23). On the surface, the schematics of the discriminator and the ratio detector seem to be alike in that both circuits use duo-diodes in similar configurations. Although there are minor differences in these circuits, both have the same basic alignment requirements: (1) the primary of the detector transformer must be tuned for maximum output; and (2) the secondary of the detector transformer must be tuned for exactly zero output. Both circuits are aligned in the following manner:

Connect a d.c. voltmeter to the audio takeoff point of the detector. To prevent the meter from detuning the detector circuit, use an isolating resistor (between 500,000 ohms and 1 megohm) in series with the meter. Use the largest resistor that will still show a usable deflection on the meter.

Apply an unmodulated 10.7-MHz signal to the grid of the last i.f. amplifier tube and tune the detector transformer primary for maximum deflection. Then tune the secondary

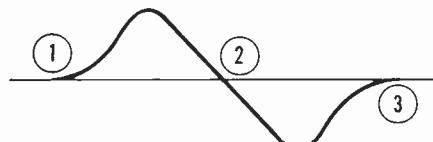


Fig. 24. The output characteristics of an FM detector circuit can be represented by an "S" curve. During alignment, the secondary of the detector transformer must be nulled at point 2 only. Nulling at points 1 or 3 would result in improper alignment of the detector.

for exactly zero voltage. Because of interaction between these two adjustments, you should repeat the adjustments a couple of times.

To make sure that the secondary is tuned to point 2, instead of points 1 or 3, in Fig. 24, check the tuning by turning the secondary adjustment slug first in one direction and then the other. In one direction the d.c. voltage will rise sharply to a positive peak, while in the other direction the voltage will rise to a negative peak. After you have checked the tuning in this manner, peak the primary again for maximum deflection, and retune the secondary for exactly zero volt output. The detector alignment is now complete.

## SERVICING HINTS

It is just as important for you to know how to use a piece of test equipment as it is for you to have the right equipment. For if the equipment is not used properly, it will be of little value as an effective servicing tool. For example, when you are using the signal generator for alignment, the signal should be attenuated to the lowest level that will still provide a readable indication on an output meter, or an audible tone through the receiver loudspeaker.

And when you're troubleshooting transistor radios, check the battery voltage and the current drain before you do anything else. If the trouble doesn't show up by then, inspect the set for a possible broken circuit board, a loose or broken connection, or other physical indications of failure. If you're still looking down a blind alley, try signal tracing or signal injection. If this doesn't do it . . . throw the radio out!

When you find a faulty component, always try to replace it with one similar to the manufacturer's original part. And be sure to observe power ratings. Above all, never underrate a replacement part.

If you follow the guidelines provided in this chapter, there's nothing to prevent you from repairing radios for pleasure or profit.

# **CHAPTER 4**

## **INSTALLATION AND MAINTENANCE OF TV/FM ANTENNAS**

**By JAMES G. LEE**

### **ANTENNA TYPES AND ACCESSORIES**

Antenna Characteristics  
VHF Antennas  
UHF Antennas  
FM Antennas  
Transmission Antennas  
Antenna Rotators

### **ANTENNA INSTALLATIONS**

Mounting Considerations  
Antenna Assembly  
Antenna Orientation

### **ANTENNA SERVICING**

**O**ne look around any residential neighborhood will convince the viewer that there is an inexhaustible variety of TV and FM antennas. There will probably never be a concrete answer as to which antenna is best—not because there is no such thing as a good antenna—but because each antenna installation situation is different from all others. In the case of TV, some receivers with less sensitive front-ends must use bigger and better antennas than a TV installation next door that has a Nuvistor r.f. stage. Color TV has introduced a whole new set of problems, requiring better bandwidth characteristics, correct impedance matching, noise suppression, etc.

The installer of a TV or FM antenna need concern himself with only one or two facts regarding the propagation of radio waves. Radio waves can reach a given point by any number of separate paths—each of which will be somewhat different in overall length. Radio waves can be bounced off buildings, or land masses, and arrive at a given point completely reversed in "phase." Ghosts in black-and-white TV reception and slurred colors in color TV reception are both the result of TV signals getting to your antenna by different paths.

Phase is simply a measure of time displacement. For the best possible reception, the entire frequency spectrum of a TV signal should arrive at your receiver at one time. If the receiver is not tuned properly, the composite signal of a color TV transmission will suffer. Since a TV antenna is really a "tuned circuit," the antenna itself must have the proper response, or bandwidth, and be tuned to the frequency of the TV signal.

The illustrations on the next page show the way ghosts are created. In Fig. 1 the receiving antenna is illuminated by three different signals—one directly from the transmitter, one reflected from the small building and the last one reflected from the larger building. The two reflected signals take longer paths to reach the receiver and result in the creation of two ghosts. These ghosts are negative ghosts since they have undergone a single polarity reversal. Ghosts that bounce twice to get to the receiver (see Fig. 2) are positive ghosts. In urban areas, where ghosts are troublesome, they are a combination of the two polarities and appear with about equal regularity.

### **ANTENNA TYPES AND ACCESSORIES**

The TV antenna installer should appreciate that the physical size of the antenna is an important consideration. Technically, this is referred to as the "wavelength factor"—the relationship between the size of the antenna and the current flow, or voltage, that can be induced in it by the TV signal. Generally speaking, the bigger the antenna (physical size is determined by the resonant fre-

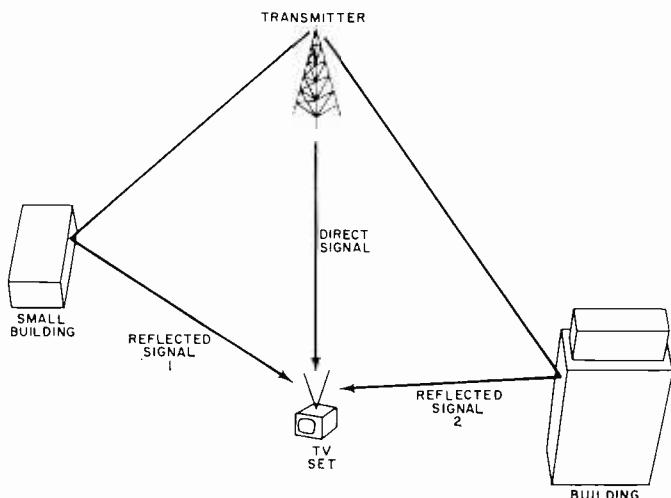


Fig. 1. In metropolitan areas where tall buildings act as reflectors, the TV signal can arrive at the receiving antenna over several different paths. The direct signal is usually the strongest and this signal activates the receiver circuit. Reflected signals arrive at the antenna "later" than the direct signal and are displayed in the TV picture as ghosts.

quency), the greater the voltage induced; or, stated another way, the lower the TV signal frequency, the larger—and less elaborate—the antenna.

For low-VHF-band TV and FM, a relatively simple antenna will often be sufficient. For high VHF band or UHF TV, you must have a more elaborate antenna so that the effective intercept area, or "aperture," is large enough to give good signal pickup.

**ANTENNA CHARACTERISTICS** Three characteristics that typify any antenna are (1) gain, (2) directivity, and (3) bandwidth. Gain is not the same "gain" used when talking about tubes or transistors. Antenna gain is a focusing effect similar to that of a flashlight reflector. A simple dipole will show about 2 db gain over the standard "isotropic" or point-source antenna.

Directivity is related to gain in that the focusing effect causes less response in other than the favored direction. Like the flashlight, the antenna must be pointed in the desired direction for maximum signal pickup. This has advantages since it can materially reduce adjacent channel or co-channel TV interference.

Adjacent channel interference is best reduced by proper orientation of the antenna to put the interfering station in a "null" in the directivity pattern of the antenna. Co-channel interference results when two stations are on the same channel even though they are located a hundred miles apart. A viewer in between the two stations would receive about equal signals if he used only a simple nondirectional antenna.

Bandwidth is the characteristic of an antenna that allows it to respond about equally to all signals in a given frequency range—say the low VHF TV band. If only one or two channels are operating in the viewer's area, then a relatively simple antenna with a narrow bandwidth will be satisfactory. Antennas cut for Channel 4 will usually respond to signals from Channels 2 through 5. If there is a station in the high VHF

band (Channels 7 through 13), the low-band antenna will probably not have sufficient bandwidth to permit good reception on the high band.

**VHF ANTENNAS** Every antenna installation requires a careful survey of the TV receiver placement to determine the physical problems of antenna erection and feed-line routing. Also, you'll need to make a decision on exactly what size (or gain) antenna will be required. In the metropolitan areas (and to 20-25 miles away), the average TV signal strength is high enough for a modest antenna installation. Ghosts may be a problem, but antenna orientation—not gain—is the solution to that problem.

**Dipoles** The simplest antenna for the high signal strength area is the resonant half-wave dipole. For VHF TV, you should have one dipole for the low band cut to about Channel 4 and a second cut to Channel 10 for the high band. The two dipoles should be mounted separately—the high band dipole about 3 feet above the low band dipole—to allow for individual antenna orientation. The dipoles should be coupled via a combination filter so that only one feed line is required.

If you need a little more gain, you can stack a second dipole for each band over the original dipole. The distance between the stacked elements should be roughly half their length. To connect the feed line, make a regular connection to the bottom dipole in each case, then connect the upper dipole to its mate by a length of feed line which has been given a twist so that the feed line is transposed.

For better bandwidth, the "folded" dipole is used. This is simply two dipoles spaced about 3" apart with their ends joined. The upper portion is not split at the center—only the bottom one—for attaching the

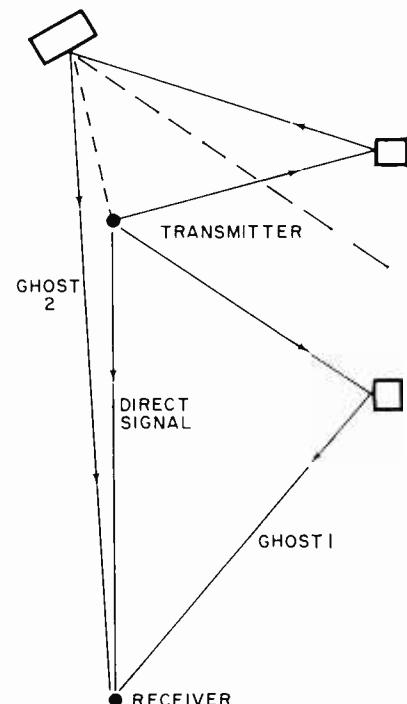


Fig. 2. The generation of negative ghosts is explained in the text on the preceding page. Note numerous reflections and development of polarity reversal.

feed line. A variation of the dipole is the fan or "bowtie"; this antenna looks like a squashed "X" and may be mounted singly or stacked.

The radiation pattern of a simple dipole is like a figure-8. It responds well to signals coming from the back as well as the front. There is very little signal response off the ends. Dipole gain can be increased by the addition of elements called reflectors and directors. They are known as "parasitic" elements. The reflector is cut about 5% longer than the dipole and placed behind it, while the director is about 5% shorter and is placed in front of the dipole opposite from the reflector.

When a reflector is used with a dipole, the signal strikes both dipole and reflector and the reflector re-radiates a small portion of the signal back to the dipole in proper phase to reinforce the signal at the dipole. When a signal strikes the reflector first, the signal seen by the dipole is cancelled by the phase of the re-radiated signal. Thus, the reflector essentially eliminates the "back-lobe" of the figure-8 pattern.

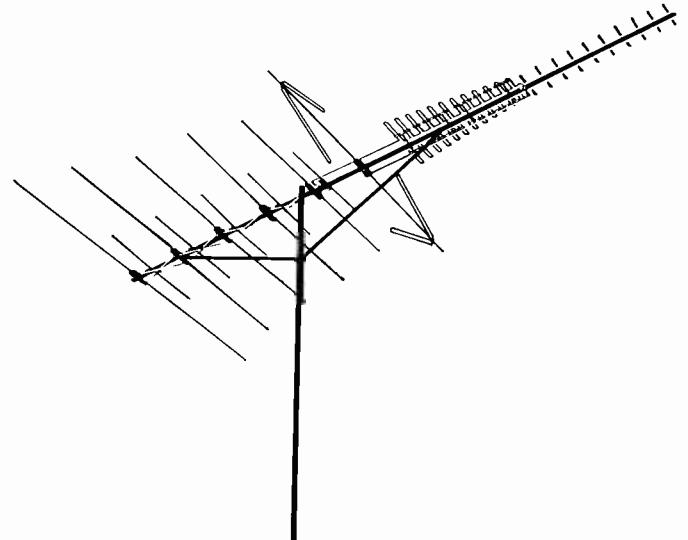
The action of the director is the same as the reflector, and adding either a reflector or a director effectively increases the gain of the antenna by about 4 times. Adding both a reflector and a director gives about a 6-fold gain to the dipole. Normally the gain is further increased by adding directors only, and as each one is added, the directivity of the antenna becomes sharper and sharper. These antennas can be stacked for additional gain.

**MULTI-ELEMENT ARRAYS** For TV signals which must be received in the medium signal area—25 to 50 miles distant from the station—the multi-element antenna with directors and reflectors is necessary for good results. For fringe areas—greater than 50 miles distant—the multi-multi-element antenna is used. This is the same type array as the simple 3- or 4-element antenna described above, but with many more directors. The boom length can approach 8 or 10 feet on these arrays, and it requires sturdy construction.

Though it might seem that you can keep on adding directors and keep on increasing gain, there is a practical limitation. Doubling the number of directors doubles the gain, so once you are past 5 or 6 directors, the number required becomes quite large and the mechanical considerations for support and strength increase accordingly. It is easier to stack two smaller arrays to double the gain. This keeps mounting problems to a minimum while still providing the doubled number of elements.

One important advantage of stacking antennas is the focusing effect of the vertical response of the antennas. Adding elements such as directors focuses the horizontal response, but leaves a broad vertical response. Stacking effectively focuses the vertical response to concentrate the gain exactly at the horizon. You should always consider stacking when you need better TV reception.

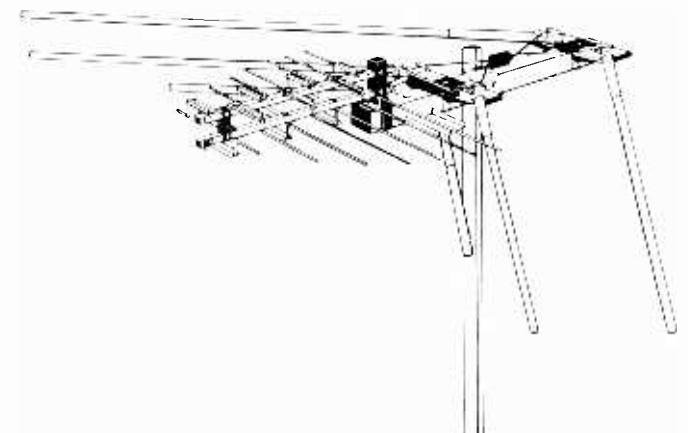
The bandwidth over which a multi-multi antenna



**CHANNEL MASTER 3634G** This is a modern antenna combining all the necessary ingredients for VHF and UHF TV reception. The rear section is a design based on the manufacturer's "Crossfire" with 11 active elements. While the rear section resonates in the VHF spectrum, the forward section is a copy of the manufacturer's "Ultradyne" and is tuned to the UHF TV channels. The 3634G is ideal for suburban areas.

maintains a relatively constant gain is still limited to a few percent of its center frequency. As you tune farther away, the gain lessens and the directivity is reduced. Recently there has been a type of antenna developed which maintains good gain over a very wide bandwidth. It is the log-periodic array, and is a multi-element array whose dimensions are determined by relatively precise mathematic formulas. The elements of a log-periodic array appear to have a constant, increasing taper from front to rear and the element halves are offset—one slightly higher than the other—instead of being inline. This antenna has such wide bandwidth characteristics that one antenna can do a good job for VHF and UHF TV as well as FM reception.

**UHF ANTENNAS** The same general problems which apply to VHF antennas also apply to UHF. The physi-



**FINNEY UVF-10** In viewing areas not too distant from the transmitter, this antenna captures VHF and UHF TV, plus having a good response in the FM stereo band. Both of the antennas on this page resulted from the development of UHF TV and the simultaneous surge in color TV. Both are easy to install.

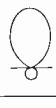
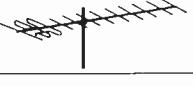
cal size of the UHF antenna is considerably smaller, but due to the wavelength factor, only the higher gain UHF antennas give satisfactory signal reception unless the UHF TV station is close by. Rapid strides are being made in the development of low noise tubes and transistors to lessen the responsibility of the antenna to provide high signal strengths. But rural areas that are dependent solely on distant UHF signals for reception still need the best antenna system that is available.

The simplest UHF antenna for the high signal

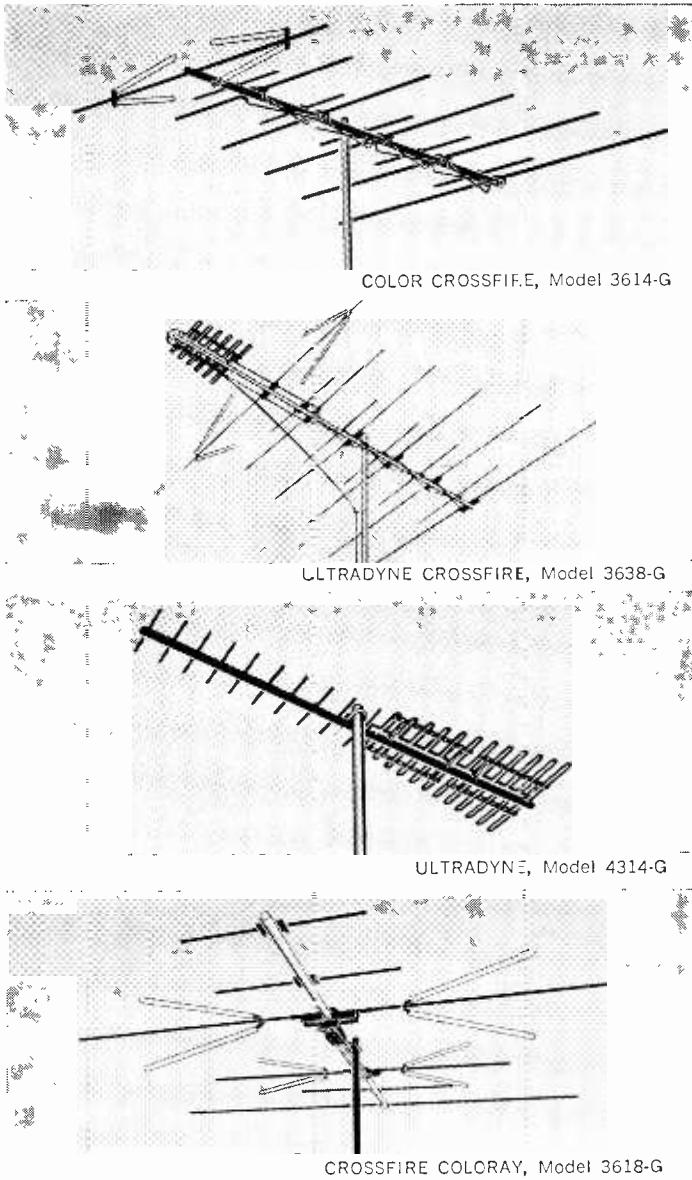
strength area is the bowtie. It is usually made of solid sheet metal and frequently it is backed up with a perforated, rectangular reflector plane. The rectangular plane is necessary for efficient, broadband operation. Often the reflector will be bent in the shape of a right angle and is called a "corner" reflector.

The log-periodic is a good UHF antenna. The log-periodic gives excellent broadband gain and will outperform the simple bowtie with reflector. For single station reception, the multi-multi element antenna (cut to frequency) is quite small and will give good

## UHF ANTENNA CHARACTERISTICS

ANTENNA TYPE	APPEARANCE	TYPICAL LOBE	GAIN OVER ISOTROPIC (AVERAGE DB)	FRONT-TO-BACK RATIO (AVERAGE DB)	COMMENTS
Dipole (half-wavelength)			2.14	0	Good for narrow frequency coverage. No front-to-back ratio. No rejection for back path reflections.
Dipole with Screen Reflector			6.24	under 20	Good for narrow frequency coverage. Improved front-to-back ratio.
Single Bow-Tie with Screen Reflector			6.24	under 20	Slightly greater frequency range than dipole with screen.
Two Bow-Ties, Stacked, with Screen Reflector			9	under 20	Better gain than single bow-tie.
Corner Reflector			11	20	Limited frequency range.
Periodic			10-11	over 25	Uniform gain and VSWR over the entire UHF range. Very good front-to-back ratio.
Two Periodics, Stacked			13-14	over 25	Same as single periodic antenna, but there is a 3 db increase in gain.
Log Periodic (3/2 wavelength elements)			10-15	over 20	Good uniform gain and VSWR over the entire UHF range.
Yagi			7-17	over 20	High gain. Narrow frequency range.
Bow-Tie Arrays			10-17	20	High gain. Limited to narrow frequency coverage.
Parabolic Dish Reflector Dipole			16-21	over 20	High gain. Narrow frequency coverage. Very narrow beam. Installation is critical.
Parabolic Dish Reflector Broad-band Antenna			16-21	over 20	High gain. Broad frequency coverage. Very narrow beam. Installation is critical.

*NOTE: The figures given above are average values. Antennas of the same type made by different manufacturers often have a different set of readings.*



# The Winners!

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**COLOR CROSSFIRE SERIES** Seven models for VHF/FM/FM Stereo from near suburban to deepest fringe areas.

**ULTRADYNE CROSSFIRE SERIES** Revolutionary 82-channel plus FM and FM Stereo antennas. Six models for suburban to near fringe reception.

**ULTRADYNE SERIES** Unique no-coupler-required design in three UHF only models for metropolitan to near fringe areas.

**COLORAY SERIES** Amazing electronic ghost-killers in two VHF/FM/FM Stereo models and one 82-channel plus FM/FM Stereo model.

**CHANNEL MASTER**

Ellenville,  
New York

ment is encountered. Coax cable is also finding considerable use in antenna installations for color TV. Because color TV is extremely sensitive to mismatching, coupling effects to nearby metal objects, etc., a coax cable is used to avoid these headaches. This coax cable is especially manufactured for color TV and has a 75-ohm impedance. Very few color TV receivers have 75-ohm input connections and a 300/75-ohm balun must be used between the cable and receiver. On the other hand, many of the elaborate 1966 TV antennas have provisions for either 75-ohm or 300-ohm feed-line connections.

Shielded 300-ohm twin lead is available for color TV installations where the signal loss from 75-ohm coax might be prohibitive. Some 300-ohm twin lead is sold with a heavy-duty covering for protection from salt water corrosion. Salt spray will devastate copper wire in short order, and only maximum protection through shielding plus complete sealing of any open ends will give trouble-free operation. Coaxial cable and shielded 300-ohm twin lead are more expensive for initial installations, but when used properly, they'll outlast flat twin lead by several years.

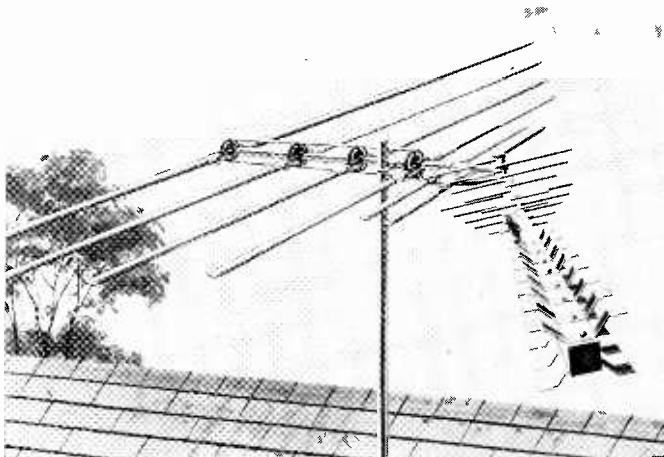
Where feasible, twin lead should be twisted as it is run down the mast between standoffs and over to the point of entry into the house. This will help cancel out unwanted signals and noise induced in the feed line. The lead should be spaced about 4" from the mast and roof to prevent the metal mast and any collected water on the roof from affecting the quality of the signal.

For the same reason, feed lines should never be run near electrical wiring. You may staple twin lead to wooden framing but make sure that the staples are inserted in the center of the feed line and parallel to the conductors. Never staple across the twin lead. Keep the staples as far apart as possible and the number to a minimum.

Open-wire line should never be used inside of houses or apartments since it must be spaced away from all objects by at least the width of the two conductors, and no metal should be allowed between the conductors. Coax, on the other hand may be clamped, stapled, twisted around nails, run near metal objects—and even buried—with no ill effects unless the cable is squeezed too tightly. Coaxial cable will "cold flow" under pressure and the inner insulator will slowly give way and cause the spacing to change between the inner and outer conductors.

Matching impedances is important for maximum signal transfer. Mismatching will cause some of the signal energy to be reflected back up to the antenna, and when it hits a mismatched antenna, it will be sent back again to the receiver slightly out of phase—thus causing a ghost. Ghosts that are not removable by antenna orientation are due to poor impedance matching.

**ANTENNA ROTATORS** Ten years ago, antenna rotators were used by city dwellers to try and eliminate



**JERROLD** This antenna bears the trademark "Coloraxial Pathfinder PXB-50." The rear section is rigidly mounted to the supporting pole, but the front section can be turned to face a UHF TV transmitter. Use either 75- or 300-ohm output.

ghosts and by TV viewers in the deep fringe areas. The move to the "suburbs" has introduced a new market for rotators—the viewer who wants to catch a program that has been blacked-out in his local area. Thus, rotators are becoming more and more common, and you should be familiar with the installation and servicing of the various kinds available.

The rotator is a geared low-voltage a.c. motor with clamps for attachment to the mast and antenna. An indicator box located near the receiver supplies the necessary power to the mast-mounted rotator through a four-conductor cable. Some indicators have illuminated scales which show you where the antenna is pointed, and you must depress a bar or lever until the antenna is properly aimed. Others have a knob which can be set to a particular direction. The rotator automatically turns to that position and shuts itself off.

There is a weight limitation with any rotator—not so much a matter of sheer poundage, but because of wind resistance twisting the antenna and mast. This twisting is transmitted to the gears and bearing in the motor. Some of the gears are made of fiber or soft metal and prolonged torque on them can cause failure. If the antenna you install exceeds the weight limit for the rotator, get a thrust bearing and install it below the rotator to support the weight of the an-



**CHANNEL MASTER** This "Coloray" antenna is a simple VHF antenna for the city dweller. Because of the phasing arrangement of the elements, the antenna can be used to null ghosts.

tenna. Heavy-duty rotators are designed to take the twisting torque of even the largest TV antenna arrays without difficulty.

FM stereo has given antenna rotators an additional reason to be used. Because the stereo effect is dependent on the phase relationship of the subcarrier, and because most FM stations are not in the same direction from the listener, the rotator is the only means of keeping the antenna pointed in the optimum direction for each individual stereo broadcaster.

## ANTENNA INSTALLATIONS

The best antenna will not perform as expected if it is not properly installed. Optimum results are achieved with most antennas if they are at least five feet above surrounding electric power wires, telephone lines, or other nearby TV antennas. Just having a clear shot off to one side is not enough. If the nearest TV antenna is over 50 feet away from the one you are installing, you need not go above it. Never place an antenna so that it looks directly into power or telephone lines.

**MOUNTING CONSIDERATIONS** The type of support you use is dependent on the array to be supported, the mounting position, and the height required. There are many types of masts such as telescoping, constant cross-section 5' and 10' lengths which fit together with swaged ends, and three-sided towers for both roof-top and ground mounting. The most important point is that the mount must be mechanically sound, well-constructed, and heavily plated for corrosion resistance. Tubing masts should be made of heavy-gauge, seamless aluminum or steel.

Often overlooked is the base mounting for these masts. The tower which sits on the ground should have a good concrete base and generally the manufacturer will supply instructions for the type he recommends. Roof-mount bases should be well constructed since all of the weight plus any additional force exerted by the guy wires under stress is transmitted to the base.

