Complete plans for 16 speaker systems

60c ■ MAR. 1969

Radio-Electronics®

TE... ...RVICING · HIGH FIDELITY

SPEAKERS
ENCLOSURES
CROSSOVERS

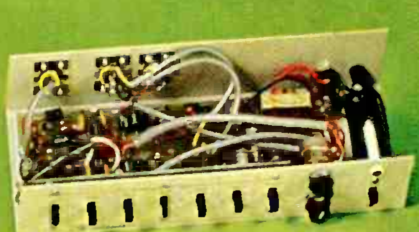
starts on page 32

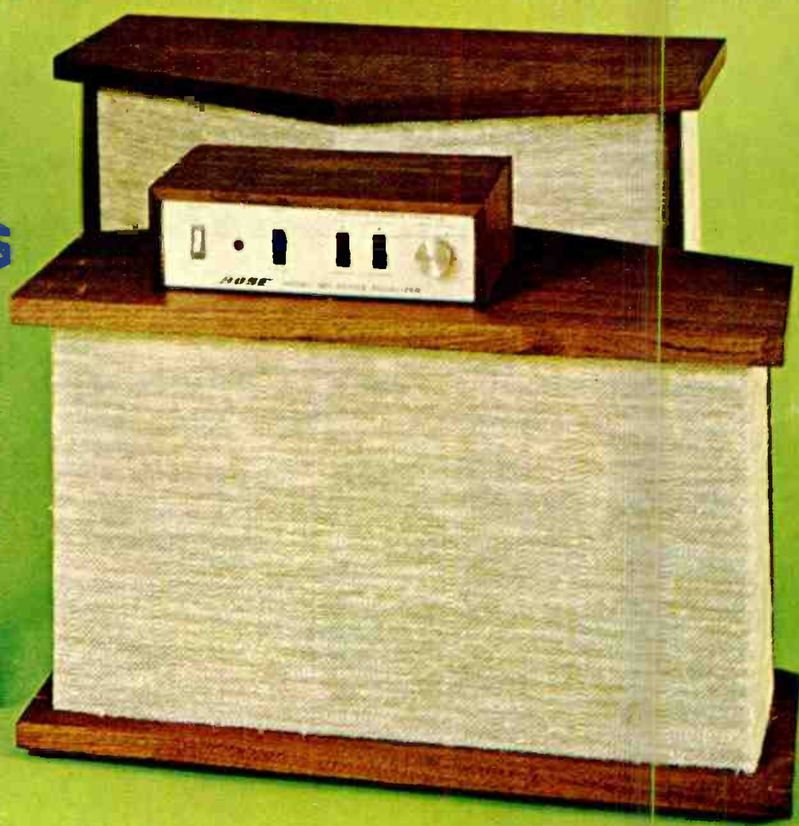
BUILD
Portable IC Stereo Phono

10 Emitter-Coupled Circuits

K... olor TV faults

F... ith Nixies





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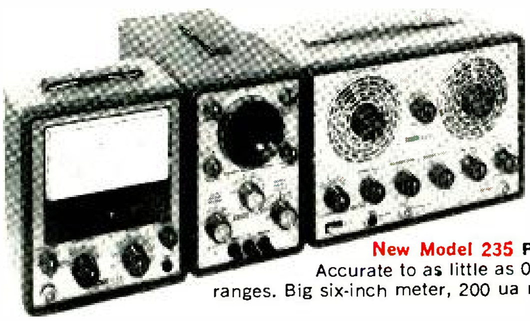

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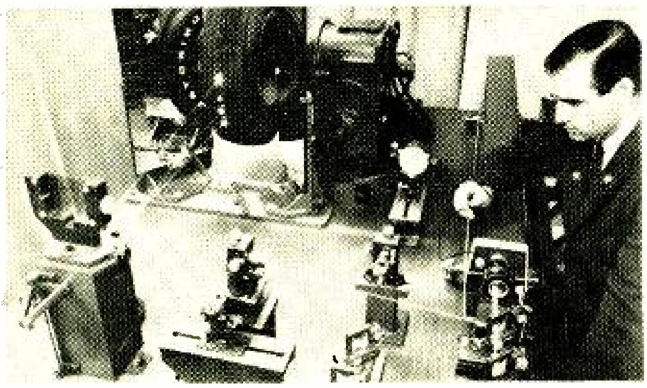
NEW & TIMELY

Volume 40 Number 3 RADIO-ELECTRONICS March 1969

LASER SPOTS TIRE DEFECTS



A blast from a laser beam may be used one day to test your tires for hidden defects. The setup in the photo is now used developmentally by Uniroyal, and plans call for using the nondestructive testing technique on costly aircraft tires. Less expensive versions may eventually be used at automobile service centers and for routine production-line tests.

The process combines three-dimensional laser photography — holography — and laser interferometry to spot tire flaws that can affect durability and performance. When a tire is inflated, these defects show up as concentric circles of light and shadow on a hologram transparency, since normal tire expansion is distributed evenly throughout the tire. Even if the defect is buried deep inside the tire, it stands out on the hologram as if it had been circled. The brief exposure to the laser does not damage tire rubber.

International Panel Backs Metric System

WASHINGTON, D.C.—An international four-member panel recently voiced strong support of the metric system at a recent 50th anniversary meeting of the USA Standards Institute. Only one panel member, Harry E. Cheseborough of SIMCA, opposed the change to metric units in this country, and he, too, felt the change would eventually take place.

One panelist, Maryland Senator Claiborne Pell, said the change to the metric system would mean an increase of U.S. exports to metric-oriented markets of the world, and greater efficiency in our domestic economy.

A British representative indicated his country's change to the metric system has brought about cost savings, reduced trade barriers and cut design and drafting time. The opposing panelist felt that the changeover would result in confusion without substantially improving U.S. international trade.

IN THIS ISSUE