Before you make a "fair-size" antenna installation, be sure you understand and comply with any existing city and fire ordinances. Poorly installed, weakly guyed installations will topple over in a short time particularly under heavy wind or ice loading. Falling towers and TV antennas can cause damage to property, power and telephone lines, and possibly personal injuries. The ordinance may cover the minimum requirements for roof-top base mounts, guy wire type, number and position of guy wires, plus inspection after installation.

Make sure the property owner has given his permission for the antenna installation. This is no problem if you are the owner, but if the property is rented or is an apartment house you will need such permission. When you are sure you are on safe ground,

one-channel performance. Another common UHF antenna is the dipole with parabolic "dish" reflector. This antenna has a circular, concave reflector, and is generally made from perforated or strip metal to reduce wind resistance. It has high directivity and gain.

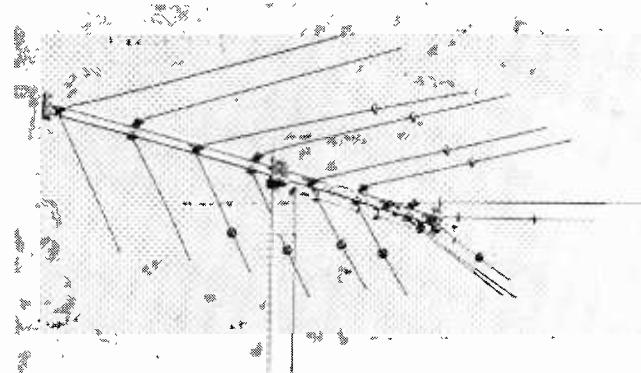
Boosters are commonly used to insure good fringe area reception. These are tube or transistor r.f. amplifiers which mount at, or near, the antenna proper. The feed line attaches to the booster and also supplies the necessary voltage—through suitable filtering—to power the booster. Old-style boosters used at the TV receiver did not overcome the basic problem, which is loss in the feed line of the desired signal.

**FM ANTENNAS** Before stereo became popular, a simple dipole—five or ten feet above the roof—was quite satisfactory for FM reception. One later innovation was a pair of crossed dipoles often called the "turnstile" antenna. This antenna has the advantage of requiring no particular orientation since it has an almost circular response pattern. It does have a loss when compared to a single dipole in its favored direction because the energy is split between the two crossed dipoles. In the city, where signal strength is high, it is a quite satisfactory antenna.

When stereo arrived, the simpler antennas did not always give good performance. The requirement for proper phase information from the radio signal became almost as important as in color TV. As a result, many people put in "splitters" so they could use their low-VHF-band TV antennas. Today, many of the more exotic TV antennas not only cover VHF and UHF TV channels but also do a good job on FM. The big disadvantage of using a TV antenna for FM is its fixed orientation. Generally FM stations are more geographically spread out and the high directivity of the TV antenna limits its performance.

Some FM receivers are designed for a 75-ohm input impedance in contrast to the 300-ohm input impedance of most TV receivers. This means that, in some instances, when you use a TV antenna for FM reception, you'll need to put a matching transformer at the FM receiver to step the impedance down from the 300-ohm twin lead feed line to 75 ohms. These special matching transformers are called "baluns"—an acronym for "balanced-to-unbalanced" transformer.

**TRANSMISSION LINES** Transmission lines, or feed lines, are the all-important link between the antenna and the TV or FM receiver. The three most common types of feed lines are (1) open-wire, (2) molded plastic lines such as twin lead, and (3) coaxial cable. All feed lines cause loss of signal to some extent that is directly proportional to the feed-line length and frequency. Open-wire line has the least loss, coax the most, and twin lead is somewhere between the two but closer to open-wire lines in loss than to coax. A 100' run of coaxial cable can reduce a 300-microvolt TV signal on Channel 83 to about 10 microvolts.



JFD The small nodules on the elements of this VHF TV antenna are capacitor loads. This design has been labeled log-periodic because of the very broad resonant characteristics.

Open-wire line will deliver about 275 microvolts over the same length.

For VHF TV and FM, all feed lines are quite satisfactory if the run does not exceed 70-75 feet. Flat twin lead is affected by dust, oil, and water in the air, and some of the cheaper varieties undergo physical breakdown of the plastic polyethylene covering in sunlight due to the ultraviolet rays. The better brands of twin lead avoid physical breakdown for some time, but even so it eventually will occur.

Coaxial cable is useful where a lot of noise from machinery, auto ignition, and other industrial equip-

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survey the job from all angles. You can mount the antenna support to a chimney, vent pipe, or attach the support to the roof, or eaves.

If necessary, set up a temporary antenna and connect it to the TV receiver. This is helpful in a new residential area where there are no previous installations to guide you. While surveying the location, make a note of where and how you will spot your ladders, make the guy anchor installations, and seat the mast base. You should also be making plans for safety procedures in case you have to work near power lines or the edge of the roof.

Normally, two men will be required to make any outdoor TV antenna installation. Small arrays on short masts are no problem, but fringe area arrays with a rotator atop a 30' mast get to be quite unwieldy. If the job is properly planned ahead of time, two men can raise even the biggest array without too much effort.

**ANTENNA ASSEMBLY** Always try to do as much preliminary assembly work at ground level as possible, unless the antenna will be located on a flat roof. Peaked roofs are difficult work areas because of insecure footing and the probability of tools rolling off the roof. If the antenna is too cumbersome, or is liable to be damaged by hoisting it up to the roof, you'll have to assemble it on the roof. Go over the procedure on the ground so you'll know what must be done on the roof.

Once on the roof, one man should assemble the antenna to the mast, hook up the feed line, attach the standoff insulators, and thread the feed line down to the base section. Bring the feed line down to the first standoff at about a 45° angle to keep it clear of the boom. Leave a little slack at the first standoff to prevent strain at the antenna connection. As you run the 300-ohm feed line between standoffs, be sure to give it about one twist per foot all the way down to where it enters the house.

Guy all tall masts every ten feet. Masts over 30 feet high should have four guys at each level equally

spaced 90° apart. Masts under 30 feet need only three equally spaced guys. Guy anchors should be long enough to reach through any roofing material and go at least 1½" into the rafters. Be sure they go into the rafters and not just into the boards that hold the shingles. When using a rotator, be sure to guy up as close to the bottom of the rotator as possible, and don't let the antenna protrude more than about two feet above the rotator.

The second man should spot the guy anchors, set the base mount, and assist with the mounting of the guy wires after the antenna and feed line are attached. Once the guy wires are securely fastened to the mast rings, insert the mast in its base mount, and support the mast about two-thirds up from the base.

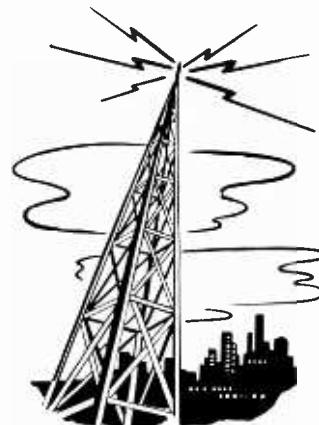
Raise the mast by walking it up into position. Steady it, and then, while one man holds it, the other should quickly move around and tighten up the top guys first. This will give you leverage on the mast where you need it most. Next, tighten the next set of guys down; unless the mast is unusually high, it will now be possible for both men to tighten the remaining guys. When tightening the guys, make sure the mast is straight and true. Leave a very slight amount of slack in the guy wires—tighten them just enough to hold the mast in a firm vertical position.

The feed line should be run between standoffs spaced about 10 feet apart. Try not to make any sharp bends with the feed line as you route it over the roof and down to the receiver. When you are ready to leave the roof, be sure to put a sealing compound around each guy anchor, screw, or standoff you have used on the roof to prevent leakage of rain beneath the roof material. If this is not done, the wood around the screws will eventually soften and rot, causing the anchors to pull out.

Ground the mast to a water vent pipe on the roof for lightning protection. Just before you enter the house with the feed line, attach a lightning arrestor near the ground

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level. A short copper rod driven in the ground close to the point of entry will allow a good connection for the lightning arrestor ground connection.

There are several ways of entering the house with the feed line—a hole drilled in a window frame, routing the feed line under the house and entering via a hole drilled in the floor near the baseboard, or through a wall fitting (which may require use of a masonry drill). Seal any holes which lead directly to the outside. Run the feed line along the baseboard to reach the set. Coax feed line can be painted to match the color scheme if there is any objection to its appearance.

**ANTENNA ORIENTATION** Once the feed line is attached to the receiver, antenna orientation is next. One man on the roof loosens the bolts holding the mast in its base. Then, via sound-powered phones, or a pair of CB walkie-talkies, the "inside" man checks each channel for picture quality. If other antennas are in view, a reference bearing can be taken from them. If not, or for fine adjustments, swing the antenna about 10 or 20 degrees to each side of the expected direction. Check each channel for each movement of the antenna.

It is entirely possible that the best position for all channel reception will not be the best for one or two individual channels. The antenna orientation you pick should be the one that gives a good, ghost-free picture on all channels received. One good way of checking it is to use a VTVM with demodulator probe on the picture grid. Measure the relative signal voltage on each channel, and try to orient the antenna for roughly equal voltages.

In industrial areas, or near hospitals, sufficient electrical interference is generated to spoil good TV reception. It is recognizable as a mesh of dark lines, horizontal bars, herringbone patterns, or simply bright dots which flash across the screen. Antenna orientation can help eliminate some of this interference but not all of it. Low-pass filters, which reject all signals be-

low the TV band, can be installed close to the tuner section. Automotive or power line interference cannot be filtered out, and the only solution is a stronger signal.

## ANTENNA SERVICING

Actually, very little servicing or maintenance is usually required with a good antenna installation. Weathering, together with general wear and tear, may take a slight toll—but this is easily caught by making a visual inspection of the installation at least once a year.

Things to look for include the obvious (broken elements in the antenna itself, lead-in wires that may have snapped because of high winds, rusted or corroded hardware) and a few not so obvious.

For instance, if you live near a seashore and the installation is subjected to salt spray, check the feed line carefully for salt encrustation. If you can feel any deposit at all on the line, wash the entire line down with a high-pressure spray from a garden hose. You'll be amazed at the improvement in signal quality.

Similarly, if you live in a high-smog area, check for a carbon-fill deposit similar to soot. This may require that the feed line be replaced, but sometimes the high-pressure spray works surprisingly well here too.

In the mountains or in the sunny southwest, check the feed line for deterioration due to the ultraviolet component of sunlight. Polystyrene is decomposed by ultraviolet; all reputable feed lines include ingredients to counteract this effect, but eventually most 300-ohm lines will succumb (although it may be a matter of 8 to 10 years for the better grades of feed line).

If any faults are found during the inspection, the decision as to what to do about them depends on many factors. If the fault involves the safety of the installation, repair or replace the faulty component at once. If, on the other hand, it involves only signal quality, then the decision may be deferred until quality demands improvement.

# CHECKING YOUR STEREO/HI-FI AND INSTALLING STEREO TAPE IN YOUR CAR

By IVAN B. BERGER

## INSTALLING HI-FI EQUIPMENT

- Cooling
- Cables and Leads
- Hum and Grounding
- Speakers
- Input Level Matching
- Antennas

## INSTALLING AUTOMOBILE STEREO TAPE PLAYERS

- Speaker Requirements
- Installing the Speakers
- Installing the Tape Unit
- Check-Out and Operation

## SERVICING HI-FI EQUIPMENT

- Test Tapes
- Troubleshooting Techniques
- General Troubles
- Distortion
- Frequency Response

**A**udio high fidelity is more or less unique in the field of electronic servicing, because so many of the problems encountered in installation and servicing are of a mechanical rather than a purely electronic nature. Except in the most complex custom hi-fi systems, installation of hi-fi equipment is usually simple and straightforward. Only a few trouble spots are likely to be encountered—assuming that equipment is fully operative when unpacked from the shipping carton.

## INSTALLING HI-FI EQUIPMENT

A good hi-fi installation depends upon your finding the correct and—simultaneously—most practical physical location for the various components. Hundreds of articles have been published on determining the best positions for hi-fi speakers. The manufacturer and the housewife will have their own ideas, and usually a compromise arrangement must be worked out. The remainder of the components should be placed in a position of maximum operating convenience.

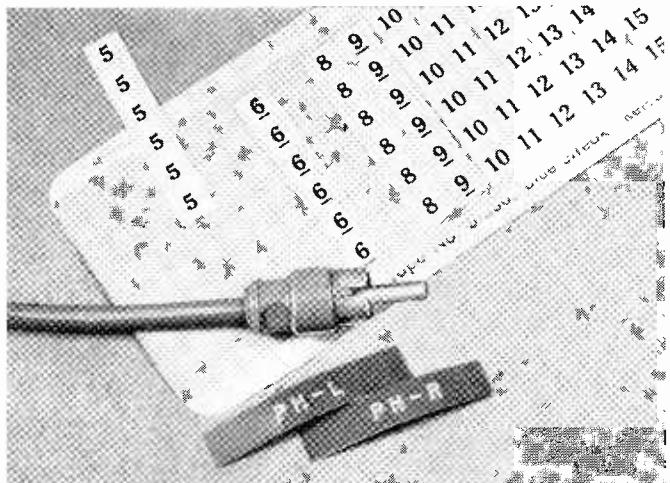
**COOLING** It may seem odd to start off with a discussion of cooling—especially in these days of more and more transistorized components—but ALL electronic instruments produce some heat and require some ventilation. Obviously, tube-type equipment requires more ventilation, and lack of ventilation will cause premature failure of tubes, capacitors, and other components in the electronic circuitry.

In open-shelf installations, providing ventilation is simple: leave at least 3" of space above and 2" of space on each side of an amplifier, power amplifier, or tuner. High-wattage power amplifiers will require more space and these should be located "out-of-the-way" so that they will not be accidentally touched by small children. Stacking components is permissible in some transistorized hi-fi installations. Cabinet-mounted tube-type components in a hi-fi system will run cooler if the decorative enclosure is removed. And shelf-mounted hi-fi components will heat up if the ventilation louvers of the cases or enclosures are blocked by magazines or books.

When the hi-fi system is cabinet-mounted, extra ventilation holes should be drilled in the bottom and back of the cabinet. Generally speaking, most commercially available custom-made cabinets fail to provide enough holes or louvers for adequate air circulation. You can improve air circulation by installing a small quiet-running fan.

**CABLES AND LEADS** Cables between hi-fi components should be as short as possible. Short cables will minimize a.c. hum and extraneous electrical noise pickup. There should be enough slack left in each cable so that the components can be pulled out of the cabinet or mounting for routine checking.

It's a good idea to label all connecting cables,

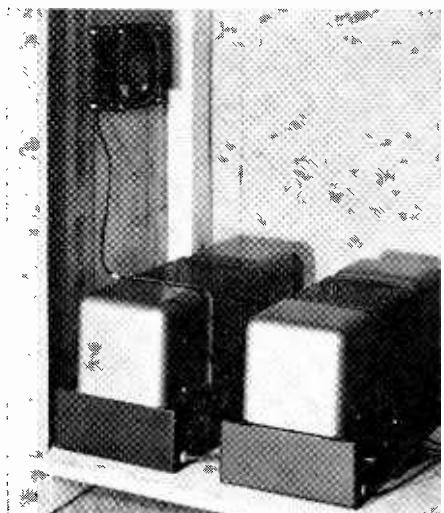


**LABELING** Simplify tracing of connecting cables by labeling them on installation. Plastic labeling in red for the left channel and green for the right channel is both attractive and useful. Brady Wire-Markers are adhesive-backed—see text. Attach matching numerals to identify each plug and jack.

especially in a complex multi-component system. Writing each cable's function on a piece of masking tape which is then wrapped around the wire is a clear and unambiguous way to do it, if not terribly neat-looking. Raised-letter, adhesive-backed label tapes, punched in a hand label-making machine (such as the Dymo or Rotex label guns) are more professional-looking. Different color tapes can be used for channel identification. Rotex makes a thin-base label tape, called "Super-Flex," that wraps snugly around even thin plugs and cables.

A less expensive and simpler labeling system uses Brady Wire-Markers—small, adhesive-backed numeral strips that wrap around plugs and wires. If you place matching number strips on each plug and jack, it will be easy to re-connect the system after maintenance or servicing. In simpler systems, color-coded plugs may do the job.

For a neat installation, cables can be fastened out of the way with standard, hammer-driven insulated staples available at hardware stores. (But beware of ordinary staples and stapling guns—thin wire staples



**COOLING** This installation gave out excessive heat until it was cooled down by a small circulating fan on the upper wall. Made by Rotron, this fan draws only 14 watts and is switched on at the amplifier.

can cut through the insulation of a cable.) Cable clamps will also work.

**HUM AND GROUNDING** Audio cables—especially those from phono cartridges, tape heads or microphones—should be carefully routed away from power transformer fans, or motors in other components; if you encounter a hum problem, first rearrange the cables to move the hum-sensitive lines away from the hum fields.

Proper grounding can help cut a.c. hum pickup. It's usually a good idea to ground one—and only one—component to a "true" ground, such as a water pipe or the screw on the plate of the wall-socket, then ground all the other components to the one grounded component with a short length of wire braid. Check the system for hum with each ground connected and disconnected, since adding a ground connection sometimes increases hum, by setting up a "ground loop." A loop acts as a pickup coil in which any nearby hum fields induce hum voltages.

To cure excessive hum on phono inputs, try grounding the tone arm to the motor of the record player. If the record player comes with a ground lead, be sure to connect it to the amplifier, but be equally sure to check hum level with and without the ground connection.

**SPEAKERS** Ordinary lamp or "zip" cord will usually do nicely so far as the speakers are concerned, though heavier #12 wire is better for long runs of over 50 feet or so; the higher resistance of thinner wires may affect speaker performance by lowering the damping factor, or causing a slight impedance mismatch. The mold mark running along one side of the "zip" cord will also help distinguish between the two sides of the line, for proper speaker phasing.

To double-check phasing, use any monophonic music source, turn the bass controls up, and reverse one pair of speaker leads—the speakers are in phase when the bass is loudest. If you can't hear a difference, place the speakers side by side, then re-check.

**INPUT LEVEL MATCHING** "Tape" and "Tape Head" inputs may cause some confusion: the first input accepts the output from the preamplifiers built into a tape deck or recorder, while the second is for direct connection to the playback head in tape transports with no electronics of their own. Mixing up the two will cause either a shrill, uncontrollable blast of distortion even at low volume settings, or a very weak, muffled sound.

Some amplifiers have both "high" and "low" level phono input jacks. If you are not sure which is the right one, set the volume control about halfway up, and play a record first through one input, then through the other input. Whichever gives the more comfortable listening level—neither too loud nor too soft—and the least hiss and audible distortion is undoubtedly the correct one.

A few amplifiers also have "hidden" level-set controls. To use these controls, set the two phono input level-sets for comfortable listening with the amplifier's volume control about halfway up, then adjust the other level-sets (tuner, tape, etc.) so that overall output level remains constant when switching from phono to other functions. Volume controls on tuners, tape decks and other signal sources should be set about two-thirds of the way up.

**ANTENNAS** Some tuners and stereo receivers have inputs to accept both 300-ohm balanced-line and 75-ohm coaxial antenna lead-ins. Be sure to use the proper input and—with 75-ohm coax—check that the shield is connected to the grounded side of the antenna input.

The stranded wires in 300-ohm antenna lead are real trouble-makers in most hi-fi installations. Your best bet is to twist the strands together and coat them with solder. This will prevent the strands from unraveling and shorting out the antenna input. From the soldered strands into a partial loop and slip the loop under the screw terminal. Tighten the screw enough to insure a good metal-to-metal contact, but not too much or the wires may break.

## INSTALLING AUTOMOBILE STEREO TAPE PLAYERS

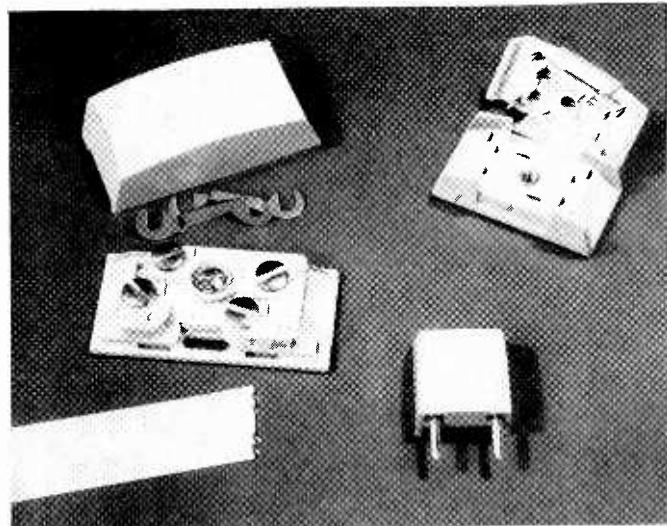
With the increasing popularity of automobile stereophonic tape players, installers and servicemen are trying to keep up with the unexpected demand for their services. New-car dealers are now offering both stereo tape players and radio-tape player combinations as optional equipment and they are doing a land-office business.

Auto stereo tape players are relatively simple to install, once their operating requirements are understood, and a few pertinent basic techniques mastered. Except for radio-tape player combinations designed for custom installations, all currently available stereo and mono units mount on a support bracket below the dash. These units are usually self-contained, requiring only attachment to the car's battery for operation.

Some cars have a positive-ground electrical system while others operate with negative-ground systems. It is essential that you check the manufacturer's data to make sure the tape player you are about to install has been designed to operate with the same battery voltage and polarity as your car.

About the only tools required for installation are a small electric drill, a set of high-speed bits, an elbow adapter to let you drill in tight quarters, a 4½" circle cutter, and a few ordinary shop tools.

**SPEAKER REQUIREMENTS** The typical stereo installation requires four speakers. These speakers can be purchased with the tape player, or the speakers may be selected from the wide variety available at elec-



**SPEAKER CABLING** To keep speaker wires off the floor, try using 3M "Scotchflex" adhesive-backed four-wire flat cable. Various connectors and terminations make installation quite easy. The cable and terminations can be painted room-color.

tronic equipment suppliers. Where speakers are purchased as separate units, identical sets must be chosen for the left and right channels.

Because of space limitations, front-door speakers are shallow and usually about four or five inches in diameter. But much larger speakers—usually 6" × 9"—can be selected for mounting in each corner of the rear deck of a sedan. Where mounting space and money are not limiting factors, it is advantageous to install two identical speakers in each front door. This combination enhances the stereo effect.

Installations in most compact cars require only one speaker for each channel. The speakers are usually placed in the front and back of the car, instead of at the sides.

Surface-mounting speakers are generally more convenient for installations in station wagons. Two speakers—one on each side—can be mounted above the door post behind the front seat, while the remaining two speakers are mounted at the same height towards the rear of the vehicle. The exact location of the rear speakers would be determined by the size and style of station wagon involved.

**INSTALLING THE SPEAKERS** After deciding where you want to mount the front-door speakers, use a circle cutter to cut out the proper size hole. Then drill the holes for the bolts to mount each speaker, using the metal grille as a guide. Secure the speakers with locknuts or nuts and lockwashers to prevent them from loosening up with the car's vibration.

Your next step is to run the speaker wires from the door to the dash panel. Most cars have a few extra holes in the door through which you can run the wires, but should you need new holes, don't be afraid to drill them. Wires running through doors should have enough slack to prevent them from being pulled out when the door is opened. However, be careful not to leave too much slack or the wires may sag and get

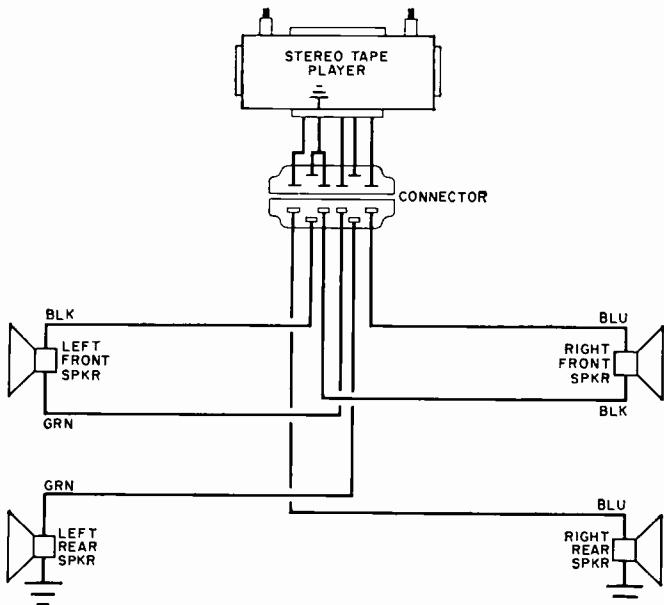


Fig. 1. In the Delco Radio Model DS-501 stereo tape player wiring arrangement, the front speakers have return path connecting leads, although the rear speakers can be grounded to the car frame. Color-coded wires preserve speaker phasing.

crushed between the door and the jam. A good practice is to knot or tape the wires together to prevent pull-out.

Some stereo speaker systems require two separate leads all the way from the tape player to the speaker, as shown in Fig. 1. In this case it is advisable to use different-color wires to aid in the phasing of the speakers. On the other hand, some installations, such as the one shown in Fig. 2, call for a single wire and use the car's chassis as the return path. Either system will work, provided the loop is completed, but here there is always the danger of a poor ground connection that can cause intermittent or noisy operation. It is recommended that two wires be run.

Matched sets of stereo speakers are generally marked as to polarity, and need not be phased unless the leads are accidentally reversed. However, off-the-shelf individual speakers must be phased. This can be done on a trial and error basis just before finally buttoning down the whole installation. Be prepared to reverse the leads to the speakers in one channel if the sound lacks bass, or if the "stereo effect" appears weak.

**INSTALLING THE TAPE UNIT** The ideal location for the tape unit is below the dash panel, just over the hump in the floor. Be certain that the unit does not interfere with the opening of the glove compartment door or ash tray.

Tape units are usually sold with mounting hardware and include installation instructions and a hookup diagram as well. Using the mounting dimensions provided, drill all holes necessary to attach the mounting bracket. Then insert the tape unit and level it on each side. Tighten all retaining bolts.

Wire the tape unit power lead to the ignition switch.

Check to make sure power is applied through the switch only. Insert a fuse holder in the lead unless the unit comes equipped with its own fuse. Use a fuse rating of about 1.5 or 2 amperes. Then connect the speaker leads to the right and left channel speaker terminals.

The Lear-Jet uses a three-prong connector to provide easy connection or removal of the unit for servicing. The black wire is common to all speakers, and is also connected to the car's chassis.

**CHECK-OUT AND OPERATION** Before inserting a cartridge in the player, turn on power and make sure that the drive motor is running. Select a tape cartridge and insert it—label side up, and open end first—into the tape slot. Push the cartridge in until it is firmly seated. The tape unit should now play.

Adjust volume, tone, and balance for best listening comfort. The balance control equalizes the outputs from the right and left channels for the most pleasing stereo effect. From here on you should follow the operating instructions supplied with the tape unit. A word of caution: before turning the unit off, always pull out the cartridge completely—or at least one inch away from its seated position.

Most tape players are essentially immune to interference from the ignition system or other electrical devices in the car. If you encounter any trouble with electrical noise, use one of the techniques detailed in Chapter 7 of this Handbook.

## SERVICING HI-FI EQUIPMENT

Locating most hi-fi troubles generally takes only one tool—common sense. Some troubles, for instance, are

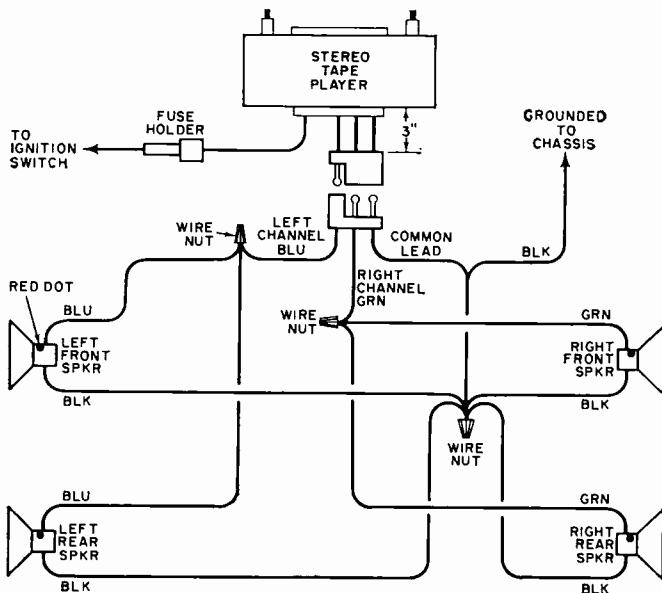
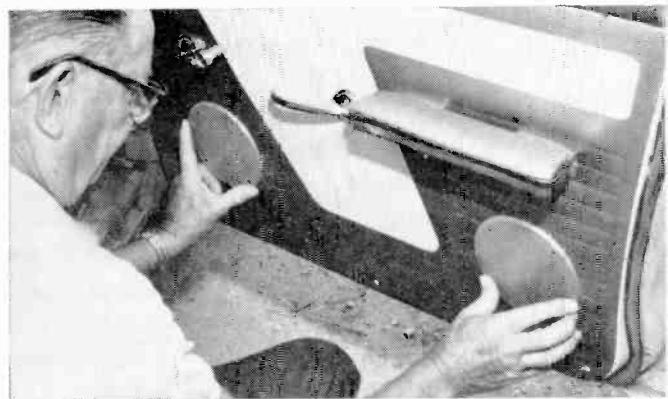


Fig. 2. All of the black leads from the four speakers in the Lear-Jet Model ASR-830H may be grounded to the car frame. To simplify phasing, each of the speakers is marked by a dot. When the terminal nearest the dot is connected to the appropriate blue or green lead, all speakers will be phased.

# INSTALLING A STEREO TAPE PLAYER



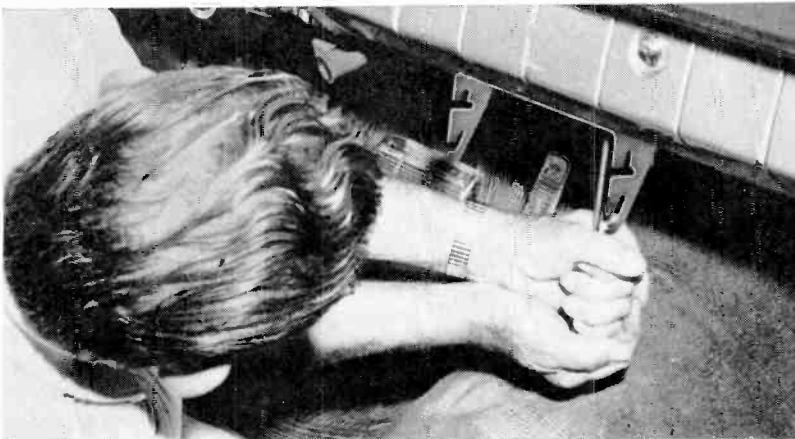
Now there's something more than an AM or FM car radio for your listening pleasure—a stereo tape player that you operate by merely turning it on. Photo above shows under-the-dash installation that can be made on any car.



For maximum stereo effect, a pair of matched speakers can be flush-mounted, as far apart as possible, in each of the automobile's front doors.

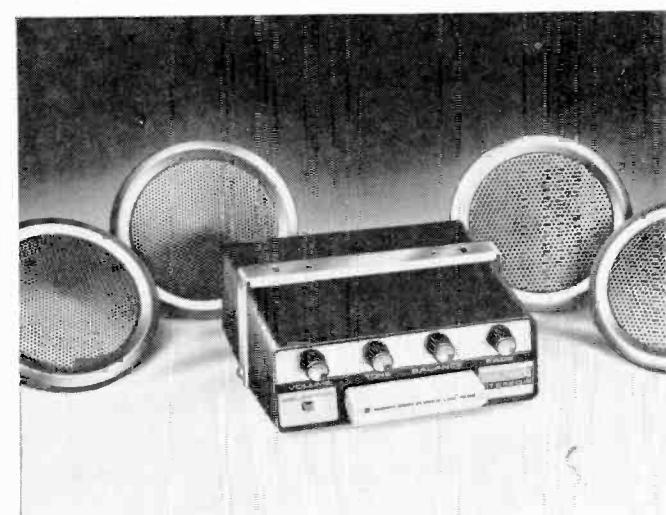


Surface-type speakers are preferred for station wagons. If you install two speakers on each side, place one towards the rear and the other up front.



In most autos, the ideal place to install the tape player is under the dash at a position just over the hump. This puts the unit within easy reach of the driver and out of the way of passengers in the front seat.

Put out by Lear Jet Corporation (Wichita, Kan.), the car stereo tape player below features 8-track playback. Standard tape packs provide up to 1 hour and 20 minutes of stereo. Combination radio/tape players are available.



## TEST TAPES

Unlike the variety of test records discussed on page 100, there are very few test tapes; but the tapes that are available will enable you to judge the performance of your tape recorder playback head and playback amplifiers. In general, moderately-priced tape recorders will actually record somewhat better than they play back. So, if your test tape indicates that playback is okay, it is reasonably safe to assume—barring obvious recording faults—that your record/playback performance is satisfactory.

The most important use of a test tape is in checking playback head alignment. Most test tapes have a high-frequency tone signal recording for this purpose (also see page 106). Test tapes may also include a series of discrete frequency tones that have been recorded according to the playback levels set by the RIAA standards. You will find these test tones valuable in verifying the equalization characteristics of your playback system.

Oddly enough, there is no standard for recording on tape—just standards on playback alone. Also, don't expect to find a standard for playback above 15,000 hertz (recorded at 7½ ips), or above 7500 hertz (recorded at 3¾ ips). Tapes don't go that high.

The best test tape is "individually" recorded by Ampex at one of three speeds; 3¾ ips, 7½ ips, and 15 ips. These tapes are expensive (about \$22) and are all ¼" wide with full-track recording.

Low-cost alignment tapes include a version manufactured by Audiotape. This tape, however, is recorded at 15 ips and is of somewhat limited use. The Audiotape No. 200 sells for about \$6.00. Nortronics offers a similar test tape, called "Alignment Tape" No. AT-100, which is recorded at 7½ ips and sells for about \$5.00.

The Audiotex "Audiotester" tape is sold in three different versions. A high-quality tape costs about \$8.50 (list) and a fair-quality tape of the same material sells for about \$2 less. Recorded at 7½ ips, the "Audiotester" includes segments to determine intermodulation distortion (an oscilloscope or IM analyzer should be used), flutter and stereo balance.

The only RCA test tape known to be available now was recorded to check out the RCA 3¾-ips, 4-track tape cartridge machines.

indigenous to certain components and no others: only tuners can drift, only tape and record players exhibit wow and flutter, and speakers can never be a source of hum. More general troubles—hum, noise, distortion—can be tracked down by following the signal path back from the amplifier to its source. A hum that persists when all other components are disconnected from the amplifier must originate in the amplifier; a noise whose level rises as the volume control is advanced must be in a stage before the volume control—and if it occurs on all inputs is somewhere in the preamp; a buzzing heard only on FM is probably a tuner problem; and so forth.

There may be any number of relatively minor factors responsible for the sudden, or unexpected, absence of sound from your hi-fi system. It may simply be that there is no 117-volt a.c. input. Always check the household current source first. If your system has a number of interconnected components, consider the possibility that one of the a.c. plugs has been accidentally disengaged.

Almost all hi-fi equipment has some sort of fuse protection. If a blown fuse is discovered and the replacement immediately blows, the trouble is obviously of significant enough proportions to create excessive current drain. The older tube-type hi-fi gear used cartridge fusing, but the newer transistorized circuits frequently have resettable fuses. The resettable fuse is generally faster-acting and in a transistor amplifier is a prerequisite for overload protection of the output circuit.

Look for switches or controls that may have been reset since you last checked them. Source-selector switches may have been changed, and in this area the most notorious is the "Tape Monitor" switch which effectively disables the whole amplifier to prevent feedback while recording.

**TROUBLESHOOTING TECHNIQUES** The four tables that accompany this article will give you a detailed outline of good troubleshooting procedure. Once you've located the trouble in one part of the system, check not only the components involved, but the cables connecting them.

Check your diagnoses by component substitution. If the trouble is in only one channel of a stereo system, plug what you suspect to be the guilty component into the opposite channel, and see if the trouble switches channels when you switch connections. In mono systems, or stereo systems with trouble in both channels, try bypassing components. The tuner, for example, can be plugged into the tape recorder inputs, without an intervening preamp, and both tuner and tape recorder can feed the power amplifier directly.

Signal injection is another good technique. Using a signal generator (the pen-sized, pocket variety will frequently do), inject a signal into the power amp input, then work back through the system until the signal disappears. With a sine-wave generator of

reasonably low distortion, you can check not only for weak or missing signal, but for distortion as well; strong distortion should be plainly audible, or visible on a scope.

**GENERAL TROUBLES** Of all the troubles hi-fi is heir to, silence is the easiest to fix. In all but the rarest cases, silence where there should be signal is due to a broken cable connection, a component not plugged in or turned on, a blown fuse (in either the component or the house wiring), or a switch turned the wrong way ("tape monitor" and "speaker on-off" switches are the commonest culprits). Tubes usually deteriorate long before they blow, and unless you have ears of tin, the hum, noise, or distortion created by an aging tube will tell the story before the tube has a chance to fail completely.

Sudden hum troubles are usually due to broken or loose connections, either where the cable braid is soldered to the plug or in the ground wires (if there are any) between components. Maybe the most common cause of hum is an aging tube (especially in the low-level input sections of the preamp). Make sure not only that the cable braid makes a good connection to the phono plug, but that the plug makes a good connection to its jack. If necessary, clean it with an emery cloth or a swab of tuner cleaner, and crimp the skirts if they seem to fit loosely.

Noise, unlike hum, may be due to the speakers; a

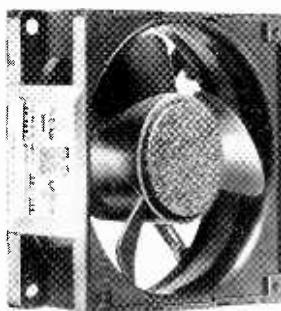
tweeter control set too high will accent any hiss already present in the system. If the decor of a room is changed, it may affect the optimum tweeter level setting. If the rugs or drapes are taken away, for example, a lower setting is advised to match the "harder" acoustics of the room.

More likely causes of noise are tubes (especially first-stage tubes and output tubes) and controls or switching contacts. Tone and volume controls and switch contacts can be cleaned with any of the standard contact-cleaning fluids.

Noise on phono or tape-head inputs is usually due to a defective input tube in the preamp, though poor connections may also be at fault. Tape heads should be demagnetized regularly, or they will leave a permanent fog of noise on every tape that passes across them.

Tuner noise may be due to broken or corroded antenna connections, or to misalignment of the tuner. Check the antenna first, since damage or corrosion will be plainly visible.

**DISTORTION** Every component in a hi-fi system is capable of creating distortion, and getting to the root of the cause can be a time-consuming problem. However, the most common cause is the overloaded input. This frequently occurs when the cartridge or tape deck output is fed into the wrong amplifier input jack. Overloading may also occur when the "hidden" level-



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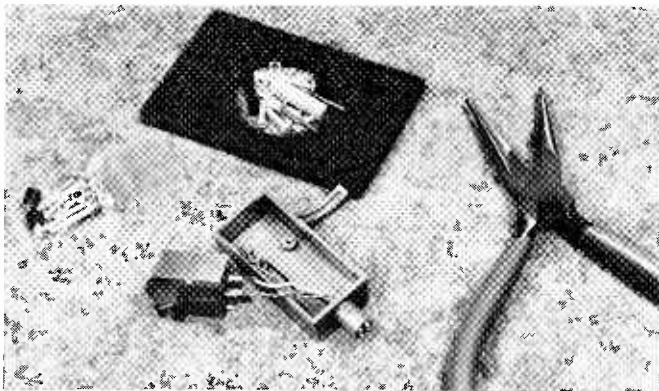
Write for descriptive literature and name of nearest dealer.



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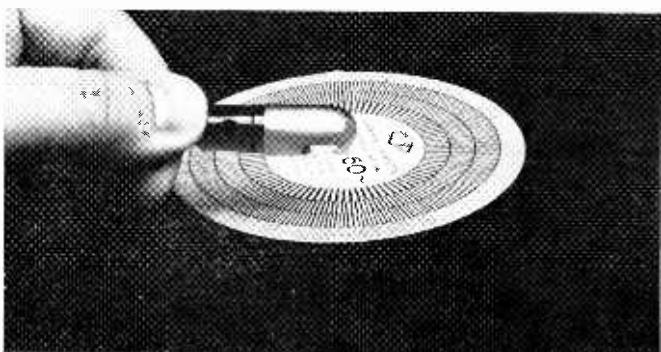


**CARTRIDGE INSTALLATION** There is considerable standardization on colors to identify the two stereo channels. In this cartridge and shell, the color "red" indicates that the leads are those of the hot side of the right channel and "green" the hot side of the left channel. Most manufacturers supply an assortment of bolts, washers, and clips to ease installation.

set controls are boosted too high, or when the volume controls on separate tuners and tape decks are feeding too much signal into the amplifier. One other major cause of distortion is the amplifier itself—especially when a small under-powered amplifier is asked to drive an inefficient speaker system to an outrageously high volume level.

Distortion of the sound from a record player or turntable is commonly due to a dirty stylus. The effect is particularly noticeable when you're listening to stereo recordings. Generally a collection of dust fibers can be seen around the stylus. These should be removed gently, so that the stylus is not twisted or bent out of shape. Persistent phono distortion may be due to the cartridge shell not being properly seated in the tone arm socket, a sudden increase or decrease in stylus pressure, or even the wrong radius stylus for the music being played.

Tape transports and tape recorders will generate their own brand of distortion problems. If you can eliminate power supply troubles, check the tubes in the biasing and playback circuits. If distortion occurs only when you are making your own recordings, you can be sure that the trouble is in the biasing circuit.



**TURNTABLE SPEED** Many record players and turntables have a speed adjustment control to accurately set the revolutions per minute for true pitch reproduction. This calls for use of a strobe disc and a neon lamp, such as this small one manufactured by Switchcraft. The strobe disc is usually calibrated for all four record playing speeds (16 $\frac{2}{3}$ , 33 $\frac{1}{3}$ , 45, and 78 rpm).

Many of the new thinner tapes for high-quality recordings—especially those of the "low-noise" variety—will require more bias than many tape recorders manufactured three or four years ago were set up to provide.

If you are fortunate enough to have a tape recorder for which the bias is adjustable, you can reset the level following this procedure: Record a 1000-hertz tone signal on a sample of the best tape you intend to use. Increase the bias until the output meter (use your VTVM, or the recorder's vu meter if fed from a separate playback head) indicates a peak reading. Then go beyond this point until the output drops about 1 dB. Always set the bias for the best tape you will use. If an inferior tape is used, you will lose some treble notes due to over-biasing, but this effect will not be as bad as the distortion obtained from under-biasing.

Tape playback-only distortion can be due to dirty, worn, misaligned, or magnetized tape heads. Be prepared to demagnetize the tape heads if the tapes start sounding noisy and there is a noticeable loss of treble notes. Tape heads should be cleaned regularly, and the tape recorder fan is well advised to keep a kit of tape cleaning tools at hand. On rare occasions, distortion in tape playback might be due to aging components in the equalization circuits. To check this trouble, you will need an alignment test tape. Note that equalization varies according to playback speed.

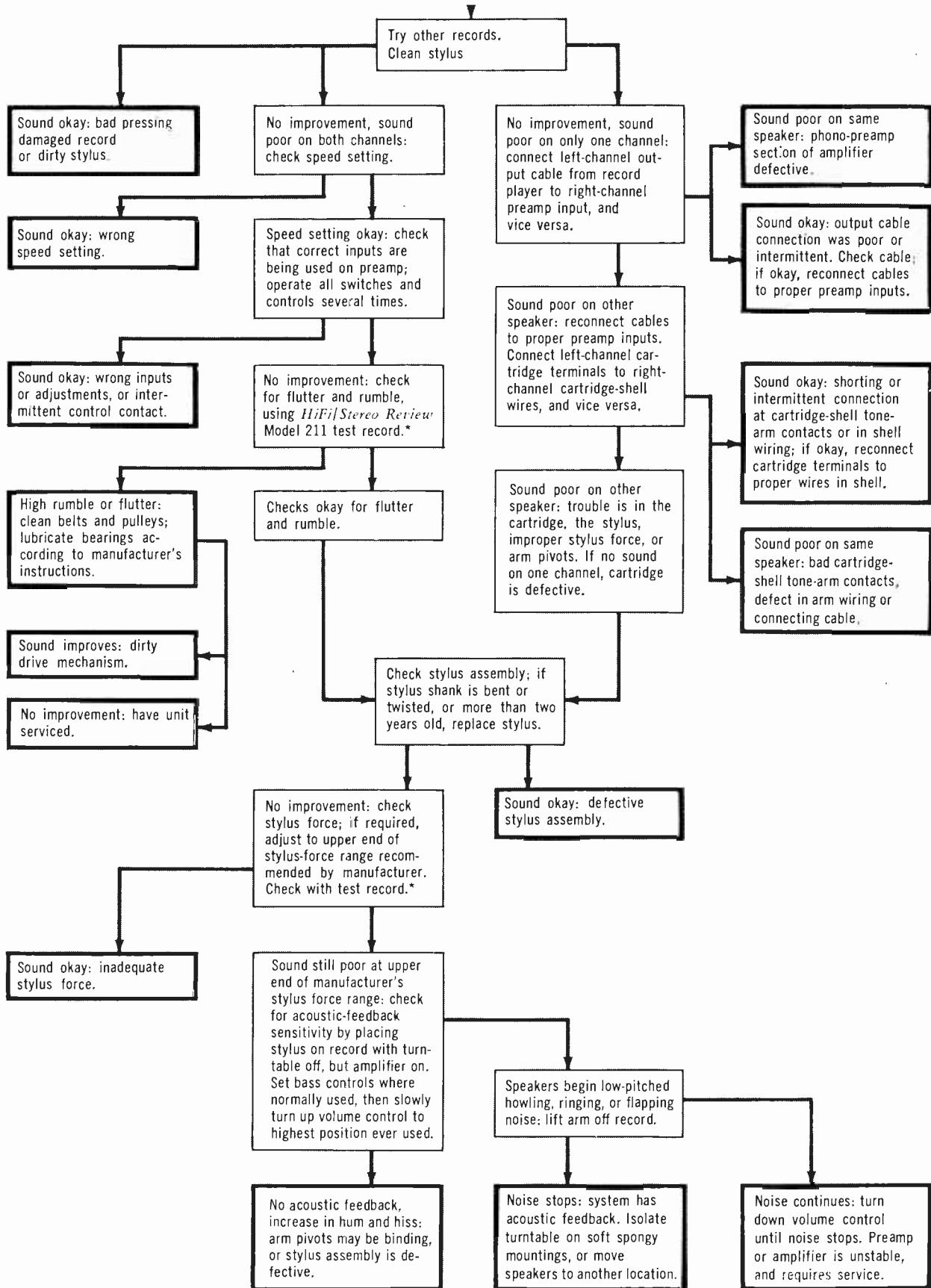
If you notice distortion in FM reception, the first thing to check is the strength of the FM signal itself. Is your antenna facing the proper direction and are you really getting all of the signal you need to secure good limiting action in the tuner? Stereo FM broadcasts suffer from phase distortion due to FM signal reflections (similar to TV ghosts). Obviously, distortion can also be due to misalignment of the FM tuner. In factory-wired equipment, this is rare and, generally speaking, is frequently the result of tube aging. In home-built tuners, the manufacturer's instructions on alignment should be followed to the letter to put the tuner back "on the nose."

Distortion in hi-fi amplifiers can be checked out using minimal test equipment (see page 104); however, it is always worthwhile to check the voltage level from the power supply and to test the power output tubes (if used). Distortion in some 25-watt-plus output amplifiers may be due to improper setting of the "Bias" and "Balance" controls.

Hi-fi speakers are reasonably sturdy and generally don't produce distortion unless they have been damaged.

**FREQUENCY RESPONSE** When a hi-fi system is set up in a living room, the sound output is never completely flat—regardless of how well the equipment reproduces the signals from top-quality discs or tapes. The trouble generally lies in room acoustics and the user must be prepared to juggle tone controls and

## POOR SOUND ON RECORD PLAYING ONLY



\*Available at \$4.98 from *HiFi/Stereo Review*, 1 Park Avenue, New York, N.Y. 10016.

speaker level settings to secure the best possible balance of good clean sound.

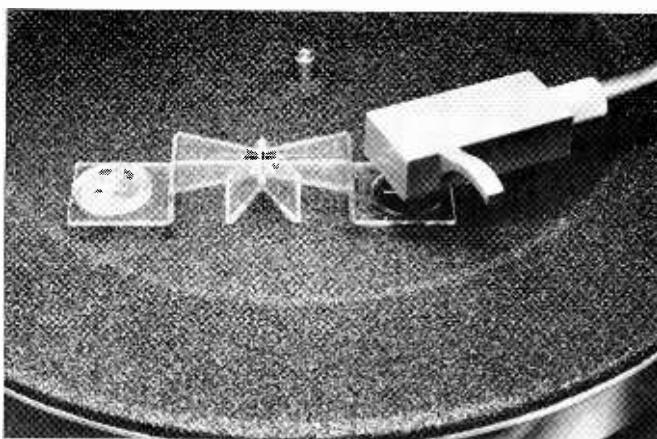
If your system appears to lack "something," check the amplifier control settings—contour, filters, tone controls, etc. If you are satisfied that the amplifier has a "flat" output and that the loudness or contour control is "off," the next thing to check is the setting of the speaker level control.

Probably the best method of setting the "Presence" and "Brilliance" controls on a speaker system is to use "white noise." A good facsimile of white noise is readily available to the hi-fi enthusiast: you simply tune the FM receiver between broadcasting stations. The rushing sound that will be heard is white noise—a sound which is analogous to white light since the noise contains random noise pulses scattered throughout the entire audio spectrum. If the rushing noise sounds shrill, turn down the "Brilliance" or tweeter level control. On the other hand, if the rushing sound is muffled, turn up the tweeter level until you can just hear the tweeter adding highs to the sound output.

Speaker level controls will occasionally go bad with age, and if your hi-fi system suddenly loses high frequency response, don't hesitate to suspect the control. Generally you can "clean" the control by rotating it back and forth a dozen or so times. On rarer occasions there may be trouble with the jumpers between the terminals to the separate speakers—check them if the sound unexpectedly loses "Presence" or "Brilliance."

**TEST RECORDS** A simple VOM suffices to measure output across the speaker terminals—one channel at a time. But if you want to test your cartridge alone—without your amplifier—you need an a.c. VTVM to provide the signal amplification necessary for a clear reading. And as a signal source, you need one of the more technical test records.

The basic procedure is simple. Most test records begin frequency runs with a so-called reference tone. You adjust the gain of your amplifier (or VTVM) so that the meter reads 0 db for the reference tone.



**STYLUS PRESSURE** Distortion can be the result of insufficient stylus pressure permitting the stylus to rattle around in the record grooves. Too much pressure can cause excessive record wear. This AR stylus gauge is simple and easy to use.

Ideally, the meter should remain at or very near 0 for all other test tones. This means that you have "flat" frequency response. Most likely you don't. But by plotting on a chart just how many decibels the meter rises or falls at various frequencies, you can plot the frequency response curve of your equipment.

Among the many test records available for this type of checkout, Vanguard's Stereolab Test Record (VSD-100, \$2.98) offers a frequency run from 30 to 15,000 hertz, in addition to tests for channel balance, phasing, flutter, noise, and distortion. Columbia's excellent "Stereophonic Frequency Test Record (STR-100, \$8.50) runs through 30 spot frequencies between 20 and 20,000 cycles, which are suitable either for ear-testing or for calibrating the system with an output meter. This disc also offers sweep frequency tests (for detecting rattles and resonances), channel separation tests, phasing, and cartridge compliance and tracking tests.

An unusually elaborate test record is Folkways' "Sounds of Frequency" (FPX6100, \$5.79), a mono disc with frequency runs for both 78 and 33 1/3 rpm in small intervals all the way from 15.6 to 22,500 hertz. It is the only record in this group with square-wave tests to measure the ability of your cartridge and amplifier to respond quickly to extremely sharp, percussive sounds, and it also contains a test band for intermodulation distortion. However, to interpret these last two items, you need an oscilloscope to show the waveforms generated, and an IM distortion meter.

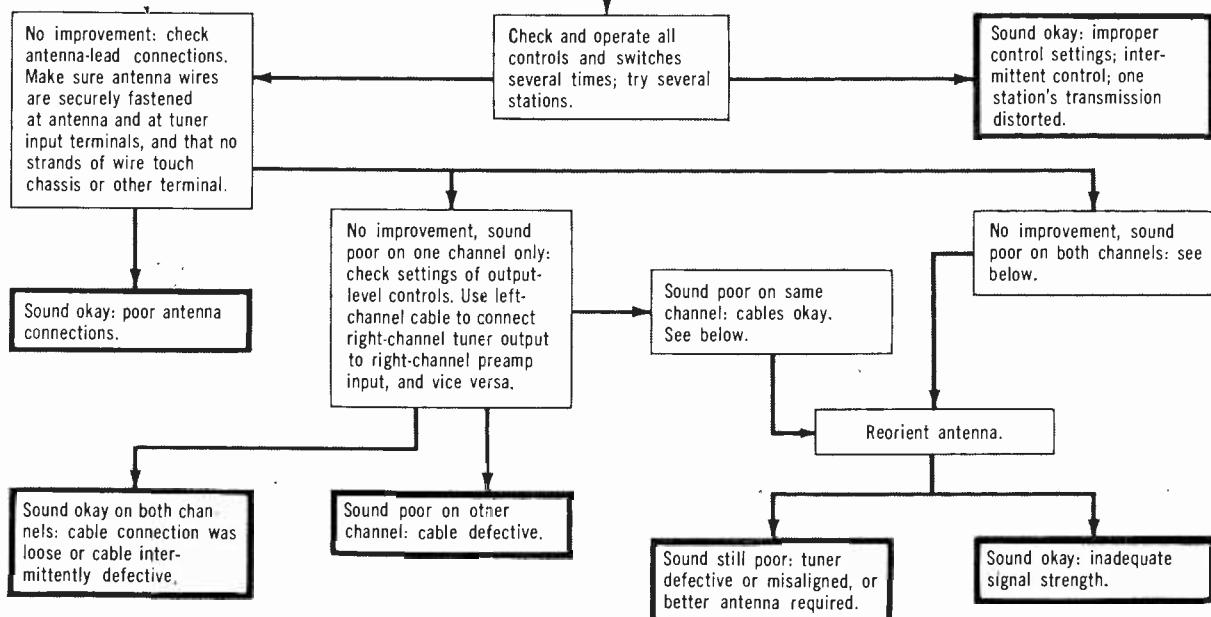
A specialized group of professional-type test records is issued by Cook Laboratories, Inc., of Stamford, Conn. One of these discs is the Series 60 Chromatic Scale Record. Unlike other test records, it doesn't contain test tones at round-number frequencies (e.g., 50, 100, 400 cycles, etc.). Instead, it has the regular musical scale from a low C of 32.7 hertz to a high C at 6372 hertz. Cook's Stereo Crosstalk and Interaction Test Record (Series 301) is devoted entirely to testing stereo separation and channel interference at various frequencies throughout the range; and for those with an IM distortion meter, Cook offers a special Intermodulation Distortion Test Record.

For a general stereo checkout, Cook's Series 302 record contains the usual frequency run, balance, and crosstalk tests. For special types of frequency checks, Cook's Series 12 has two different types of frequency runs: one equalized according to the standard RIAA curve, the other recorded "flat" without equalization. All discs in the Cook series are priced at \$4.98.

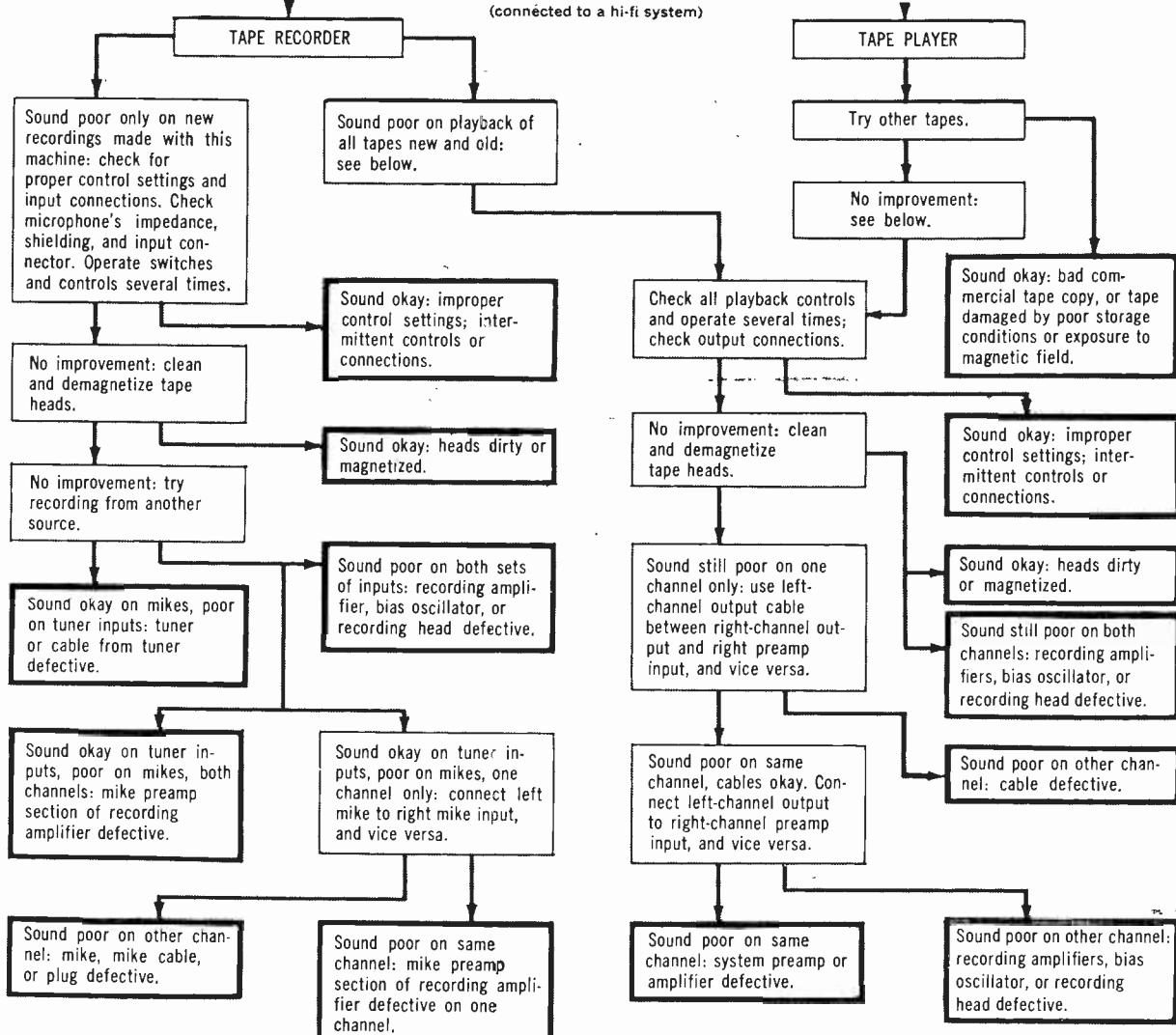
Though most of these records are intended for professional engineers, advanced audio amateurs—especially those designing their own equipment—may find them helpful.

**SPECIALIZED TROUBLES** Some hi-fi troubles, by their very nature, can be immediately restricted to certain parts of the audio system. Wow and flutter, for example, are caused by record player, turntable, or

## SOUND POOR ON TUNER ONLY



## SOUND POOR ON TAPE MACHINE ONLY



tape transport defects; rumble is strictly a player or turntable problem, though occasionally a defective turntable at a broadcasting studio may cause rumbley FM reception (the cure—tune to another station), or a slight, low-frequency oscillation ("motorboating") may masquerade as rumble (the clue here is that the rumble can be heard on tape and tuner).

Phono player and turntable troubles are, in fact, about the most common. In the necessarily light mechanical construction of a phono cartridge, a lot can go wrong, and does. Ask yourself the following questions. Is the stylus clean, unworn, unbent, and in place, and is the arm allowing it to track properly? Are the cartridge leads properly connected? Are there any breaks in the leads between the cartridge and the plug to the preamplifier? (Disconnect the cartridge before trying continuity checks.) Does the cartridge itself work?

Squeaks in phono equipment usually signify that something needs oiling—but never lubricate without consulting the manufacturer's instructions or service

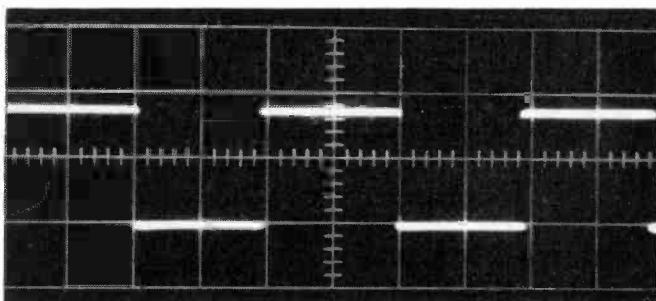
literature. Lubrication will frequently cure an under-speed turntable.

Drive belts and wheels may wear out and slip. It can help to clean all driving surfaces with alcohol. In real emergencies, glazed driving wheels may be saved—for the time being—by *light* buffing with an emery board, or application of one of the commercial non-slip preparations available at electronics parts houses. But such solutions are usually temporary—eventually, you'll need to install a replacement drive wheel or belt.

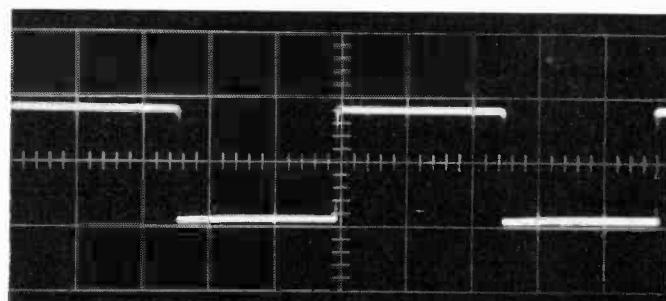
Idler wheels will acquire flat spots if they are left in contact with the driving or driven wheels when the power is off, and these flat spots cause "thumps" and flutter when records are played. Turn off the turntable by means of its own switch, and never plug an idler-driven turntable (or tape deck) into the "switched" a.c. power outputs on the amplifier or tuner.

The mechanical variation of changer mechanisms is too wide for them to be covered here. Always refer

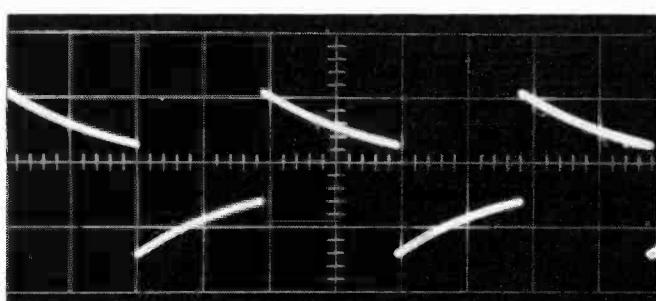
## SQUARE-WAVE AMPLIFIER TEST RESULTS



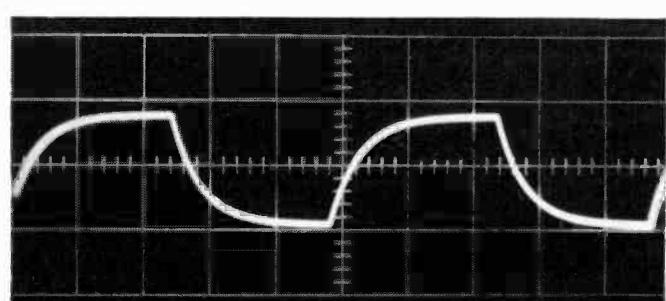
Very clean waveform at 50 hertz.



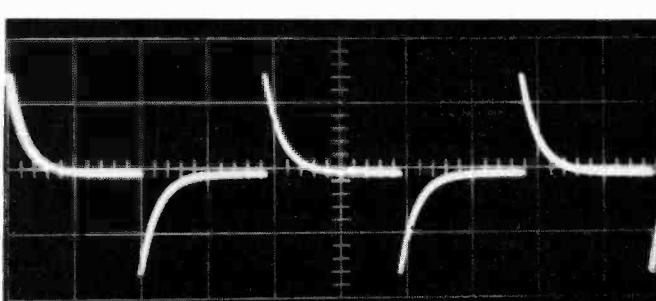
Clean waveform observed at 10,000 hertz.



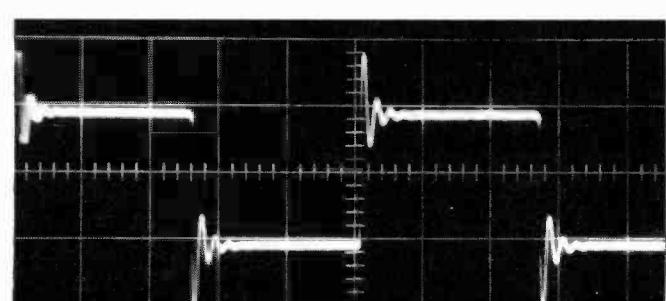
Degraded response on the low frequencies.



Poor response in the treble note region.

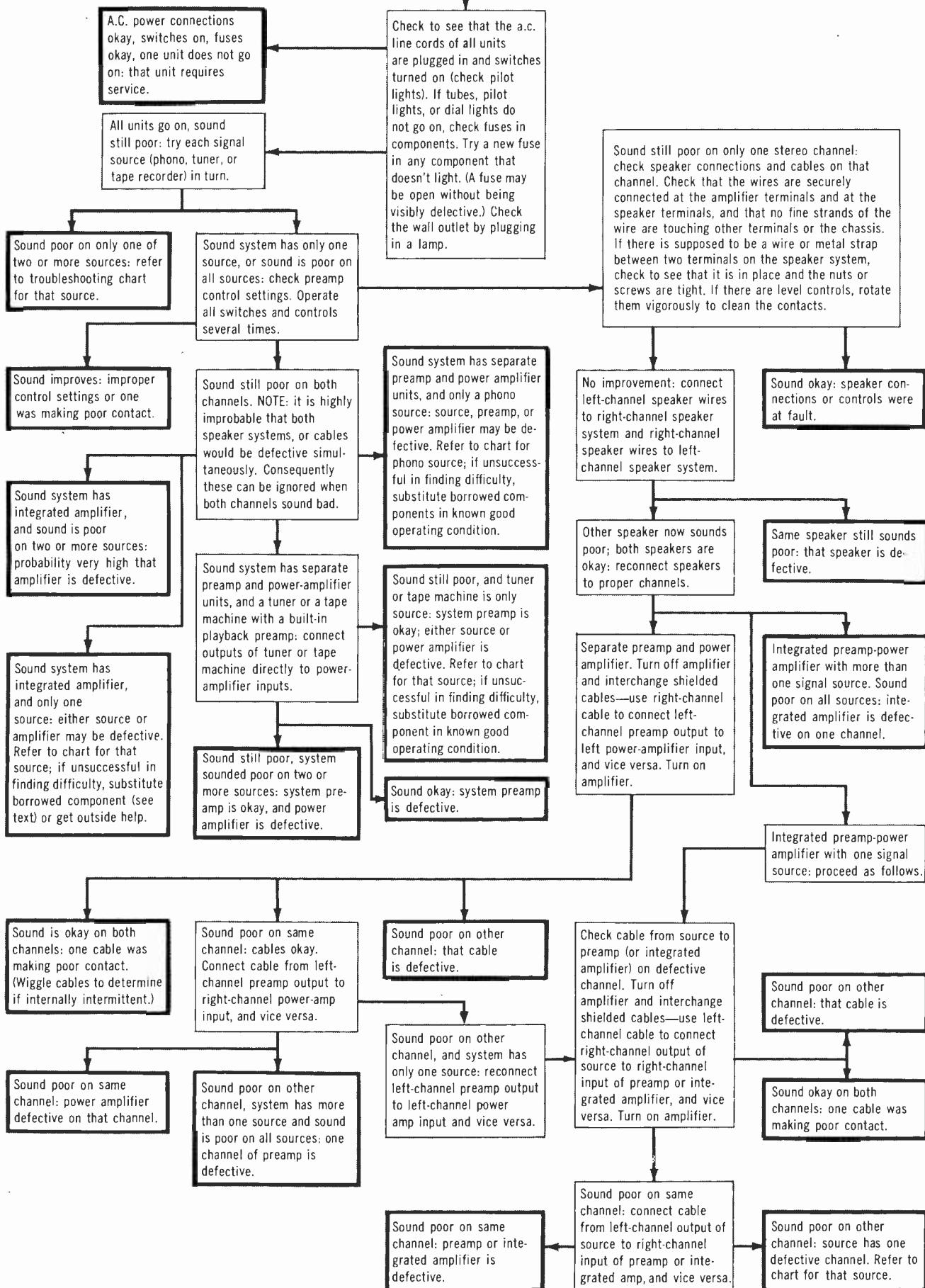


Extremely poor low frequency response.



Amplifier "ringing" at the high frequencies.

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to the changer's service manual, if you have one. If not, cautious exploration and common sense will usually turn up the trouble.

Tape recorders are similar to record changers in their mechanical complexity, and a look at the service manual is usually a must before attempting a cure for any trouble.

**REPLACING TAPE HEADS** When the tape heads are worn till the gap is plainly visible, or when the internal coil has opened up, they must be replaced, and the replacements properly aligned. Alignment requires an alignment test tape and a meter—either the recorder's own vu meter, if it is calibrated and reads output from the tape, or your VTVM.

After replacement, align the playback head. While playing the high-frequency band of the alignment tape, adjust the head mounting screws as you watch the meter until a maximum reading is reached, indicating that the head gap is more or less perpendicular to the tape's path. If the output reading falls off as you adjust the head, turn the alignment screws the other way till it rises to a peak, the point of optimum alignment, then begins to fall away again. Rotate the screws well past this peak before adjusting back up to it, since there are sometimes smaller, false peaks on each side of the true adjustment. While a full-track alignment tape will work with all heads, it is best to use a quarter-track alignment tape—this not only insures correct alignment but helps you get the tracks in the right places, too.

The record head, in a three-head machine, is adjusted similarly. While recording a high-frequency signal (7 to 10 kHz), adjust the head azimuth and monitor playback output. The record head is properly aligned when the output reaches its peak.

Last to be aligned is the erase head. Record a strong signal, of any frequency, then re-wind, turn down the record gain control, and start the tape again in "Record" mode. On a three-head machine, you need only listen to the tape output

to determine when the tape is being efficiently erased. On a two-head machine, you'll have to start and stop the machine constantly, winding back a few feet and replaying after every adjustment of the erase head's position.

**INSTRUMENTS AND TOOLS** Audio servicing requires no special tools other than your standard electronic tool kit, plus an Allen wrench and (occasionally) splined wrenches for tape recorders and some turntables or changers.

The two basic instruments used are (1) the a.c. VTVM, for standard circuit checking, and checking output voltages, and (2) a sine/square-wave audio generator for checking response. The audio generator should have a "flat" output that does not vary with frequency.

Test records and tapes are another must; a brief run-down of the test records available was given on page 100.

You can do fairly adequate audio servicing without an oscilloscope—but why limit yourself? Of all the test instruments, it's by far the most useful. You can't check square waves without a scope, nor can you check the distortion in a tape recorder's bias oscillator waveform. A scope and an audio generator together will help you track down major distortion problems. You can even make fairly accurate amplifier power measurements using only your audio generator; your VTVM; the scope; a low-resistance (4-16 ohm), high-power (15-200 watt) resistor; and an Ohm's law slide-rule.

It's a good idea for the serious hi-fi serviceman to have on hand distortion analyzers and multiplex signal generators to tell you when you've really got an amplifier or tuner working properly.

A few other gadgets that will come in handy are: strobe discs for measuring phono speed (and strobe wheels or tapes for checking tape speed), possibly with an NE-57 neon lamp to cast a 60-cycle flicker on them; a stylus-pressure gauge; a pocket stylus microscope; a supply of phono plugs; and a roll of insulated, shielded phono cable.

# **SECRETS OF SUCCESSFUL CB INSTALLATIONS**

**By JOHN D. LENK**

## **INSTALLING CB TRANSCEIVER IN AN AUTO**

Connecting to the Power Source

Automobile Antennas

Final Tune-Up

## **CITIZENS BAND SETUP FOR BOATS**

Connecting to the Power Source

Marine CB Antennas

Getting a Marine Rig on the Air

## **FIXED BASE STATION INSTALLATION**

Selecting the Antenna Location

Mounting the Antenna

The Lead-In

## **SERVICING CB EQUIPMENT**

The Antenna

The Transceiver

**A**lthough much has been written about Citizens Band (CB) equipment, it is difficult to find any one book or magazine article which gives you complete instructions on how to install a CB rig in your automobile or boat. Even the various handbooks on CB are a little vague when it comes to step-by-step installation. If you are to believe some books, a typical CB installation is nothing more than a pleasant hour's work. In real life, a CB installation—auto, home, or boat—can be a thumb-banging, knuckle-cracking, exasperating experience. With this in mind, photographs of actual installations have been provided here—photographs which will show you what the "experts" do and how they do it.

Before going into details, let's assume that you know it is not necessary to take any kind of examination for a CB license. The only requirement is to fill out the appropriate FCC Form 505 and forward it, with the \$8 application fee, to the Federal Communications Commission, Gettysburg, Pa. 17325. The rest is automatic. Let's also assume that you know a first or second class radiotelephone license is required if you make any tests or adjustments (during either installation or servicing) that would affect the transmitter frequency.

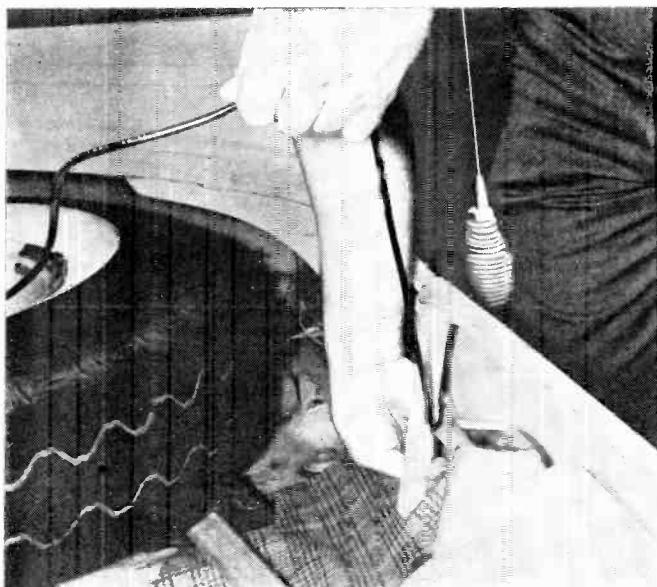
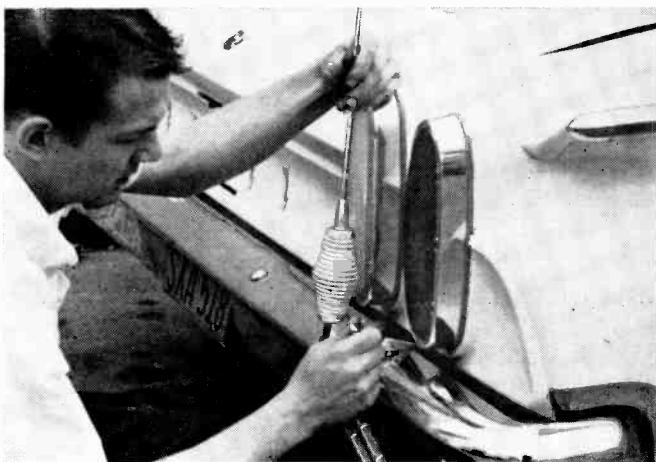
Once you have your equipment in hand—transceiver, antenna, coax cable, mobile mounts, etc.—there are four steps to getting on the air: (1) installing and mounting the transceiver; (2) connecting the transceiver to a noise-free power source; (3) installing the antenna and routing the coax cable to the transceiver; and (4) tuning the installation for maximum efficiency. These four basic steps apply to installation in an auto, a boat, or at a base station. However, each type of installation has its own problems. Let's look at the auto installation first.

## **INSTALLING A CB TRANSCEIVER IN AN AUTO**

There are two schools of thought on where to mount your auto transceiver. One (school) says that you should make a cut-out in the dashboard, and mount the transceiver behind it, perhaps in the glove compartment; the other (school) says that you should suspend it on a universal mount under the dash.

The first method has the obvious advantage of the equipment being out of the way (it won't tear off your knee cap if you should make a sudden move across the front seat), but it has several disadvantages. First, a behind-the-dash installation is difficult to service, and it will probably affect the auto's resale value. Second, no matter how well shock mounted such an installation may be, your CB transceiver will receive far more road shock attached to the dash than if it is suspended on a universal mount under the dash. Finally, making the dashboard cut-out is a major project, whereas installing a universal mount is a relatively simple job.

The universal mount usually has a number of holes



**MOUNTING A MOBILE TRANSCEIVER** Position the universal mounting frame (top) and bolt it to the underside of the dashboard. Attach antenna spring mount (above) and thread coaxial line (right) through a small hole in car body and into trunk.

spaced along the longer mounting edge for attachment to the underside of the dash. The transceiver is balanced or supported in the mount by snap fasteners or knurled thumb screws.

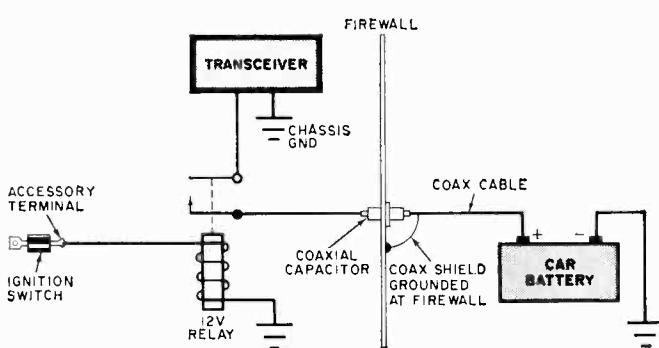
**CONNECTING TO THE POWER SOURCE** The auto CB installation is powered by the 12-volt car battery just as a conventional auto AM radio is. The average CB transceiver should consume no more power than most auto radios. However, automobile manufacturers did not have CB installations in mind when they

designed their electrical systems. There is no provision for a transceiver power connection.

This means that you must route a transceiver power lead to the (12-volt) source. But, since your CB rig is connected to the battery, it is also connected indirectly to the generator (alternator), voltage regulator, and ignition system, all of which create electrical noise that is conducted back along the 12-volt lead to the transceiver. This noise results in your otherwise clear reception being cluttered with buzzing, whining, and popping interference, unless provisions are made to minimize the noise at the time of the CB installation.

There are two methods of connecting CB mobile equipment of any kind to power. One method is to run the transceiver power lead directly to the battery, thus minimizing the effect of conducted noise from the ignition system. However, unless this power lead is shielded, noise pickup via radiation from the ignition system may be a serious problem.

The alternate method—frequently preferable—is to power the transceiver from a "switched" 12-volt source under the dashboard. This method is definitely preferable when the CB transceiver is being used by someone likely to leave an "unswitched" direct battery connection "on" all night—at least



**SWITCHED POWER CONNECTION** To prevent your CB transceiver being ON when the car is parked, wire in the above circuit. Capacitor feeds voltage through firewall and cuts down noise.

partially or completely running down the battery capacity.

You can connect the CB rig power lead to the "accessory" terminal behind the ignition switch. You should find three terminals on most ignition switches. The longest terminal is usually for accessories. If connected to this terminal, the transceiver cannot be left on inadvertently to discharge the battery.

If you decide to try a direct power connection to the battery, you can keep the noise problem at a minimum by using a shielded cable. Coax cable (such as RG-59/U) will serve the purpose. Run the coax cable from the positive post of the battery up to the firewall, cut a hole through the firewall and insert a special coaxial bypass capacitor (Sprague Type 80P3). On the other (transceiver) side of the firewall, mount a 12-volt relay, and run the main power line from the capacitor through the relay contacts to the transceiver. See diagram on facing page. Connect relay coil to the ignition switch accessory terminal so that when the ignition is off the main power to the transceiver is broken. Ground the shield of the coax at the firewall, but leave it ungrounded at the battery. Should excessive noise occur on CB receive, try grounding the shield at the battery end also, but make sure there is no short circuit.

If your CB transceiver does not have a built-in fuse, you *must* install one in the 12-volt power lead. The most convenient method is to use a line fuse holder mounted a few inches from the set. This will permit you to replace the fuse without removing the set, or without lifting the hood. Do not install any electrical equipment without a fuse. If there is a short circuit in the CB rig, or in the power line, your battery could be ruined, and you may have an electrical fire.

**AUTOMOBILE ANTENNAS** There is an infinite variety of CB antennas available for auto installation. This great variety, in itself, is cause for much confusion. However, CB mobile antennas can be divided into three classifications: (1) the quarter-wave whip; (2) shortened or loaded whips; (3) dual-purpose antennas.

The most popular CB mobile antenna is the bumper-mounted whip. Its popularity is probably due to the simplicity of installation. The spring base can be fastened to a bumper with chain links, and tightened up in a matter of minutes. From there, you screw the antenna into the spring, and route a coax cable to the transceiver. And the bumper type mount can be removed just as easily.

Unfortunately, a bumper antenna installation is not the most efficient. One reason is that the bumper antenna tends to radiate (and receive) towards the greatest mass of the car. This means that the CB signal becomes directional, and results in signal fading as you make turns.

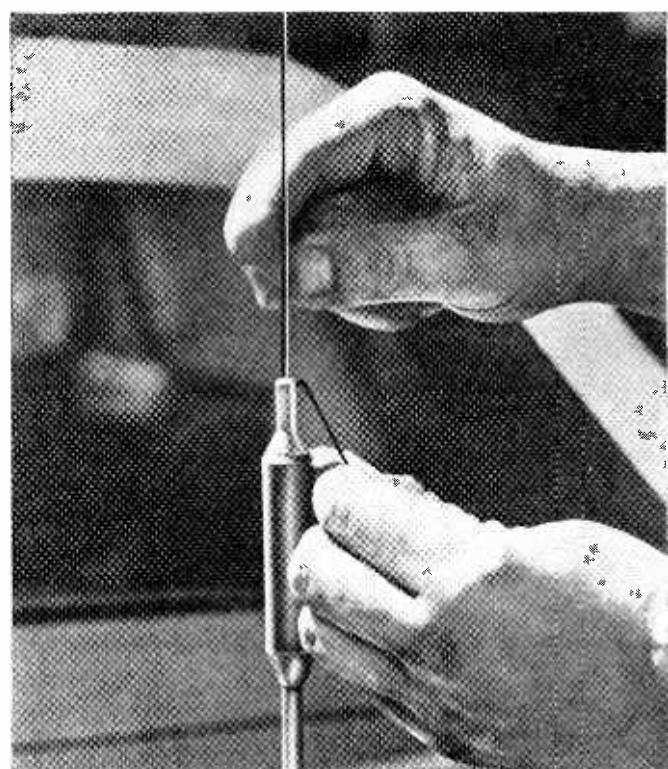
If you want maximum efficiency, and a nondirectional radiation pattern, the roof-mounted antenna is your best bet. But there are two giant snags here.

First, you generally must drill at least one small hole in the roof (non-CB wives will love this!). Even worse, you will have a "fishing pole" on your roof, which is excellent for catching beams of a low ceiling garage or carport. Antenna manufacturers are aware of this problem and short-short loaded whips (18-20") are now being offered as an alternative to the 30-40" loaded whip.

A third alternative is to install a combination CB AM antenna on the cowl in place of the regular AM receiver antenna. A coupler is used to permit the same antenna to receive AM broadcasts and the CB frequencies. The cowl antenna is "shortened" by some method of loading, but is not collapsible.

Antennas radiate and receive signals most efficiently when they are cut to the wavelength of the radio signal, or to submultiples of the wavelength (full-wave, half-wave, quarter-wave). A quarter-wave antenna for 27 MHz is 108 inches long (102 inches for the antenna, and about 6 inches for a spring mount). This is not too unwieldy for a bumper mount antenna, but it wouldn't be practical on the rooftop. So a loading coil is added to make up the required electrical length. The loading coil can be located at the top, center, or base of the antenna (and there are continuously loaded antennas besides). The base-loaded antenna is slightly less efficient, but is the most rugged. It is a matter of compromise (convenience and rugged construction versus efficiency) that will determine your choice of a shortened loaded whip antenna.

No matter what type of antenna you select, you



**ANTENNA ADJUSTMENT** Shortened whips must be carefully tuned for maximum efficiency. This A/S model MS-130 is being tuned by changing the length of the whip above loading coil.

must use coax cable to connect it to the transceiver. These cables are usually cut to a predetermined length, and are often supplied with the antenna. Your only real problem is in routing the cable from the antenna to the set.

**FINAL TUNE-UP** Once you have the CB transceiver and antenna mounted in place, and you have suppressed as much engine electrical noise as possible, you are ready to tune up and go on the air. Although the FCC Rules do not permit an unlicensed person to make any adjustments that affect transmitted frequency, there is nothing to prevent you from making adjustments to the transmitter final amplifier. The location of these adjustments on your CB rig, as well as the specific tune-up procedures for your transceiver, should be spelled out in boring detail in the manufacturers' installation and service manual. Study this manual before you attempt any adjustments. We cannot describe all tune-up procedures, but here is a summary of what to expect.\*

Make sure that the CB transceiver is putting out maximum power. The FCC allows a maximum of 5 watts input and 4.0 watts output. The best way to check true power output is with a commercial power output meter. The average CB rig has a power output of between 2.5 and 3.5 watts. If adjustments are available, tune for 3.0-3.5 watts output into a dummy load.

Next, check the resonance and power radiating ability of your antenna. Resonance means matching and in CB the item of test equipment to be used is called an SWR meter. This instrument will determine if your antenna is resonant and drawing the maximum amount of power from the transmitter. The SWR meter tells the ratio of power going "Forward" to the antenna and power being "Reflected" back down the feed line and not radiated because of lack of resonance.

Many fairly accurate SWR meters are available to CB'ers at very low prices. All SWR meters read in ratios similar to 1.2 to 1.0 and 1.5 to 1.0, meaning that there are small losses in the antenna and/or feed line. If your SWR is under a ratio of 2.0 to 1.0, your antenna is reasonably efficient. Any SWR greater than 2.5 to 1.0 is cause for concern. Obviously, the better the match, the lower the SWR; and in mobile antennas a ratio of 1.1 to 1.0 is not uncommon.

Finally, your overall operation can be checked by measuring relative field strength (RFS). This involves placing an RFS meter some distance from the antenna, and watching for an indication when the transmitter is keyed. In fact, you can walk around the antenna and check the field pattern. While relative strength is not a true test of power output or antenna efficiency,

it will permit you to tune up quickly, and will tell you that you are at peak output.

There is a wide choice of tune-up equipment available. Some technicians prefer a separate instrument for each type of measurement (maximum power, forward power, SWR, RFS), while others get along with a single instrument. The meter shown on page 114 will perform all four measurements. Remember, no matter what test equipment you select, its efficiency will be limited only by how well you learn to use it.

## CITIZENS BAND SETUP FOR BOATS

A marine CB installation is similar to an auto CB setup with a few specific exceptions. Since auto installation is thoroughly discussed above, let's mention here some of the differences you will encounter in the installation of marine CB equipment.

Where you place a marine CB rig is just as important as how you mount it. The most convenient location is not necessarily the best. For convenience, the transceiver should be near the helm. (If you were alone at sea, you wouldn't want to leave the helm to place an emergency call!)

Although the installation shown in the photos on the next page is easy to make—and is the most convenient to service—the disadvantage to this installation is that the unit is more exposed to moisture and salt spray. The transceiver would be better protected from moisture and spray if it were mounted below, in the forward compartment. But some CB transceivers are "spray-proofed" and specially protected from moisture and salt spray.

The next thing to think about in locating your marine CB unit is the fact that it must be connected to both the power source and the antenna. For best results, the length of both the power lead and the antenna lead-in should be kept to a minimum. This doesn't make too much difference in a small boat, but could be a problem for a large craft.

Finally, a marine CB unit must be installed on a shock-absorbing mount. Generally, a marine transceiver is subjected to more shock and vibration than an auto installation. There is no way to avoid this, but you can keep the shock effects down to a minimum. A good bet is to suspend the unit from an overhead beam with shock mounts. This will give you maximum protection.

**CONNECTING TO THE POWER SOURCE** A marine CB unit is usually powered by the boat's battery, which may be an auxiliary or, more likely, the engine's battery. No matter which power source you choose, make certain that there is a fuse in the line from the CB unit to the power source. An unfused set is a particular hazard in marine use. A short in the set, or in the power line, could cause a fire. Most CB units have built-in (or in-line) fuses, but a few do not.

If you have had any marine electronics experience,

\*Many solid-state CB transceivers have no final amplifier adjustment within reach of the installer. These CB rigs are carefully tuned at the factory and when properly connected to a good antenna rarely, if ever, require further adjustment.

you are aware that the engine interference and electrical noise problem is far worse on a boat than in an automobile. An auto engine is surrounded by a natural metal shield consisting of the hood, body, and firewall. A marine engine is usually surrounded by wood, and nothing else. This creates some excellent noise problems, which are discussed in Chapter 7.

**MARINE CB ANTENNAS** The big difference between an automobile CB antenna system and one for marine use is that you must conjure up an adequate radio ground for your boat. In either case, you do not use an actual earth ground as you could in a base station CB installation, but you must have something comparable to a large mass of metal to provide the same

effect. In an auto installation, the automobile body serves this purpose. If your boat has a metal hull, your problem is solved by connecting the CB rig ground lead to the hull. Unfortunately, most pleasure boats have wooden or composition hulls. This means that you must improvise a ground.

On boats that are used for hire, the FCC requires that the medium frequency radiotelephone ground be made up of metal sheeting (or similar material) mounted below the waterline, and in contact with the water. In this setup, the metal sheeting combines with the surrounding water to provide an effective ground. However, such an arrangement means that you must cut holes in the hull. Most boat owners would rather walk the plank! But there are alternatives.



**MARINE CB INSTALLATION** Position the antenna mount (above, left) so that the antenna will be in the clear when erected, but may be tilted for servicing or passing under bridges. For convenience, locate the transceiver at the helm (top). Tune the antenna (left), and as a final measure, be sure all connections are secure (above) and all holes caulked.

One way out is to use a commercial ground plate. Such plates are much smaller than the typical commercial ground installation, but make up for the lack of mass by using porous metals. However, the plate must be secured to the hull, and a ground lead must be routed to it.

An alternative to the ground plate is the 8" ground tube sold by Heath (MD-14). A hollow tube will provide approximately double the water contact area of a solid rod of the same size (water passes inside and outside the tube surface). Of course, you must still route a lead to the tube mounted on the outside of the hull.

Another possible ground system is the installation of wire mesh or screen material within the hull, or below the foredeck (if that is where the antenna is to be mounted). This arrangement does not require holes in the hull, and it does provide a metal mass, but it is a difficult installation to make, and is not used too often for that reason.

The easiest ground system to install, and the one which is the most commonly used (but not the best), is achieved by connecting the transceiver ground lead to the engine. In this way, you get a large metal mass and, since the shaft and propeller are below the waterline, you get contact with the surrounding water. The choice is up to you, but you *must* improvise a ground for really good marine CB operation.

As for the CB antenna itself, you will want to get the radiating element as high and as free from obstructions as possible. At the same time, you must have the antenna mounted so that it is rugged enough to withstand the vibration and pounding of normal cruising. A variety of antennas are specifically made for marine CB installation. A typical installation was shown on the preceding page.

Whatever type of antenna you install, remember to keep it high, and make certain that it is securely mounted. In heavy seas, CB antennas have been known to pull the woodscrews or bolts from the deck mount. We needn't discuss the results!

**GETTING A MARINE RIG ON THE AIR** Tune-up of a marine CB unit is essentially the same as that of an automobile CB transceiver. Tune the transmitter final amplifier for peak power output into a dummy load. Then connect the antenna and tune the antenna (if possible) for minimum SWR. If your antenna's radiating element (length) is adjustable, you can vary the length to get minimum SWR. As a final test, make a check of the antenna's radiating pattern with a relative field strength meter.

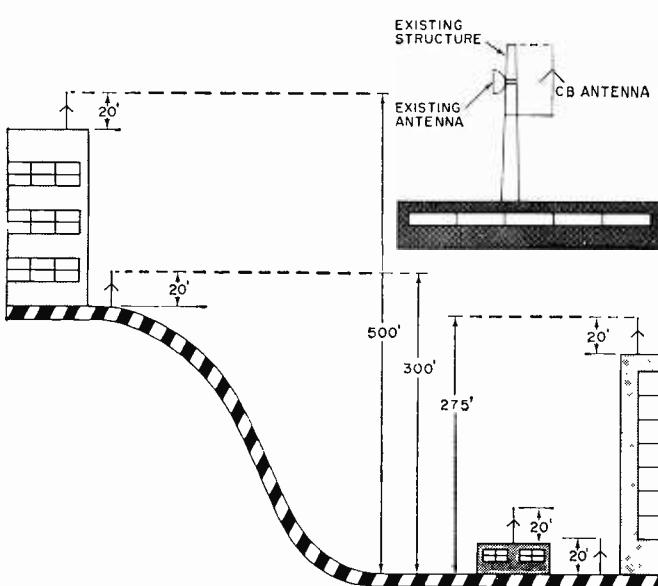
## FIXED BASE STATION INSTALLATION

The only installation problem of consequence in a base station concerns the antenna, both in mounting it and in routing the coax cable. Mounting the transceiver and connecting it to a power source should offer no problem at a base station. Usually, the transceiver is mounted at any convenient location. Often it simply sits on a desk, table, or kitchen counter, and is connected (plugged in) to the 117-volt a.c. house power. There are exceptions, of course, and you may want to hide the transceiver behind a panel or in a cabinet. In that case, the mounting falls into the domain of the home carpenter.

The installation of a base station antenna involves planning—or it should if you want to do a good job. Even though you will buy a manufactured antenna, there are many variables in every CB installation, so each base station antenna must be considered a custom job.

**SELECTING THE ANTENNA LOCATION** The first point to be considered is the antenna height limitation. Keep in mind that the top of your antenna must not be more than 20 feet higher than the highest point on the building or existing structure on which the antenna is mounted. The height limitation drawing shows some typical examples. One major exception to the 20-foot height limitation is when a CB antenna is mounted on an existing antenna structure. But the CB antenna must then be no higher than the existing structure.

The next step is to select the proper mounting location for the antenna. All other factors being equal, the highest possible location is the best location (provided you don't exceed the FCC limits). But there are other considerations. For instance, the highest spot may be inaccessible (or worth your life to reach it!), or there may be obstructions surrounding the highest point, such as another building, trees, antennas, power lines, etc. Likewise, the highest spot may be a structure that is not strong enough to sup-



**ANTENNA HEIGHT RESTRICTIONS** The FCC regulations restrict the height of a CB antenna so that the tip is not more than 20 feet above ground level or the building to which the antenna is attached. If you live on a hill, you're in luck.

port the weight of the CB antenna. Most CB antennas offer quite a bit of wind resistance. Consequently, the structure to which you attach the antenna mast, and the guy wires, must be sturdy.

The routing of the coax transmission line should also be considered when picking a location for the antenna. All coaxial cables have some loss; the longer the cable, the greater the loss. You might find a location that would put your antenna high and free of obstructions, but which would require an exceptionally long run for the coax cable feed line. In this case, the coax losses could offset the benefits of a good location.

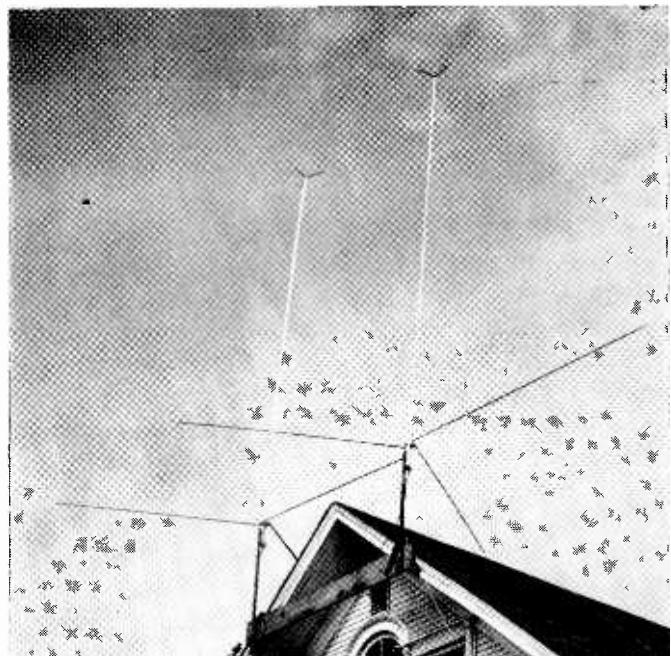
**MOUNTING THE ANTENNA** Once you have selected a spot for the CB antenna, you get down to the business of making the installation. Actually, installing the antenna should not be too difficult a task—but much depends on the mounting location. Sometimes a CB antenna is bulky and unwieldy, even though it may not be heavy. Assemble most of the antenna on the ground. A sloping rooftop, or a flat apartment house roof with a tangle of TV lead-ins is not the place to assemble even the simplest of Citizens Band antennas.

Don't hesitate to call in plenty of help. Even if your assistants can't give you any direct help, they can hand you wrenches, pliers, etc., as needed. Once the antenna is assembled, you should scramble to the roof and set up the mounting brackets. Then, have those on the ground pass you the antenna. Do not carry the antenna to the roof by yourself. Most CB antenna manufacturers provide detailed assembling instructions. Follow these instructions as if they were hammered out on stone tablets. Remember the rule: "When all else fails, follow instructions."

Many local safety codes require that the antenna mast be grounded, thus providing some lightning protection. Lightning follows the easiest path to ground, which is often through the antenna, and down the coax lead to your transceiver.\* Most electrical safety codes require a good earth ground, such as a copper ground rod which is driven six or seven feet into the earth.

One of the most popular and most convenient methods of mounting a CB antenna is to strap it to a chimney using a TV antenna mount. If you do not have a convenient chimney, do not despair; there are special brackets for ridge roofs, peak roofs, and flat roofs, and for mounting an antenna directly to the wall of a building or under the eaves.

Any mast over 10 feet high and shorter masts with heavy loads, such as a beam antenna, must be supported by guy wires. One end of each guy wire is fastened to a hole in a ring that fits around the mast and is fastened to the mast with a clamp. The bottom



**DIRECTIONAL CB ANTENNAS** Power output restrictions imposed by the FCC have brought about significant refinements in antenna design. This Hy-Gain CLR-2 installation consists of two identical antennas fed through a "Co-Phaser." Without rotating these antennas, the base station can change the radiated signal pattern to increase signal strength and cut out QRM.

end of each wire is anchored with an eyebolt or hooks. At least three wires are needed to maintain equal tension around the mast. Support the mast at a minimum of two points. As a rule of thumb, at least one-fourth of the total mast length should lie between the two supporting points.

**THE LEAD-IN** Support the coax lead-in from the point where the coax attaches to the antenna down to the point where it enters the building. The coax lead can be taped to the mast or supported with standoffs. If the lead-in is left to hang free, it will flap in the wind and eventually break or rupture.

One of the most troublesome spots in any installation is the point where the coax passes into the building. A hole must be drilled through the building, the cable inserted, and the remainder of the hole filled up to waterproof the cable entry. This can be done with putty, or a plastic sealing compound.

Never attempt to splice a coax cable. Make sure the cable is long enough before you start. If the CB antenna is mounted on a rotator, as is a beam antenna, allow enough play in the cable to account for a 360° turn of the antenna.

If a hollow tube or pipe is used for the antenna mast, do not allow the bottom of the tube to rest directly on the roof surface. Leave room for the rain water going down inside the mast to escape.

One final word: If you do not own the building, get an okay from the owner before you start installation. It is possible to install an antenna without any damage to the roof, but it may be difficult to convince the owner of this fact.

\* Some CB antennas are electrically designed so that the uppermost element is always at ground potential and other antennas include a sheath to bleed off static electricity. Special lightning arrestors for CB or ham antennas are also sold by most radio jobbers.

## SERVICING CB EQUIPMENT

You may not legally service the transmitter portion of your CB transceiver unless you hold an FCC radio-telephone license (second class or better). But you can check the antenna, power source, and receiver portion of the transceiver, and you can make a limited number of final amplifier adjustments.

Generally speaking, it is not advisable for you to open your CB transceiver and attempt to replace any non-plug-in parts, unless you are a competent electronics technician—no more than you would tear down your automobile engine unless you were a fair auto mechanic.

**THE ANTENNA** Once your antenna is properly installed, and has been tuned for minimum SWR, it should require very little "service" in the true sense of the word. Of course, the antenna and coax lead-in should be inspected at regular intervals for obvious damage and corrosion at the terminals. However, the best test of an antenna is whether it produces a reasonably minimum SWR across the CB frequencies. Periodic SWR checks are in order. Many of the better equipped CB stations leave a SWR meter connected in the coax transmission line at all times, thus providing a constant check on the performance of the antenna.

**THE TRANSCEIVER** If your CB transceiver is totally inoperative, the first step is to check the power source. This can be done with a voltmeter. Usually, the base station power source will be 112-118 volts a.c. If the voltage is low (below 108 volts), it is possible

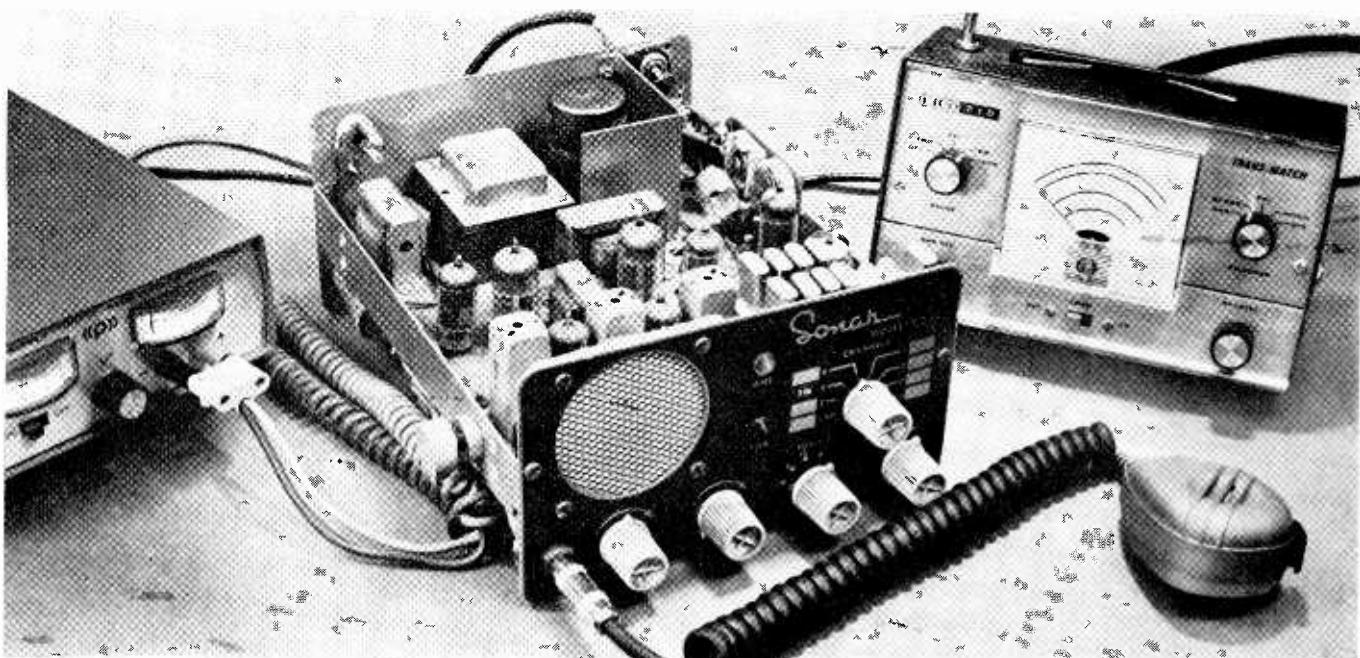
that some transceivers will not operate properly. Most transceivers will operate with an input of from 110 to 120 volts, but some units may exhibit poor performance if the voltage is on the low limit borderline. Most mobile power sources will be 12.6 volts d.c. from the engine battery. Here, a low voltage will usually show up in other ways.

Once you are sure that the power source is okay, check for a blown fuse. Never replace a fuse with one of a higher rating. If the transceiver pilot lamp goes on and stays lit, you can be sure that the power source and fuse are okay. Do not continue replacing fuses if they blow immediately after replacement. Determine the cause of the trouble first.

If your mobile transceiver uses a vibrator (which is likely if it has vacuum tubes and operates on 12 volts d.c.), try replacing the vibrator when you replace the fuse. Vibrators will "stick" and blow out fuses. If the fuse blows with a new and presumably good vibrator, give up—you have serious trouble—and consult a technician.

If the transceiver is operative, the next step is to determine if the trouble is in the transmitter or receiver portions, and if the trouble is on one or all channels. If the trouble is on one channel only, the most likely cause is a defective crystal. Try replacing the crystal for that channel.

If the trouble appears to be in the receiver, try testing the receiver tubes. The same procedure can be applied to the transmitter portion. However, assuming that you find and replace a defective transmitter tube, it is likely that you will have to re-tune the transmitter circuits. This requires an FCC license. However, a tube replacement will frequently put you back on the air—even if only on a temporary basis.



**SERVICING SETUP** This Sonar CB transceiver had given years of faithful service before popping its first vibrator. While it was on the bench, the technician replaced the vibrator with a solid-state substitute. The transceiver was air-tested for mobile operation using a PACE 5803 power supply and the EICO 715 "Trans/Match." Modulation percentage was upped by substituting an E-V/American D-501K microphone with built-in transistorized amplifier and speech clipper. Then the unit was ready to go again.

# **WHAT TO DO ABOUT YOUR AUTOMOTIVE ELECTRONIC EQUIPMENT**

**By JOHN D. LENK**

## **RADIO NOISE INTERFERENCE**

What Causes Ignition Radio Noise  
Suppression at the Spark Plugs  
Shielding Systems

## **GENERATOR**

## **ALTERNATOR NOISE**

Noise Filters for Ignition Systems

## **ELECTRONIC IGNITION SYSTEMS**

Transistorized Ignition  
The CD System  
"Breakerless" Systems

## **ELECTRONIC ACCESSORIES**

The Tachometer  
Voltmeter and Ammeter  
Tune-Up Instruments

**T**he scope of automotive electronics has expanded in the past years so that it is no longer limited to installation and servicing of the AM radio. Electronic ignition systems, two-way communications equipment, and engine monitoring accessories are available to every motorist. Electronic tune-up equipment—once limited to professional usage—is offered in kit assemble-it-yourself packages, and is available in numerous low-cost models.

Generally speaking, the buyer receives detailed installation and use instructions on his automotive electronic accessories. However, these instructions rarely tell anything about how the device operates and even less about how the device should be serviced or repaired. This chapter explores the "gray" area of preliminary servicing, tells what can be repaired and what should be replaced, and discusses some of the lesser known facets of automotive electronics.

## **RADIO NOISE INTERFERENCE**

The increasing use of two-way communications equipment in automobiles has accentuated the problem of curbing radio noise interference. The major portion of most interference comes from the ignition system. To find out if your noise problem is caused by ignition interference, check the noise level with the engine on and then (under identical conditions) with the engine off. When making this test, turn off the squelch and noise limiter (if possible), and adjust the audio level until you can hear a steady background noise. It is sometimes handy to tune in a weak radio signal and adjust the audio until it is just audible. Then turn the engine off and note if the noise level drops appreciably, or if the weak signal is suddenly crisp and clear. If there is any noticeable difference between the engine-off and engine-on conditions, you should look first into the ignition radio noise problem.

**WHAT CAUSES IGNITION RADIO NOISE** There are three sources of radio noise generated by the ignition system. First, and probably the worst, is the high-voltage secondary circuit. This circuit includes (see Fig. 1) the distributor rotor, spark plugs, and ignition coil secondary winding.

Next in possible noise generation is the low-voltage or primary ignition circuit consisting of the distributor points, "condenser," and ignition coil primary. Last, though not a direct part of the ignition system, is the generator and voltage regulator circuit.

The distributor points are opened and closed by a cam at a rate determined by the engine speed. When the points close, a 4-6 ampere current flows from the battery through the ignition switch, distributor points, and primary winding of the ignition coil. The current flow sets up a magnetic field around the ignition coil. The magnetic field collapses when the points open and the contraction of the magnetic field induces a voltage in the ignition coil secondary wind-

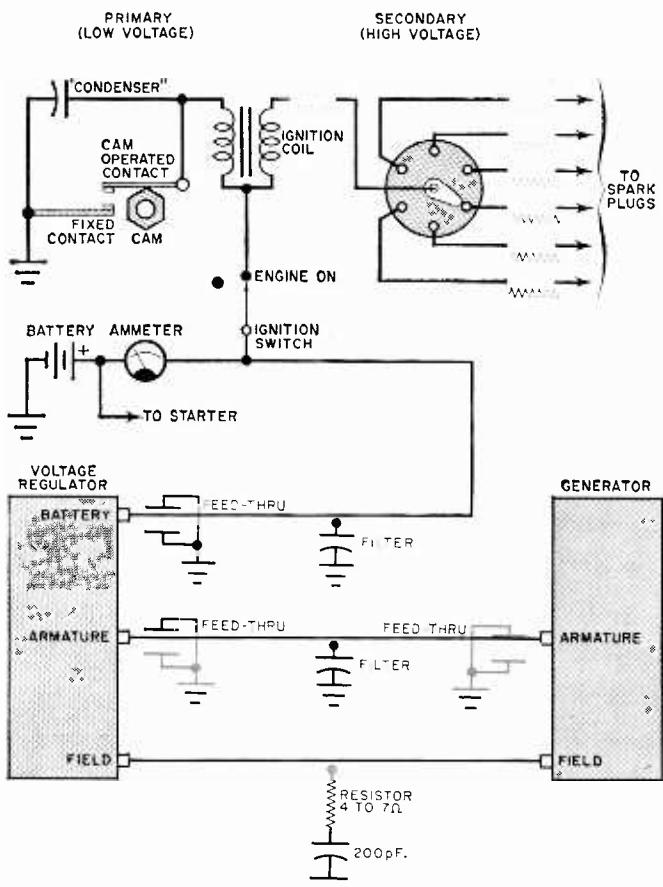


Fig. 1. There are three possible sources of radio noise associated with the ignition system. The worst source is the ignition high voltage circuit to the spark plugs where interference may be curbed through the use of suppressor resistors. The generating and regulating system produce radio noise, but of considerably less amplitude. Feedthrough capacitors and filters will suppress most of the interference from these sources.

ing. Because the secondary winding has many more turns than the primary (usually a ratio from 50:1 to 100:1), the voltage fed the distributor is 10,000 to 20,000 volts, or higher. This high voltage (low current) jumps the spark plug and the corresponding distributor rotor gap. Consequently, there are two high-voltage arcs or spark gaps each time a spark plug fires.

In the early days of radio, the spark gap was used as a radio transmitter. Electromagnetic waves are created whenever a spark jumps a gap and radio waves generated in the ignition system can be picked up by your receiver. So now what can you do about it? Obviously, you can eliminate sparking by stopping the engine each time you want to use your two-way gear.\* But that's not the answer—you must attack the problem in three ways: spark suppression, filtering, and shielding.

**SUPPRESSION AT THE SPARK PLUGS** Spark suppression systems are based on three facts: (1) although it requires a high voltage for the spark to

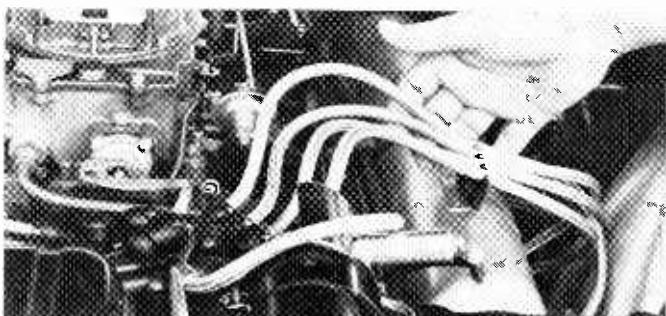
\*The "efficiency" of spark plug radio interference is worse at the higher radio frequencies than around the AM broadcast band. Interference is particularly bad between 20 and 30 MHz.

jump across the gap of a spark plug, there is very little current flow; (2) the amount of radiated spark interference is proportional to the current; and (3) if a high resistance is placed in series with the spark plug and distributor, the current can be lowered without lowering the voltage. A high value resistance in the spark circuit gives us the same spark for firing the engine, but reduces the radiated noise in proportion to the reduction of current. In actual practice, this is accomplished by installing a suppressor at the distributor and on each spark plug.

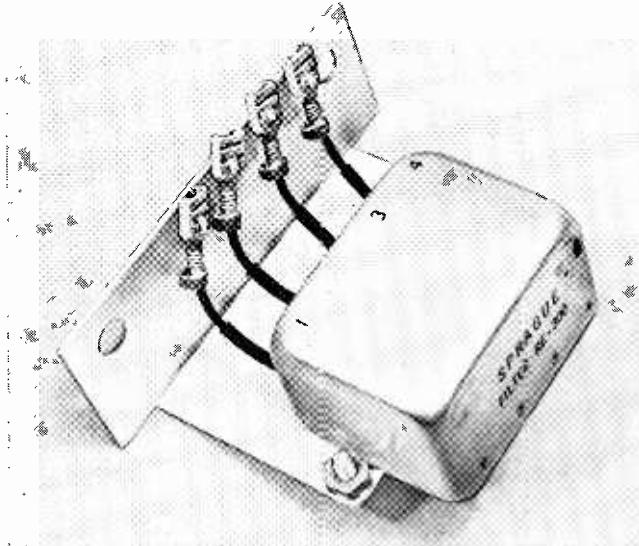
These suppressors consist of a resistor encased in a tubular insulated housing. You need only lift the ignition lead from the spark plug, place the suppressor on the spark plug, and couple the ignition lead to the suppressor. To install a distributor suppressor, pull the high-voltage wire out of its socket in the distributor cap, and insert the suppressor. Then plug the wire into the socket in the suppressor.

Although suppressor resistors are effective, you may encounter one drawback in their use. Even if you do reduce the current (and consequently the radiated noise), the remaining current will still produce some noise. If you add sufficient resistance (with suppressors) to eliminate all objectionable noise, it's possible that the current could be lowered to the point where the engine's timing or ignition characteristics might be impaired. So it's quite possible that you will require additional interference suppression in the form of shielding (for radiated noise) and filtering (for conducted noise).

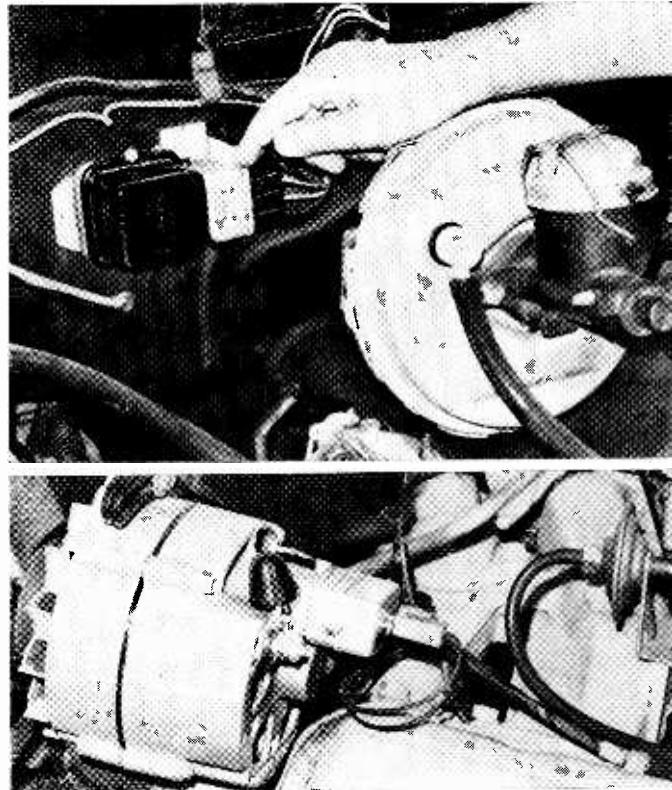
**SHIELDING SYSTEMS** Just as in the case of radio waves, electrical noise can be prevented from indiscriminate radiation by surrounding the noise source with a metal shield. Actually, there would be far more ignition interference on all mobile equipment were it not for the fact that the metal firewall and body form a natural shield separating the engine and radio receiver. However, the radiated interference in the engine compartment is picked up by power wiring and conducted through the firewall to the electronic equipment. The only sure way to prevent radiated interference is to surround the source and block the radiation. That is what mechanical shielding systems try to do.



**SPARK PLUG SHIELDING** A complete shielding kit, such as this Hallett installation, consists of metal shields for plugs, braid for plug wiring, and capacitors for the ignition coil.



**ALTERNATOR SUPPRESSION KITS** The most effective method of suppressing the whine from your alternator is to install a Sprague "Suppressikit." Be sure to get the kit that fits your car—models are available for General Motors, Chrysler, and Ford vehicles. The kit has two parts; one filter network plugs into the alternator, and second filter (above) is mounted under voltage regulator and wire leads attached to input and output terminals. Installation time is about 15-20 minutes.



Shielding may be complete or partial. A complete shielding kit consists of metal shields for the spark plugs, high-voltage wiring (from the plug to the distributor), distributor cap, ignition coil, and possibly the voltage regulator. Prefabricated systems are higher in cost than the partial shielding systems since it is necessary for the manufacturer to design parts that will fit every make and model of engine.

A typical partial shielding kit consists of spark plug shields, several feet of shielding braid, a distributor cap shield, and shield for the ignition coil with coaxial filter capacitors. These kits are sold with step-by-step instructions for installation. (Filtering will be discussed following the paragraphs on generator/alternator noise.)

## GENERATOR/ ALTERNATOR NOISE

The automotive generator/alternator is powered by the engine, and produces a continuous output of direct current at a voltage slightly above that of the system battery. This voltage is applied through the voltage regulator to charge the battery. The regulator functions to cut in the generator/alternator output each time the battery is discharged below a fixed operating point, and to cut out the generator when the battery has been fully recharged. The regulator can itself be a source of noise due to "buzzing" or intermittently operating contacts. It also distributes noise from the ignition system to the power wiring.

Generator noise is caused by the spark which occurs between the generator brushes and armature.

Although an armature brush spark is normal for any generator, the spark's noise amplitude will be increased if the armature is worn or dirty, or if the brushes are improperly seated. Naturally, the greater the spark, the more noise that will be generated.

Many automobiles use alternators which produce alternating current instead of direct current. This alternating current is rectified into direct current for use by the battery and power system. An alternator produces far less electrical noise than a generator because it uses slip-rings, rather than an armature and brushes. This results in less sparking (and noise).

**NOISE FILTERS FOR IGNITION SYSTEMS** There are three basic types of noise filters: filter capacitors, radio-frequency chokes, and wave traps. Filter capacitors are the most common and, except in special instances, the most effective.

Although there are many types of filter capacitors, the most common are the non-insulated, and the feed-through coaxial types. In the non-insulated variety, a protruding wire is connected to the "hot" side of the circuit, while the mounting lug is fastened to the automobile chassis ground.

In the feedthrough type, the circuit line to be filtered is passed through the capacitor somewhat like the inner conductor of a coaxial cable, while the metal outer case is grounded. Thus, the inner conductor acts as part of the line to pass direct current, while the outer conductor bypasses the noise to ground. Feedthrough capacitors are often used in conjunction with shielding where it is necessary to pass the line out of a shielded area.

## ELECTRONIC IGNITION SYSTEMS

The basic automotive ignition system has been in general use for over 50 years—and is still employed in most cars. However, the modern gasoline engine requires a higher secondary voltage to fire the spark plugs (due to increased engine compression ratio) and to operate efficiently at high revolutions per minute levels. When transistors became widely available, a number of electronic ignition systems were devised to overcome the disadvantages of standard ignition circuits.

Electronic ignition systems have undergone many developments and, as of this writing, the capacitive discharge (CD) system is proving the most reliable and efficient. However, you should also have an understanding of other systems in use, and those that may be used in the future.

**TRANSISTORIZED IGNITION** In its simplest form, a so-called "transistorized" ignition is very similar to the conventional ignition system. The difference between the two is that in the conventional circuit the ignition coil current flows through the breaker points, while in the transistor circuit coil current flows through a switching transistor which is triggered "on" or "off" by the action of the points (see Fig. 2). The switching

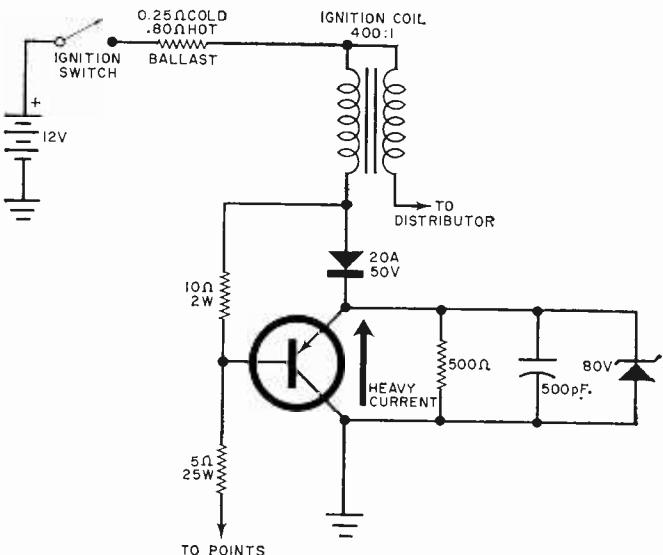


Fig. 2. Circuit diagram of a typical transistorized ignition system. Because the transistor can handle a much higher current flow than the distributor points, the transistor is used as an off-on switch. The higher turns ratio in the ignition coil results in a higher spark voltage at the spark plugs.

transistor carries the heavy current that erodes the points in a conventional system. With higher current switching capability available, the ignition coil was redesigned to a higher turns ratio, thus producing a much higher output voltage.

## TRANSISTOR IGNITION TROUBLESHOOTING TABLE

SYMP-TOM	TEST	INDICATION	PROBABLE CAUSE	REMEDY
No spark	Disconnect lead from unit to breaker point; unplug lead from center tower of distributor; turn on ignition switch; arrange hot coil lead with $\frac{1}{4}$ -inch spark gap to engine block; connect point lead, through 0-10 ammeter, to ground; measure voltage from transistor emitter to ground and note point current; remove ground lead from ammeter and look for simultaneous spark at hot coil gap; again measure voltage from emitter to ground; turn ignition off	Point current is between 0.25 and 1.0 ampere; first voltage reading is less than 1 volt; second reading is 12 volts; spark occurs when point-lead ground is lifted  Point current same as above; no spark occurs; both voltage readings are 12 volts  Same as above except that both voltage readings are less than 1 volt  Point current less than 0.25 amp; no spark occurs  Point current greater than 1 amp; other indications normal	Defective distributor rotor or cap, broken breaker points, fault in wiring harness  Open transistor, broken wire in unit  Shorted transistor or open coil primary; broken connection  Open connection in unit; defective transistor  Emitter-to-base short in transistor together with burned points	Replace or repair defective part  Replace transistor; repair broken wire  Use test 2 to determine whether coil or transistor is at fault; repair connection  Check transistor and replace if defective; repair connection  Replace both transistor and points
	Measure continuity with ohmmeter from one coil primary terminal to other primary terminal	Approx. 1.5 ohms  Open circuit	Coil in good condition  Coil primary open	Check transistor, replace if defective  Replace coil
	Measure coil current with 0-10 ammeter in primary lead	5 to 10 amperes  More than 10 amperes	Normal, coil good  Coil primary shorted	Check transistor and wiring  Replace coil
Miss at low engine speeds	Same as test 1 above	Same as test 1 above	Defective wiring, distributor, or point; ballast resistor has changed value	Repair or replace defective components
Miss at high speeds	Same as test 1 above	High point current, otherwise normal	Emitter-to-base short in transistor	Replace transistor

Most transistor ignition systems consist of two units (coil and electronic switching components), while a few have the whole system built into special ignition coil housings. In some systems, the ignition coil must be substituted for one with a higher turns ratio, while in other systems the original equipment coil is used. Installation of most electronic ignition systems is relatively simple.

**THE CD SYSTEM** While the simple transistorized ignition systems minimize point wear, they are not as efficient as the capacitive discharge ignition circuit. Even when the older transistor systems permitted use of higher turns ratio ignition coils, they could not compare with the storage efficiency of a fairly large value capacitor similar to the electronic strobe used by photographers for years.

Most CD ignition circuits use a silicon-controlled rectifier (SCR) to discharge the capacitor. A block diagram of an SCR-controlled CD system is shown in Fig. 3. In this circuit, a two-transistor d.c./d.c. converter steps the 12 volts from the battery up to about 250-400 volts. This voltage is used to charge the capacitor. The higher the voltage or the larger the capacitor, the "hotter" will be the ignition spark. At the proper time, the SCR is triggered by the breaker points and the capacitor is discharged through the ignition coil primary.

A CD ignition system has three major advantages over the older transistor systems: (1) it uses much less battery power; (2) it always delivers the same output regardless of weather or climate—since its output is independent of battery voltage, which drops off in cold weather; and (3) it is capable of literally blasting through lead fouled on aged spark plugs. When a spark plug won't fire on a CD system, that plug is far beyond hope for operation in any system.

While the CD circuit is complex, commercial units are now available for between \$50 and \$60, which is about the cost of the best ordinary transistor ignitions. Installation and service of the CD system is simpler since the original ignition coil is used. In fact, in the rare event of breakdown, the system can be changed back to an original equipment system in a couple of minutes. As in the case of any transistor ignition unit, it is best to keep the box containing the switching components as far from engine heat as practical, preferably where there will be a flow of air.

If your CD ignition system fails, first check all wiring to eliminate the possibility that you have a broken connection. Next, disconnect the ignition coil wires and apply 12 volts to the CD unit's input (you'll have to trace out the proper leads—be careful about polarity since a mistake may cost you two transistors) and listen for a very faint high-pitched whine from the unit.

If you hear the whine, the d.c./d.c. converter is operating properly, which means that the trouble is probably either a defective storage capacitor, a blown SCR, or bad components in the triggering circuit. If

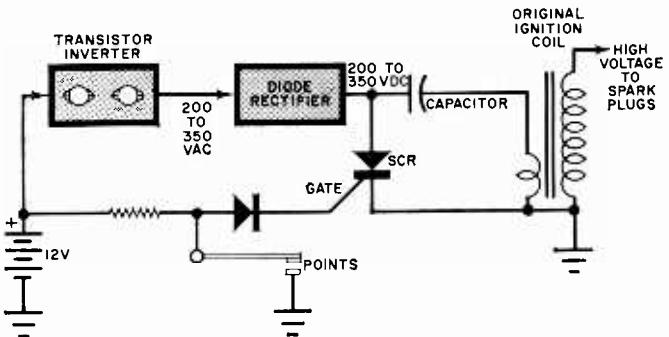


Fig. 3. The two most popular capacitive discharge ignition systems employ a circuit similar to the one in this block diagram.

the whine is missing, open up the unit (if possible) and disconnect the transformer leads from the diodes. If this brings the converter back into operation, check each diode with an ohmmeter, measuring diode resistance in both directions. A shorted diode will prevent operation of the converter. With or without the whine, the only practical way to find the fault is to trace the circuit with the aid of a wiring diagram and make the necessary part substitution.

**"BREAKERLESS" SYSTEMS** A number of ignition systems are being developed to eliminate the need for the conventional distributor breaker points. Actually any device that will close a circuit and produce a voltage or current pulse at the right instant can be used in place of points. Both magnetic pickup and photocell distributors are being manufactured in small quantities.

In a magnetic-pulse "breakerless" system, the distributor rotor shaft has a 6- or 8-point star-shaped wheel made of iron. This wheel rotates in front of the pickup coil, and every time one of the star's points moves across the field of the coil, a pulse is produced. This pulse is amplified and is used to trigger an SCR-controlled capacitive discharge system.

The photocell breakerless ignition system uses a special long-life bulb mounted in the center of the distributor shaft. A slotted shutter rotates around the bulb. A photocell is located in the rim of the distrib-



INSTALLATION of any CD system is simplicity personified. In this typical installation, unit is mounted on the fender.

utor. As the shutter wheel turns, the slots in it allow light to reach the photocell. Each time the light hits the photocell, it produces a pulse which results in the firing of the ignition system.

While the magnetic pulse and the photocell circuits eliminate breaker points, the advance of spark timing to suit various engine speeds is still done mechanically. However, a British laboratory has developed a technique to do even this by electronics. Spark-advance adjustment from the driver's seat, while the car is in use, eliminates all mechanical linkages involved in timing of the spark. This circuit is not commercially available at this writing, but the basic principles are very similar to the breakerless ignition systems described above.

## ELECTRONIC ACCESSORIES

The automatic headlamp dimmer, introduced more than 20 years ago, was one of the first electronic accessories offered for automobiles. It senses, through a photocell, the approaching headlights of an oncoming vehicle, and switches the headlamps to "dim" or "down" position as the two vehicles pass. Dimmers are sold as optional factory extras, and most of them in use even today are of the factory-installed type (although at least one model is available for do-it-yourself installation and several have been described in home construction magazines).

Installation of a dimmer is simplicity itself. The sensing unit is placed in position on the dashboard where it can "see" oncoming traffic. Normally, the unit is activated only when the lights are turned on. Shield the area so it "sees" the same view as the driver. The control unit is then wired into the dimmer switch circuit so that the headlights are always on "low" or "dim," unless the field of view of the sensing unit is in virtually complete darkness. No power switching is needed, since power is obtained from connection to the dimmer switch, and the sensing unit is activated only when the lights are turned on.

Servicing a headlamp dimmer is best done by a factory-trained technician, primarily because of the rather tightly crammed packaging of most dimmers. The most common trouble is lack of sensitivity, i.e., the lights do not dim soon enough for an approaching



THESE Sprague 3-terminal network feedthrough capacitors will bypass noise pulses to ground in a mobile installation. Bulkhead and flush mounting capacitors are both available at numerous radio distributors and stores.

vehicle. This is usually due to a weak photocell, which should be replaced with an exact duplicate.

**THE TACHOMETER** This is one of the most popular automotive electronic accessories. An electronic tach is basically a pulse counting device. Every time the ignition system produces a spark, a pulse goes to the tach. The faster the engine is running, the more frequent these pulses. All that is necessary to get an accurate indication of engine speed is to count the frequency (number) of the incoming pulses.

A basic tachometer circuit using a single zener and a pair of matched diodes is shown in Fig. 4. Some units use transistors and some eliminate the diodes. Here's how this basic circuit operates: In a conventional negative ground system, when the points close, capacitor C1 discharges through D2, the points, and

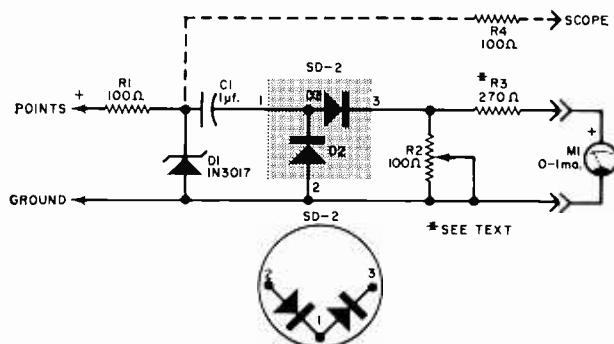


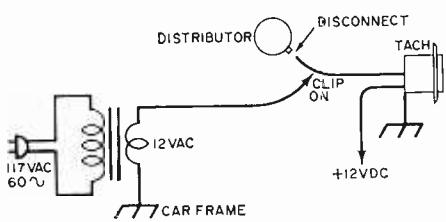
Fig. 4. This tachometer originally appeared as a construction project in POPULAR ELECTRONICS (February, 1966, issue). Unlike tachs that use choppers or transistors, this circuit employs a zener diode for voltage regulation and pair of matched fast-acting diodes. It is one of the few tach circuits that will respond to the pulse of transistorized ignition.

R1. When the points are opened, C1 takes on a charge through the meter M1, resistors R2 and R3, and diode D3. If the points remained open all the time, the meter reading would rise, then fall back as current flow came to a halt, but because the points are opening and closing, and D2 and D3 are responding very rapidly, the meter reads the average current flow according to the number of pulses—not the width or shape of the pulses. This tach circuit is particularly useful in automobiles with capacitive discharge ignition systems—where the absence of an inductive kickback across the breaker points disables the more common tach circuit.

Installation of a tach is primarily a mechanical job. Most tachometers are mounted on the steering column or above the dash, although they can be mounted in a cutout in the dash panel. A typical electronic tach will have three wires which must be connected to the ignition system. One wire goes to ground, one to the ignition switch (at the switch itself), and the last to the distributor points. These wires are usually color-coded, and the hookup is included in the instruction sheet supplied with the unit.

A good tach will normally outlast the vehicle in which it is used without requiring any service or main-

Fig. 5. Generally speaking, a tach seldom needs calibration. When it does, use this simple circuit.



tenance except occasional calibration. Such calibration is usually required only upon installation, or when the unit is transferred to another vehicle. To check calibration throughout the range of the tach, you must have an audio-frequency signal generator of known accuracy which covers the range from 20 to 600 hertz. However, you can obtain an accurate calibration using a 12-volt filament transformer as the signal source.

To calibrate a tachometer, you supply a known audio frequency, and relate this frequency to the number of pulses produced by the engine at a given speed. A four-cycle engine (the most common type) produces one spark per cylinder for every two revolutions of the crankshaft, so that its pulse rate will be equal to the number of cylinders, divided by two, and multiplied by the engine speed in rpm. Since frequencies are usually measured as hertz, the equation becomes: frequency = cylinders  $\times$  rpm/120. And since you're really interested (for calibration purposes) in knowing how many rpm it takes to produce 60 pulses per second (the pulse rate of the a.c. power line signal source), you turn this around to : rpm =  $120 \times$  frequency/cylinders. At 60 hertz, the rpm comes out to 7200/cylinders. Thus, with a 4-cylinder engine, the calibration point is 1800 rpm; with a 6-cylinder engine, it is 1200 rpm; and with an 8-cylinder engine, it is 900 rpm.

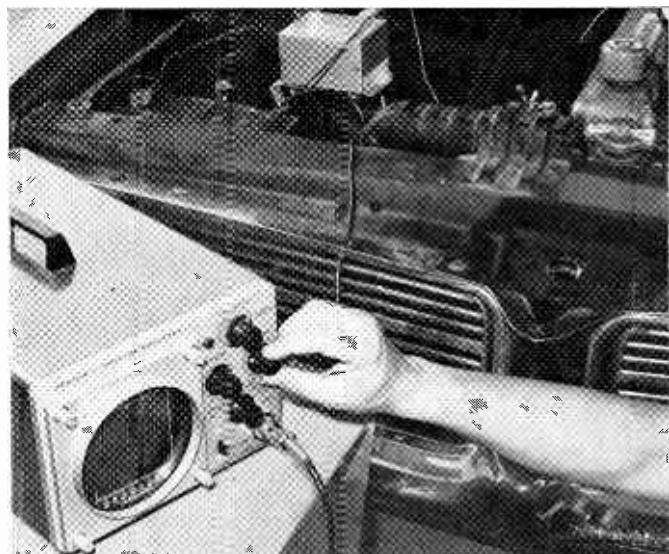
Figure 5 shows the connections for 60-cycle calibration of any tachometer. One lead of the transformer goes to the frame of the vehicle and the other lead goes to the tach lead which normally connects to the points. For calibration, this lead must be disconnected from the distributor. The auto engine need not be turned on or running unless the tach power is cut off by the ignition switch. However, if the switch is on, the engine should be running to prevent damage to the points. With the calibration signal applied, simply adjust the calibration control of the tach until it indicates the exact proper number of rpm for the number of cylinders in your engine.

Most tachs are linear and have sufficient accuracy so that this single-point calibration will hold over the entire dial range. If you want to check it, substitute the audio signal generator for the transformer and set the frequency to the points which correspond to 1000, 2000, 3000, 4000 and 5000 rpm for your engine. For a 6-cylinder engine, these frequencies would be 50, 100, 150, 200, and 250 hertz respectively. For an 8-cylinder engine, the frequencies would be 67, 133, 200, 267, and 333 hertz. At each fre-

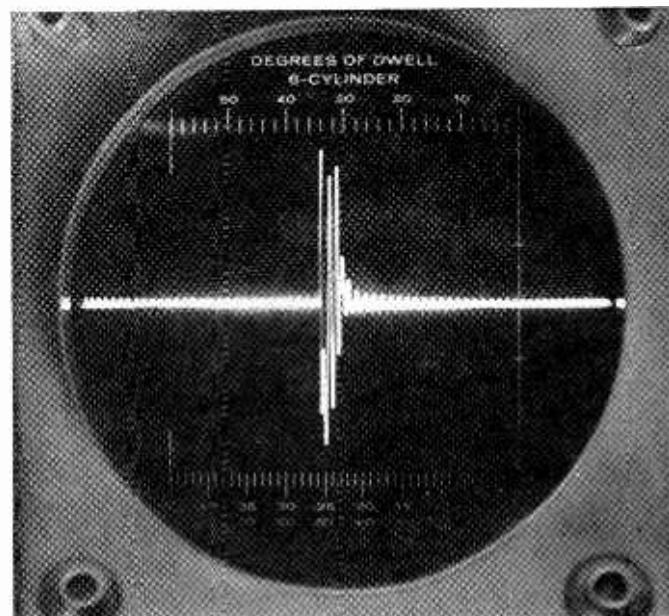
quency, note the tach reading. If it is accurate, it will read exactly even multiples of 1000 rpm. If it doesn't, you can "fudge" the setting of the calibration control to get the closest readings at the most points. At least you will know how far off it is at the other parts of the dial.

**VOLTMETER AND AMMETER** If you want a more positive check of battery condition than that provided by the blinking red charge light (so-called "idiot" light), you should install an ammeter and a voltmeter near or on the dash panel.

A voltmeter measures battery voltage. Normally, this should be about 12.2 volts for a 12-volt auto electrical system with the engine off, and somewhat higher (12.4-12.8 volts) with the engine running. If the voltage is far below normal, the battery is undercharged, weak, or dead.



THE ONLY DEVICE that tells the condition of an ignition system at a glance is the Heathkit Ignition Analyzer (above). Photo below shows a single spark plug pulse from a CD system.



A variation of the simple auto voltmeter is shown in Fig. 6. In this circuit, a zener diode is used to "offset" the zero voltage point so that small variations in voltage can be read more easily. The 10-volt zener effectively subtracts 10 volts from the actual voltage present, so that a 2.2-volt reading on the 0-5 voltmeter means a battery voltage of 12.2. This is done because the meter scale is expanded so that a single division indicates 0.1 volt rather than 0.3 volt on the 0-15 voltmeter. A 0.2-volt change in reading would be only two-thirds of a division on the conventional meter, but would be two full divisions on the offset or expanded scale variety.

Installation of the voltmeter is about the same as that for a tachometer. All you do is ground one volt-

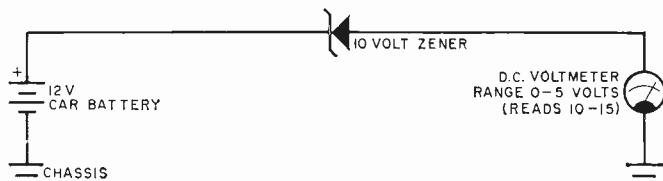


Fig. 6. In this circuit, the diode blocks all voltages under 10, and when installed, the meter reads with an expanded scale.

meter terminal and run a lead from the other directly to the positive post of the battery. Don't use behind-the-dash-panel connections since they may confuse the readings. Voltmeters almost never require service. When they do, it's usually less expensive to replace them.

## ALTERNATOR TROUBLESHOOTING TABLE

STEP	SETUP FOR TEST	PROCEDURE	INDICATION
1	Set voltmeter to 15-volt scale, connect + lead to alternator AUX terminal and - lead to ground. Engine, ignition, and all accessories are turned OFF.	Take voltage reading; switch to lower scales until lowest scale is in use.	0 volts is normal. Any reading at all indicates faulty isolation diode. Replace.
2	Same as step 1 except that ignition is on and engine is idling.	Take voltage reading.	12 volts is normal. If more, go to step 3. If less, go to step 5.
3	Same as step 2 except that + lead moves to OUTPUT terminal.	Take voltage reading.	12 volts is normal. If less, isolation diode is faulty. Replace.
4	Same as step 3 except that - lead moves to battery's positive terminal.	Turn on headlights and all accessories, take voltage reading using lowest scale of meter.	Any reading less than 0.3 volt is normal. Higher reading indicates faulty wiring or connections. Inspect, clean, or replace as needed.
5	Set voltmeter to 5-volt scale, connect + lead to alternator AUX terminal and - lead to ground.	Turn ignition on but do not start engine. Take voltage reading.	1.5 volts is normal. If otherwise, go to step 7.
6	Same as step 5 except that + lead moves to FIELD lead of alternator (pull regulator plug slightly loose for access to field lead).	Take voltage reading.	1 volt is normal. If otherwise, go to step 7.
7	Turn ignition OFF and disconnect regulator. Turn ignition back ON.	Take voltage reading.	12 volts is normal and indicates wiring is OK; trouble is in alternator or regulator. Other than 12 volts indicates fault in wiring; repair.
8	Same as step 2 except that substitute regulator is plugged onto unit in place of existing unit.	Repeat steps 2 through 6 using substitute regulator.	If system now indicates normal operation, regulator is faulty. Replace. If abnormal indications persist, trouble is in alternator. Proceed to step 9.
9	Inspect for dirt on slip rings and brushes and for worn brushes. Some disassembly of alternator is required.		Clean; replace brushes if necessary.
10	Using ohmmeter, check for continuity through rotor windings of alternator, from slip ring to slip ring. Lit lamp indicates continuity.		Replace or take to dealer for repair if no continuity is indicated.
11	Using test lamp, check for continuity from either slip ring to frame of rotor.		Replace or take to dealer if continuity is indicated.
12	Connect one slip ring directly to one battery terminal. Connect other slip ring to 0-10 ammeter. Connect other ammeter terminal to remaining battery terminal.	Take current reading. Do not leave circuit complete longer than required to obtain the reading.	2 to 3 amperes is normal. More than 3 amperes indicates possible shorted turns; take to dealer for repair or replacement.
13	<b>CURRENT OUTPUT CHECK;</b> can be done as first step of troubleshooting. Disconnect lead at OUTPUT terminal of alternator and insert 0-50 d.c. ammeter. Start engine, turn on all accessories and lights, rev engine if necessary to get maximum reading.	Take current reading under heaviest possible electrical load with auto engine running fast enough to assure maximum output (at least 2000 rpm)	Rated output should be shown; less than rated output may indicate troubles in system but may also indicate not enough load available.
14	<b>DIODE TEST;</b> perform if steps 10, 11 and 12 fail to reveal trouble. Take alternator apart to remove diode assemblies. Unsolder leads on diodes.	Use ohmmeter to check for high front-to-back ratio by reversing ohmmeter leads.	Ohmmeter should read very high resistance in one direction and low resistance in the other. If low-resistance readings are found in both directions, diode is shorted.

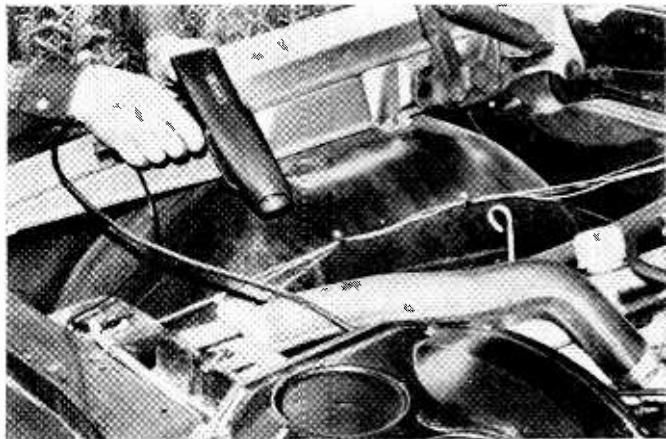
The ammeters used in automobiles are usually of the "zero center" type which measures current flow toward or away from the battery. By doing so, the ammeter gives an indication of the battery condition, the alternator or generator operation, and the action of the voltage regulator. Normally, when the car is in motion, the ammeter will show a slight "charge" indication at all times. If it drops into the "discharge" area, something is wrong and the circuits should be checked immediately.

The ammeter is mounted in the same manner as the voltmeter and tachometer. When wiring it into the auto's battery circuit, the ammeter must be connected so that the starter-motor current does not pass through the meter. Many "original equipment" ammeters use the series resistance of the connecting wires to maintain meter calibration. For this reason, the wires should never be cut short.

**TUNE-UP INSTRUMENTS** In addition to the tachometer, voltmeter and ammeter, there are a number of special electronic devices for automobile engine tune-up. These include the dwell meter, timing lights, and ignition scope. Also, there are several all-purpose tune-up instruments which combine a number of these aids in one case.

"Dwell"—or, more accurately, "dwell angle"—refers to the period of time during which the breaker points are closed in the ignition system. Dwell angle is important because the points must remain closed long enough for maximum energy to be stored in the ignition coil. If the points were to remain closed all the time, the battery voltage would short to ground. If the points never closed at all, no current would flow through the coil.

But if the points are closed half the time and open half the time, the voltage across them will fluctuate from zero to battery level and back again; a voltmeter across the points would then indicate half the battery voltage, since the meter would read the average level rather than the instantaneous voltage. Similarly, if the points are closed two-thirds of the time and open



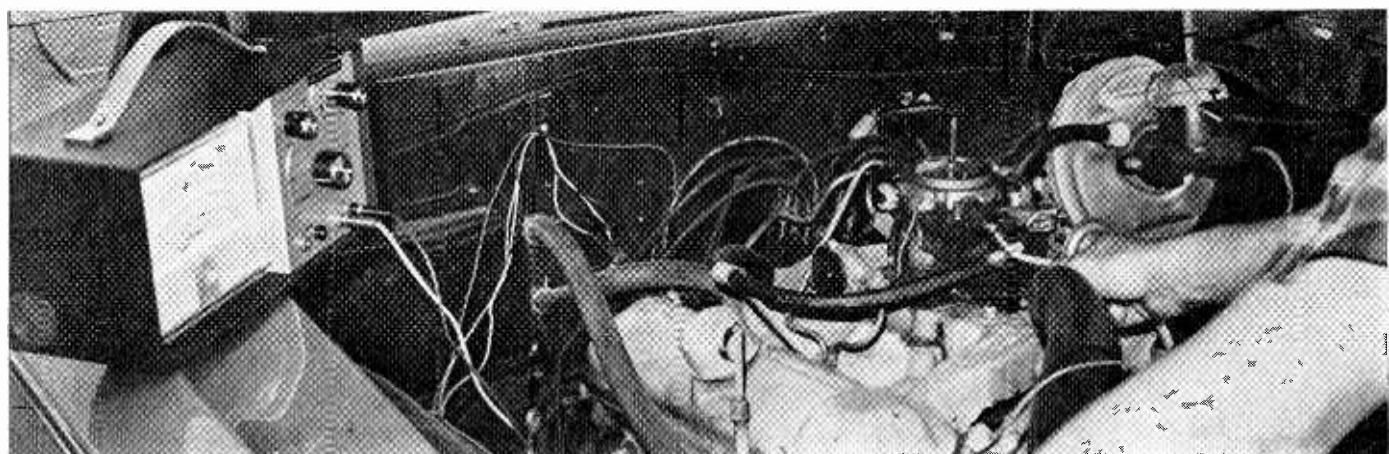
ALLIED RADIO sells this Knight-Kit Model KG-371 timing light for about \$20. The average builder can assemble the kit in under two hours. Light operates on battery voltage.

one-third of the time, the meter would read two-thirds of the battery voltage.

Dwell meters, however, are scaled to read in degrees rather than actual average voltage. This is possible because, for example, in a 8-cylinder engine the points can remain closed for a maximum of  $360/8$ , or  $45^\circ$ , and any average voltage less than a full-scale reading constitutes a linear relationship to the dwell angle. In a 6-cylinder engine the full-scale reading (battery voltage maximum) would be equal to  $60^\circ$ .

Timing lights are used to check ignition and valve timing by "freezing" a picture of the flywheel rotation every time a selected spark plug (usually the number 1 plug) fires. The simplest and cheapest such light is a neon tube, connected from the spark plug to ground by built-in clip leads. When the spark voltage is applied to the plug, the neon bulb flashes with a weak orange glow.

The neon flash is difficult to see except in a darkened area. For this reason, timing lights have been developed that produce a brilliant white flash. Automotive timing lights are very similar to a ph-



A METER TYPE ANALYZER is second only in usefulness to the ignition scope. The EICO 888 shown here is being used to set the idle adjustment on a 2-barrel, 8-cylinder engine. Meter analyzers test for spark output, battery voltage and regulation, dwell angle, alternator diodes, etc. This kit is sold for about \$45 (it can be assembled in 3-4 hours); a wired version is \$59.95.



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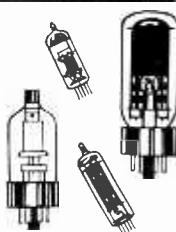
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tographic strobelight. Fig. 7 is a block diagram applicable to most timing lights.

Servicing a timing light is primarily a matter of locating the area in which the defective component lies. The first step is to locate the high-voltage output point indicated at A and measure the voltage. Anything above 250 volts can be considered normal—in the absence of specific service data for the particular unit. Lack of voltage indicates trouble in the power supply or power source.

If voltage is present at point A, move to the storage capacitor, point B, and measure again. Use caution—dangerous voltages are present. Absence of voltage indicates a shorted capacitor or an open limiting resistor.

If voltage is present at point B but the light does not operate, check voltage again at the flashtube terminal, point C. Absence of voltage indicates trouble in the cable or connections. If voltage is present at point C, yet no light is produced, check continuity of the cable from the spark plug to the flashtube, with all power off and all capacitors discharged. If this wire is in good condition, the trouble is probably a worn-out flashtube. While these tubes last for a long time, they do wear out eventually.

The all-purpose auto analyzer combines in one instrument a voltmeter, ohmmeter, ammeter, tachometer, and dwell-angle meter. Some models offer such extra functions as a spark-output indicator, ignition-

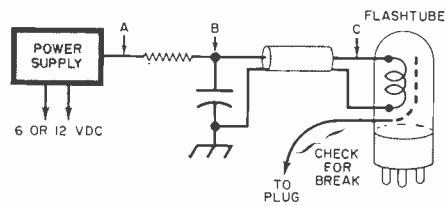
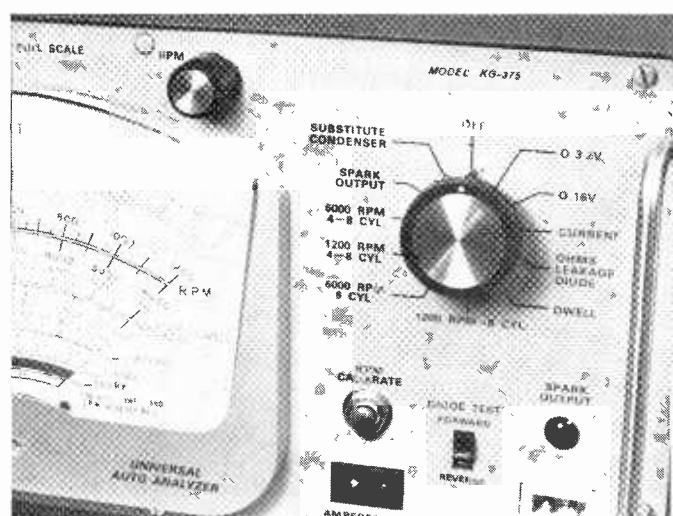


Fig. 7. Block diagram of a typical bright timing light. Letters indicate points at which voltage measurements are to be taken as described in text; locating these points must be done by inspection in the absence of specific service information.

condenser-substitution switch, and alternator diode tester.

The ignition scope is a special oscilloscope adapted to display the actual spark-plug voltage of each cylinder. To use the ignition scope, simply connect the appropriate input terminal to the distributor and a special cable to the number 1 plug (for synchronization). Abnormalities of operation in any cylinder can be visually pinpointed. Although the scope shows only spark-plug voltage, this voltage reflects valve and piston troubles as well as troubles in the ignition system itself.

In addition to the units that are directly connected with the operation of the automobile, there are such "accessories" as cartridge-type tape recorders (see page 93), dictating machines, hi-fi and reverb systems, and even television receivers (where permitted by law), two-way mobile telephones, ham and CB equipment, radar detectors, and the like. The servicing of most of them is covered in individual chapters elsewhere in this Handbook.



# HOW TO SUCCESSFULLY INSTALL INTERCOM AND PUBLIC ADDRESS SYSTEMS

By JOHN D. LENK

## INTERCOM SYSTEMS

- Multiple Wired Units
- Wireless Intercoms
- Installing Intercom Equipment
- Servicing Intercom Equipment

## PUBLIC ADDRESS SYSTEMS

- P.A. Power Requirements
- Installing Portable P.A. Systems
- Installing Mobile P.A. Systems
- Servicing P.A. Systems

It is often difficult to distinguish between an intercom and a public address system. Intercom systems can be used for paging, a function usually reserved for a public address (p.a.) system. Many p.a. systems provide for "talk-back" from one or more of the paging loudspeakers. However, for the purposes of this chapter, intercoms will be considered as those systems that provide voice communications from point to point, usually from one person to another. Public address systems will be considered as equipment used primarily for communications between one person and a group of people.

At one time, both intercoms and p.a. systems were used almost exclusively in business and industry. Today, they have moved into the home. Since many systems are sold as complete functioning units, installation is simplified, and is well within the capabilities of the home handyman. Usually, installation is no more difficult than mounting the units and routing the wires from point to point.

Deluxe intercom systems occasionally include an AM or FM tuner, and some systems have a record player input jack. Small p.a. systems provide a means to call children for meals, and music can be "piped" from one unit to another, either indoors, outdoors, or to several or all living areas.

## INTERCOM SYSTEMS

Any device for voice communications between two or more points can be classified as an intercom. A telephone could fit into this category, but the intercom which is discussed below uses wires or the house wiring lines, and provides communication in the same home, store, office, etc.

**SINGLE WIRED UNIT** In its very simplest form, an intercom will have one "master" unit and one "slave" unit. Operation of such a system is shown in Fig. 1. The *master* unit consists of the loudspeaker (which doubles as a microphone) plus an amplifier and changeover switch, while the *slave* unit is nothing more than a loudspeaker. The *master* and *slave* are electrically coupled by two interconnecting wires. The two wires are often twisted or shielded—or both—to minimize a.c. hum and noise pickup. The hum and noise pickup can also be minimized by using various other circuits, as shown in Fig. 2.

Operation of the intercom system is controlled by the 4-pole double-throw switch at the *master* unit. To place a call from the *master*, the switch is set to "Talk." This connects the *master* unit speaker to the amplifier input, and the *slave* unit speaker to the amplifier output. Any sounds picked up by *master* speaker will be amplified and reproduced at *slave* unit.

To hear a call from the *slave* unit, the 4-pole switch must be in the "Listen" position. The *slave* speaker is then connected to the amplifier input, while the *master* speaker is connected to the output. Usually,

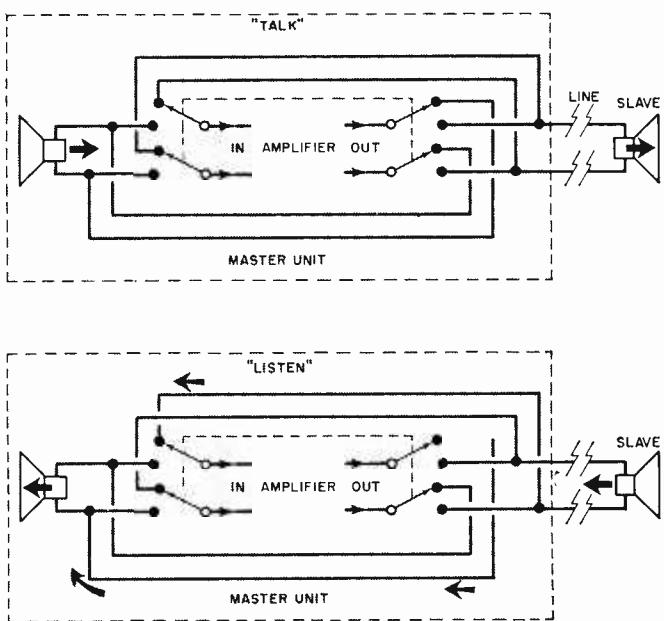


Fig. 1. This is the simplest form of two-station intercom. It requires a pair of connecting wires and two double-pole, double-throw switches. The speakers double up as microphones.

the "Listen-Talk" switch has spring action so that it automatically returns to the "Listen" position when you lift your finger.

Intercoms can use either vacuum-tube or transistorized amplifiers. However, practically all intercoms now sold are transistorized and only the older models employ tubes. A typical transistorized intercom amplifier circuit is shown in Fig. 3. This circuit is designed to work into 4-ohm speakers and has a maximum audio output of 2 watts, more than sufficient for room volume.

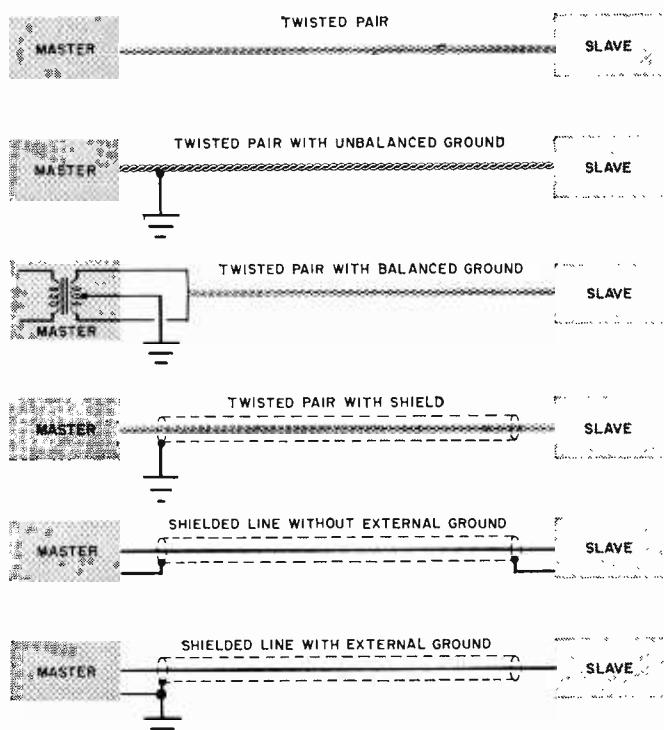


Fig. 2. Intercoms may be wired in any one of the six versions detailed above. Some systems reduce noise pickup, some don't.

**MULTIPLE WIRED UNITS** It is possible to operate a number of slave units from a single master. This requires a slave selector switch as shown in Fig. 4. When the selector switch is set to Unit 1, only Unit 1 is connected; to Unit 2, only Unit 2; and so on. This permits the master unit operator to page the slave units selectively. The other slave units can neither listen in nor communicate with the master.

The obvious drawback of such a system is that the slave units have no way of calling the master station, or even alerting the master to the need for a call. This drawback can be eliminated by means of a "Call" switch at each of the slave stations. Figure 5 shows the wiring for such a system. Each slave station is provided with a normally-open push-button switch. When the switch is depressed, power is applied to the coil of a relay in the master unit. A separate relay is provided for each slave unit. When the relay is energized, the contacts close and one set of contacts locks the relay in position. The other set of contacts provides

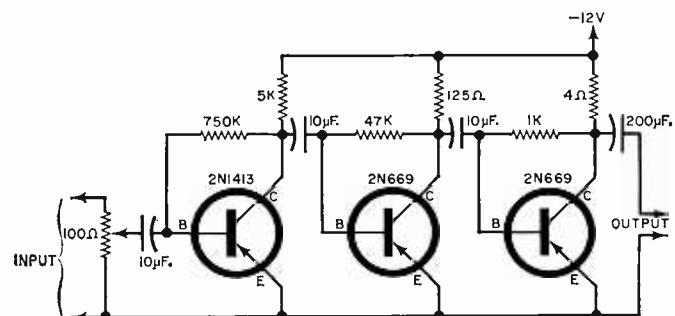


Fig. 3. Intercom circuits are not complicated—as demonstrated by this amplifier circuit using three low-cost transistors.

power to a signal lamp on the master. A separate lamp is provided for each slave unit. When the master unit is signaled by a slave, the operator sets the selector to the corresponding slave unit position and tells the slave that he is listening. The signal light can be extinguished by pressing the normally-closed push button on the master unit. This interrupts power to the relay coil, and the relay contacts open.

For the sake of maximum privacy, arrangements are usually made in office-style intercoms so that it is impossible to "eavesdrop." Listen-Talk switches are installed at each slave unit as shown in Fig. 6. In this circuit, both the slave and master units are in the "Listen" condition at all times. If the master unit wants to call the slave, the master switch is set to "Talk." This connects the master speaker to the amplifier input, while the slave speaker is connected to the amplifier output through the slave switch "Listen" contacts. To reply, the slave unit switch is set to "Talk." This connects the slave unit speaker to the amplifier input.

Although insuring privacy, the latter system has certain disadvantages. Instead of two interconnecting wires, a good grade of shielded lead must be used between the master and slave units. Even with good

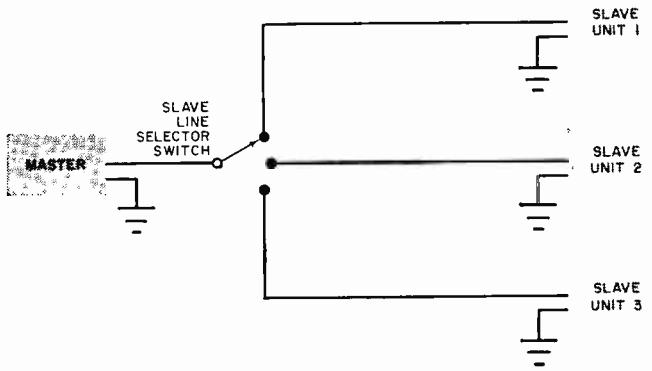


Fig. 4. Multiple-slave intercom systems require a selector switching arrangement. The ground is common to all slave units.

connecting lines, hum and noise pickup is greatly aggravated. Without resorting to involved relay and switching functions, this privacy system is only useful with one slave unit.

**WIRELESS INTERCOMS** One of the greatest disadvantages of the intercoms discussed above is the necessity to string a connecting wire link between the master and slave units. This problem can be circumvented by the "wireless" intercom. As the name implies, voice transmission takes place via radio waves —either directly\* or via line carrier systems where the signal is transmitted over the 117-volt a.c. power line.

**LINE CARRIER SYSTEMS** Similar to line carrier systems used by electric utility companies, each unit (master or slave) is a separate radio transmitter and receiver. Any number of units can be connected to the a.c. power line. In a two-unit system, the receiver of Unit A is tuned to the frequency of the transmitter of Unit B, while the receiver of Unit B is tuned to Unit A. In a simplex system, the same radio frequency is used by both transmitters.

\*Direct radio wave intercoms are subject to FCC Rules and Regulations.

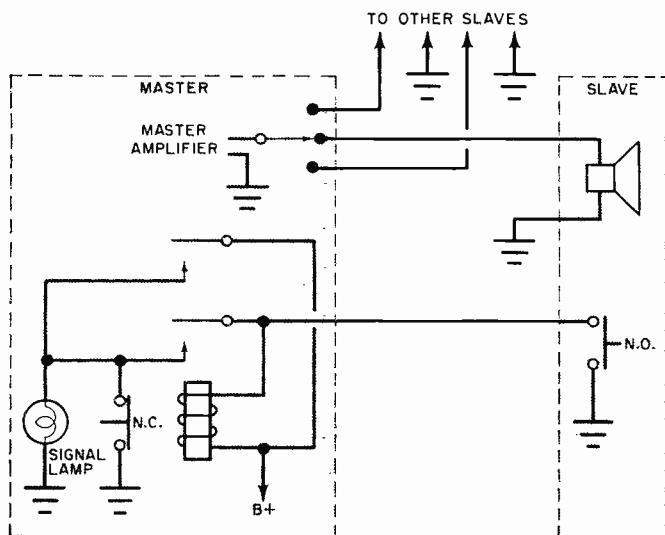


Fig. 5. Some low-cost systems use this circuit to "call" the master unit. The lamp bulb could be replaced with a buzzer.

Some wireless intercoms use *duplex* operation, similar to the ordinary telephone. This permits you to talk and listen at the same time. Duplex operation is accomplished by transmitting and receiving on different frequencies. That is, the Unit A transmitter and Unit B receiver operate on one frequency, while the Unit B transmitter and Unit A receiver use a different frequency. This is the most convenient intercom arrangement, but more elaborate and expensive than the others.

You will find just about any radio frequency used by the "wired" wireless intercoms. However, the very low frequencies between 160 and 180 kHz seem to be picked by most commercial designers. The "wired" wireless intercom systems are not limited to communication within one dwelling or office. You can communicate almost as well from building to building, provided that all of the slave units are served by the same a.c. power distribution transformer. Power transformers will block or attenuate the radio signals, just as any iron core transformers will attenuate r.f. signals.

There is a choice of "party line" or "private" communications with any type of wireless intercom system. *Party Line* operation is where all of the units are

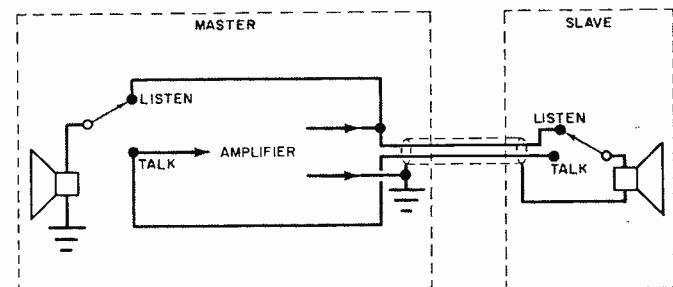
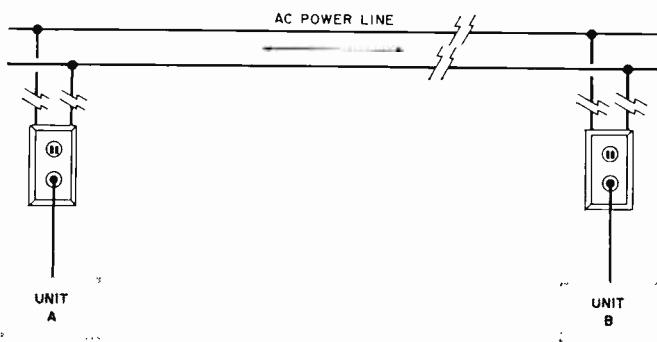


Fig. 6. This is the simplest method of insuring privacy, but far from the best. The connecting leads pick up noise, badly.

on the same radio frequency. *Private* operation is where each pair of stations is on the same frequency, but on a frequency different from all other pairs.

Some wireless intercom systems provide selective calling where one *master* station can communicate privately with one or more *slave* stations, all of which operate on the same frequency. This is accomplished by a tone squelch circuit, with a multiple tone encoder at the *master* and single tone decoders at the *slave* units. For example, assume that the *master* has a three-tone encoder (which produces three tones, each on a different audio frequency), and there are three *slaves* with tone decoders (which respond to only one of the three encoder tones). When the *master* unit is keyed to talk to a *slave*, the encoder automatically selects one of the three tones. This tone is transmitted along with the voice communication as inaudible modulation. All THREE *slave* units pick up the transmission in the normal manner, but the audio portions of the receivers are disabled, except on that *slave* unit whose decoder is tuned to the selected encoder tone frequency.

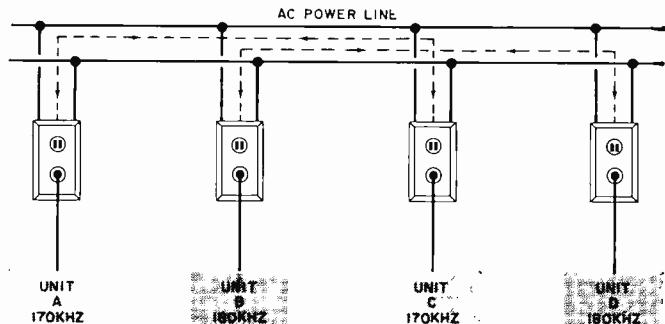


**WIRELESS INTERCOMS** To avoid the necessity of stringing a connecting cable between master and slave intercom units, the wireless system was developed. Each intercom unit is a miniature transmitter and radio receiver. In the simplex hookup, each transmitter and receiver are tuned to the same frequency.

Selective communications between a master unit and several slave units can also be accomplished with *split channel* operation. In this situation, the master unit is provided with a transmitter having three or more channels, and a single-channel receiver. The slave unit receivers are each tuned to a matching frequency of the master unit transmitter. However, the slave unit transmitters are all tuned to the same frequency and are all picked up by the single-frequency master receiver.

One drawback to any "wired" wireless system is that you must expect some signal loss on the a.c. lines. As the lines pass near metal objects, part of the signal will be absorbed and since most modern office and factory electrical wiring is inside a metal conduit, you also have a built-in attenuation problem. The best you can expect from most commercial systems is communication within one house or apartment, part of an office floor, etc., although you may find exceptions.

To increase your intercom range would mean increased receiver sensitivity. This is not too practical, however, since it also increases the receiver's sensitivity to noise. To increase transmitter power will also increase the radiation of the radio signal, and possibly make your system illegal. So, don't try to make your intercom a neighborhood communications system; be content if it does its job as an intercom in your house or apartment.



**PAIRED WIRELESS INTERCOMS** Some measure of privacy is insured in a "wired" wireless system through the use of frequency selection. In this sketch, units A and C are tuned to the same frequency and units B and D are tuned 10 kHz higher. A master station may have a switch to change frequency.

Another type of "wired" wireless intercom is the loop or *inductive* system. As the name implies, the input and output of each intercom unit is connected to a loop of wire. These loops are inductively coupled to the house wiring system, or to any wiring between the intercom units. This lets you use the wiring to transmit and receive signals, but does not require direct connection to the wires. The loop systems operate in the low frequency range (below 200 kHz), and an FCC license is not required.

**RADIO INTERCOMS** There are several radio communications services that can be used for intercom systems. These services include Citizens Radio, Business Radio, and even the Part 15 wireless microphones operating in the 88-108 MHz FM broadcast band. Of course, the applicable FCC rules and regulations must be observed for any such system, since you are transmitting radio signals through space, rather than over wires. Likewise, these systems cannot be truly private (no more than any radio communication system), nor can you avoid interference from other radio systems operating on the same frequency. But such systems are now in use and are worth mentioning.

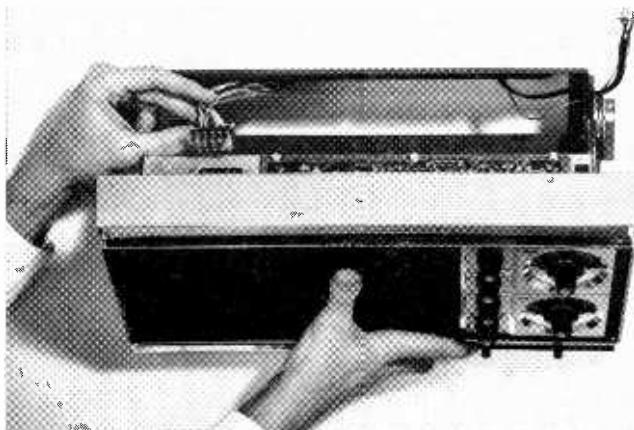
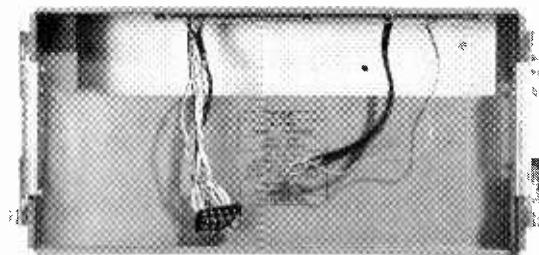
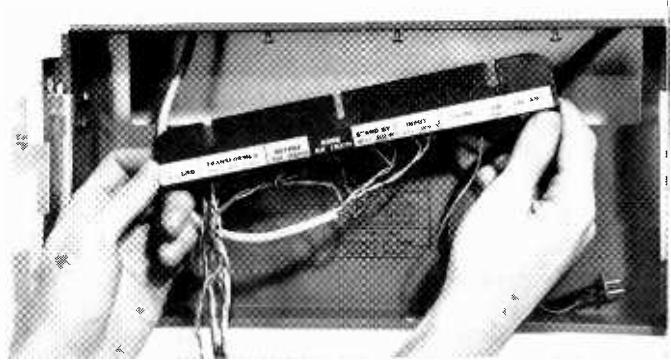
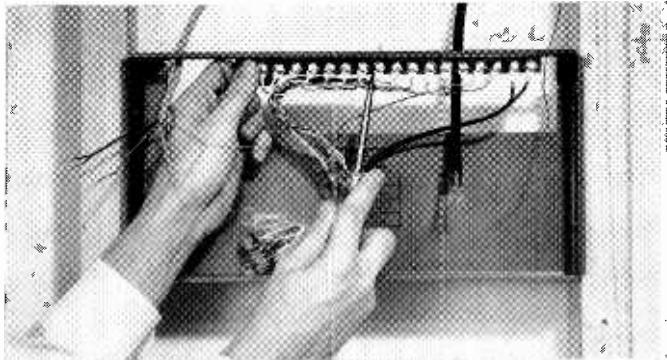
The most obvious radio intercom is two 100-mw. walkie-talkies operating in Class D CB. If the power is 100 milliwatts or less, you do not need a license. One popular use of CB is to connect the receiver audio output of one walkie-talkie to a p.a. system and page other units over this combination system.

Business Radio channels (25-50, 150-174, 450-470 MHz) can also be used for intercom purposes. If you keep the power input below 3 watts, and the center of the antenna's radiating element within 25 feet of the transmitter, all of the units can be operated under one station license.

There are also a number of one-way radio paging systems, using either the Business Radio frequencies or the CB frequencies. Pocket-sized receivers are worn by each person likely to be called. When the wearer hears the spoken page (numeral code), or when his receiver sounds off with an audible alarm (from a tone-coded signal similar to that previously described), he responds by telephone or intercom.

**INSTALLING INTERCOM EQUIPMENT** Installation of wireless intercom systems is simplicity in itself. You simply plug them in, turn them on, and away you go. There is only one point to remember, and that is not to expect proper operation between two locations where the a.c. wiring is separated by a power transformer.

Installation of the wired intercom systems is not quite so simple. Of course, the only real problem is in running the cable between units, but this can be quite a problem. The installation instructions supplied with most intercom equipment is fairly detailed, so we will not duplicate them here. However, here are a few tips that should be of value.



**BUILT-IN INTERCOM** You are always ahead of the game if you can rough in your intercom while the house is being built. In this NuTone installation, the cabling between stations is attached to the terminal board (top two photos) and terminated in terminal block plugs (photo above). As a last step, the AM-FM radio receiver/intercom is connected as shown at right.

(1) Place the intercom units in locations where the cabling will not be seen, at least where it will not be in the way.

(2) Place the master unit at a central location (in a home, this is usually the kitchen), and install it near a source of power—unless it is one of those units that operate from batteries.

(3) Wiring between units can be concealed in the walls or run along the baseboard and molding. Flat cable makes the neatest installation, but multiconductor "intercom" cable is cheaper.

(4) If you are going to run the wiring out-of-doors, where it might be subjected to mechanical abuse or beaten by the weather, use weatherproof jacketed wiring designed for this purpose.

Remember, you will be ahead of the game if you can install all intercom wiring while a house or building is being constructed. Otherwise, try to run all of the wiring in an attic or basement whenever possible. Run the wiring along the ceiling or the floor, in one corner of the room, or alongside a vertical molding, and feed it through the ceiling or floor. Make all the interconnections and junctions in the attic or basement.

**SERVICING INTERCOM EQUIPMENT** A "wired" intercom is nothing more than an amplifier, loudspeakers, wiring, and possibly some elaborate switching. A wireless intercom is a transmitter and receiver. If you are familiar with basic audio amplifiers, simple receivers and low-power transmitters, you should have no difficulty repairing any intercom. If you are totally

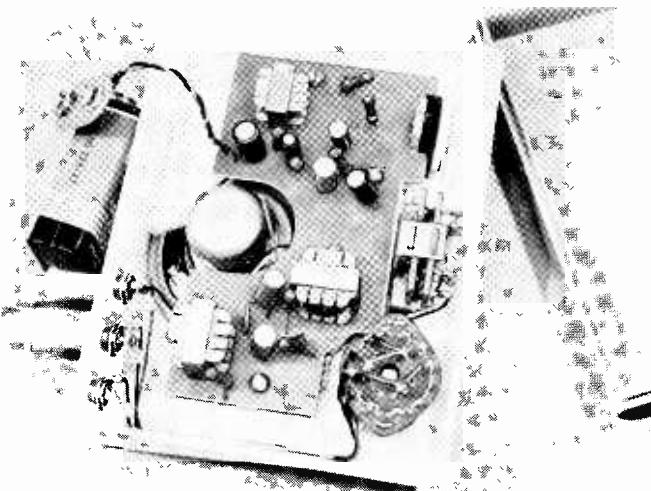
unfamiliar with any of these units, attack the problem logically.

**WIRED UNITS** If one of the slave intercoms is inoperative, try substituting a new unit, or install one of the working slave units at that location. If this clears up the problem, you know the trouble is in that particular intercom unit. If not, then you can suspect the interconnecting wiring.

If all of the intercom units are inoperative, or all show the same malfunction (weak audio, distortion, etc.), then the trouble is probably in the master amplifier. Check the amplifier tubes. If a circuit schematic is available, check the tube socket voltages. If there is a total lack of signal, try signal-tracing each of the amplifier stages. Start with the output stage and work back. Touch the output stage grid input with a bare screwdriver. If all is well between the point of signal injection and the slave speaker, you will hear a hum or buzz. The loudness of the signal should increase as you work your way back to the front end. If the intercom is transistorized, try a similar test by injecting a test signal through the transistor base at each stage.

The ohmmeter is your best bet in checking the speaker (cum microphone) coil resistance. If you don't know the correct coil resistance, try comparing it against that of other speakers in the system.

**WIRELESS UNITS** Servicing a wireless unit is more difficult. If you have three or more units in the system, it is fairly easy to localize trouble to a particular



**SIMPLIFIED DESIGN** Servicing any intercom unit should be very simple. Peeking inside this Lafayette solid-state unit, you can see that the plugs, switches, and amplifier printed circuit board are all in plain view. A battery-operated intercom like this unit rarely, if ever, requires any servicing.

unit (if two are working and one is not, the trouble is in the odd unit). Likewise, it is comparatively easy to determine if the problem is in the transmitter or receiver portion. The real difficulty comes when you have localized the problem to the transmitter or receiver section of the intercom.

To check the transmitter section, use a VTVM and r.f. probe. Locate the r.f. tank coil and measure the r.f. voltage developed across it during operation. If this voltage is absent, the transmitter is not working. If it is present, yet does not change value (or increases) when you talk into the unit, the transmitter is not being modulated. If the r.f. voltage fluctuates as you speak, the transmitter is working normally, and the problem is in the receiver of the other unit.

When both transmitter and receiver are working properly, the system still may not function correctly if either the transmitter or receiver is not set on the right frequency. It is not uncommon to find a wireless intercom system which works in one direction, but not in the other, due to a single unit being off frequency. A large frequency error will cause total failure of operation, while a small one will result in distortion.

To adjust a wireless intercom, determine the frequency at which the system is supposed to operate. If the instruction sheets don't tell you, or if they have been lost, tune through the AM broadcast band with a regular AM receiver until you find the signal. While most wireless intercoms operate at frequencies below the broadcast band, a harmonic of the signal will fall within the AM band and can be readily located. Generally, the transmitter of each unit would be on the same frequency.

Adjust the oscillator of the two transmitters until both signals come in at the same spot on the AM dial. If the receivers are on frequency, this will restore operation. If not, adjust the local oscillator of the other receiver until two-way communication, without distortion, is possible.

## PUBLIC ADDRESS SYSTEMS

There are three basic types of public address (p.a.) systems in current use: the permanently installed system, the portable system, and the mobile system. These may be small or large and may or may not include accessories and special features such as talk-back circuits, music program sources, electronic alarms, etc. Every p.a. system will include a microphone, an amplifier, and loudspeakers. If music is to be provided, the system will also need a program source such as a record player, tape transport, or FM "storecast" tuner. When more than one input is to be used at a time, some type of mixer must be provided unless the p.a. amplifier is designed for multiple input use.

In addition to basic p.a. systems, there are special-purpose p.a. lecterns. These systems combine the speaker's lectern, microphone, amplifier, and speakers into a single, readily transported unit. The p.a.-lectern reduces installation to a matter of placing the unit in position and plugging it into a power source. Since p.a.-lecterns are lightweight and inconspicuous, they are ideally suited to professional lecturers, salesmen, etc.

When you buy a portable p.a. system from a mail order electronics supplier, or from a local electronic parts distributor, all of the components of the system will probably be matched. That is, the speaker impedances will match the amplifier output, while the microphones will match the amplifier input. No calculation is involved on your part. This is not true of the permanently installed systems designed for industrial and business use. In this instance, the installer must choose loudspeakers that will match the type of sound to be reproduced (music or voice, or both), the area to be covered, the background noise level, etc. Then the amplifier must be selected to provide the necessary output (in watts). Finally, microphones to suit the particular conditions surrounding the speaking area are chosen.

While it is unlikely that you will ever have to design a complete p.a. system for a large commercial installation (unless you're going in the business), you should have a basic understanding of the problems involved. If nothing else, this will give you an edge when selecting components for your club's dance in the local auditorium.

**P.A. POWER REQUIREMENTS** The first question asked by most prospective p.a. system buyers is "how much power output will I need?" This question is like the one that goes: "How long is a piece of string?" To even make a close guess as to the power requirements for a p.a. system you must know: (1) the area to be covered, (2) the noise level existing in the area, (3) the sound level required, and (4) the type of sound to be handled. For example, a 25-watt amplifier might produce crystal-clear sound in every corner of a small

auditorium, but move this system to a larger area, say an oversized barn, and you might have difficulty in hearing anything unless you were directly in front of the speakers. Premise No. 1: The larger the area or volume to be covered, the more power output needed from the p.a. system.

Consider two rooms of the same size and volume, but with entirely different sound requirements. One room is filled with screaming teen-agers; the other room is the library of the Union League Club. It is obvious that the sound level that would get through to the teen-agers would also raise the books from the tables in the library. Premise No. 2: Power output must be fitted to the "environment" of the installation.

Now let's assume that you want to pipe background music into the library. Background music should remain in the background. It is not necessary to pin people to the walls with background music. On the other hand, if the p.a. system is to be used to provide dance music, it must overcome room noise and be capable of much greater power output. Premise No. 3: Carefully consider the minimum and maximum volume level of sound required.

Finally, when your analysis of the area is complete, you can decide on the power output required. For voice only, you can get by with minimum power. If you want some voice and music both, more power is required. And, in a system that is strictly for music, you'll need maximum power. The difference between extremes is about 3 to 1.

It is doubtful that any one rule-of-thumb will cover a majority of p.a. installations. But, as a jumping-off point, about 1.5 watts output of sound is sufficient for 1000 square feet of floor space. This is for voice-only and assumes that the surroundings are very quiet. If music is to be added to voice, the wattage would leap up to 4.5 watts.

**SPEAKER SELECTION AND PLACEMENT** The type of speaker used with a p.a. system has a pronounced effect on the amount of audio power output required for good sound dispersion. It is possible to design a speaker that will spread sound over a wide area. However, the quality of sound suffers and such speakers are used primarily for paging systems. If you want faithful reproduction of music, you must make certain compromise arrangements.

It is conventional among most manufacturers to rate public address speakers in terms of the sound pressure measured at 4 feet, on-axis, with a 1 hertz-per-second sweep from 750 to 1250 hertz at full rated power. For example, a typical p.a. speaker might have a sound pressure level of 117 dB at 4 feet with 30 watts input. This factor of 117 dB can then be related to the noise level in the area to be covered by the p.a. system.

The table in Fig. 7 shows background noise (expressed in dB) in a variety of locations. As shown, a p.a. speaker with a 117-dB level would be adequate to override background noise, even in a boiler factory

AREA	BACKGROUND LEVEL IN DB	CHARACTER
Jet Airport	110-130	Painful noise
Metal Assembly	100	Shout to be heard
Machine Shop	90	Extremely noisy
Printing Presses	80	Speak loud to be heard
Ballroom	75-80	Raise voice to be heard
Railroad Station	70-75	
Big Auditorium	75	
Light Assembly Plant	70	
Department Store	65	Normal conversational level
Restaurant	60	
Warehouse	55	
Quiet Office	45-50	
Church	35-45	
Average Home	30	

Fig. 7. Chart of typical noise levels.

—assuming that you stand no more than four feet from the speaker. As you move away from the speaker, the sound level will drop off. Therefore, you must take into account the maximum distance from the speaker that you expect the sound to be heard and fully understood.

The sound pressure level conversion graph (Fig. 8) shows the reduction of sound pressure level with distance when no reinforcing room or enclosed area reverberation is present. Using the same 117-dB speaker, note that the sound level has dropped to 100 dB at 28 feet. At one hundred feet from the speaker, the sound pressure level has dropped almost 28 dB, and you are well out of the boiler factory level of intense sound.

If the area to be covered by a p.a. system is extremely large, good results can be achieved by using a large number of relatively small speakers, each covering a certain small part of the total area. This method of dividing the sound will prevent listeners near a speaker from being "blasted." If the level of sound from each speaker is kept just high enough to

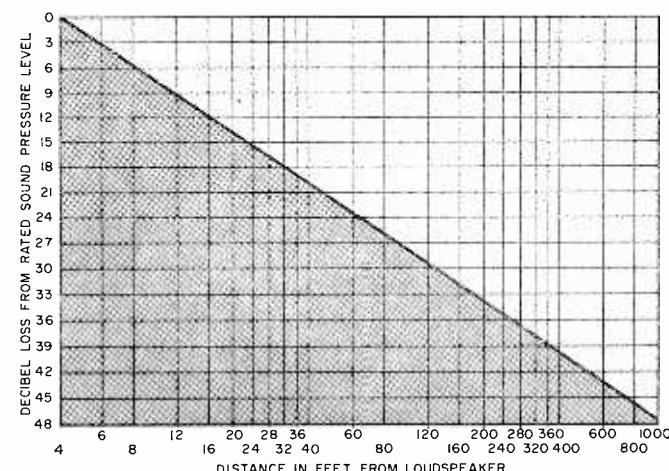


Fig. 8. Sound pressure level conversion with distance.

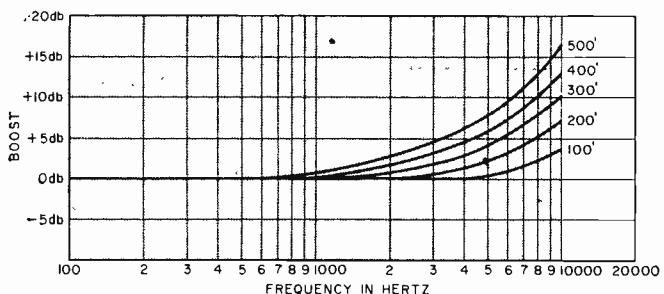


Fig. 9. Equalization required for frequency vs. distance.

assure clear reception by the audience, the illusion of natural sound will tend to be preserved. Many small directional speakers are sometimes necessary if a feedback problem is anticipated.

Another problem in p.a. speaker placement is the loss of high-frequency audio sounds. As any audiophile knows, higher frequency tones are reduced as you move away from the speaker. If the p.a. system is used strictly for voice, this does not present a problem; but if you intend to have music, it may be necessary to include treble boost. Figure 9 shows the amount of equalization (expressed in dB) needed to provide flat response at frequencies up to 10,000 hertz. As shown, there is no great loss at any distance or frequency up to 2000 or 3000 hertz; but beyond that frequency, the losses increase sharply.

**MATCHING SPEAKERS AND AMPLIFIERS** In most hi-fi systems, you match the speaker impedances to the amplifiers. In many p.a. systems, the "constant voltage line" concept is used. This is not much different from being able to plug a number of electrical appliances into your 117-volt a.c. electrical outlets. So long as you don't overload the line, the voltage remains essentially constant.



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The p.a. amplifier must have 70-volt constant output taps to take advantage of this concept. Some p.a. amplifiers also have 141- and 25-volt constant output taps. The 25-volt system is gaining popularity, since wire lines carrying 25 volts or less are not ordinarily subject to fire or building code regulations.

In the constant voltage system, each speaker has a matching transformer with one or more taps rated in watts. Two 5-watt loads, or five 2-watt loads, for example, could be connected to a 10-watt amplifier. The same speakers connected to a 50-watt amplifier operated at maximum rated output would still be drawing only 5 watts or 2 watts respectively. However, the more powerful amplifier can drive eight more 5-watt speakers or 20 more 2-watt speakers.

Wiring up a number of loudspeakers using the constant output voltage system is very simple. First, determine the power required for each speaker. Add up the power for all the speakers, and select an amplifier with this power rating. Then connect all the speakers in parallel to the amplifier's 70-volt output terminals through suitable lengths and types of wire. It is important to remember that the total wattage of all the speakers should not exceed the wattage rating of the amplifier.

**SELECTION OF MICROPHONES** Because of the possibility of a feedback problem in most p.a. systems, the microphone used must be a directional unit. It should pick up the voice of the announcer, but not respond to sound coming from the back and sides. Cardioid pattern directional mikes are to be considered a prerequisite in any p.a. system installation.

**TALK-BACK PAGING SYSTEMS** One or more of the speakers in a p.a. system can be used in a talk-back system. However, the amplifier must have switching facilities similar to that previously described for an intercom (and the speakers must be able to act as a microphone). If only one or two locations in an extensive paging system need talk-back capability, it may be better to install a pure paging system, and then install an intercom in the talk-back locations. The intercom can be patched into the paging system.

**INSTALLING PORTABLE P.A. SYSTEMS** Generally speaking, you will not be able to cover the same area with a portable p.a. system as with a permanent installation, especially when the various components in a permanent system have been specifically selected to satisfy the acoustical and program source requirements. In a portable system, the cables, speakers, and other equipment must be transportable. Conventional speaker projectors and trumpets can be mounted on collapsible tripod stands. "Sound columns" (multiple speaker arrays designed to compress the sound waves into a tight vertical beam, yet maintain full horizontal dispersion) can be used and placed on any convenient platform or ledge, or even hung on a wall.

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Frequently, a single sound column can be placed on each side of a stage or lectern to provide adequate coverage of an auditorium. To equalize the sound from this type of high-level system, aim the speaker at a point near the back of the auditorium, so that most of the listeners close to the speaker hear only the weaker "spillover" sound. The way to do it is aim, listen, then aim again, until you achieve the best possible results.

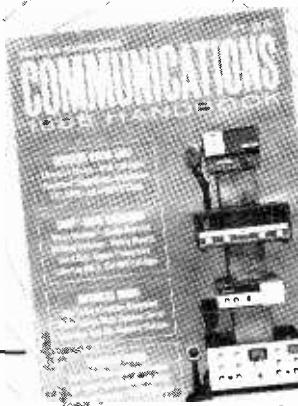
Feedback is an especially annoying problem in a portable high level (minimum number of speakers) system, more so than with a permanent system having many strategically placed speakers operating at relatively low volume levels. Repositioning the speakers and microphones, and readjusting level and tone controls may help reduce the feedback problem to a minimum. Some p.a. amplifiers are equipped with an anti-feedback control. Highly unidirectional microphones should always be used.

**INSTALLING MOBILE P.A. SYSTEMS** The mobile sound system differs from both the permanent and portable p.a. system in many respects. The complete mobile system is usually mounted on or in the vehicle rather than being spread out around an auditorium or arena. The speakers in a mobile system must be directional trumpets to project the sound and to minimize chance feedback inside the vehicle where the microphone is located. Most mobile systems use transistorized amplifiers to take advantage of the power economy possible. The microphone will usually be designed for close talking exclusively to further minimize audio feedback.

One popular type of mobile sound system consists of the modulator portion of an ordinary CB transceiver. Many transceivers are sold with p.a. switching facilities. With one of these transceivers, the only extra equipment needed is a directional speaker mounted on top or under the hood of the vehicle.

To install a complex mobile sound system, choose the amplifier and speakers on the basis of area

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coverage required. (Double the wattage values of the "rule-of-thumb" previously discussed). Mount the speakers on the outside of the vehicle, pointing in the desired direction, and bolt the amplifier in place at any convenient location inside the vehicle. Weatherproof all connections that will be exposed to the elements.

**SERVICING P.A. SYSTEMS** Servicing a p.a. system is similar to the servicing of most audio equipment, but with a few special problems. Troubles generally fall into four main categories: total system failure, partial system failure, distortion, and reduced power output.

Total system failure is usually due either to a loss of main power (blown fuse or circuit breaker, power cable broken or disconnected) or tube (or transistor) failure in the amplifier. If the system uses a number of small amplifiers, rather than one main large amplifier, total failure is almost invariably due to loss of main power. Other common troubles include defective microphones, microphone cables, connectors, and controls.

Partial system failure can be due to defective speakers, poor cabling, or (in a multi-amplifier system) failure of one of the small amplifiers. If partial system failure occurs, it may be possible to continue operation by angling the speakers that are still working to cover the dead area and turning up the amplifier level. This is strictly an emergency measure. The trouble should be located and corrected at the earliest opportunity.

Distortion can be caused by a defective microphone, speaker, or amplifier. If the trouble seems to be present only with a particular microphone input or speaker output, chances are that the main amplifier is okay. Here again, substitution of the suspected component is usually the most conclusive check.

If the power output drops off, weak tubes are the most likely source of trouble. These should be tested or checked by substitution, preferably stage by stage.

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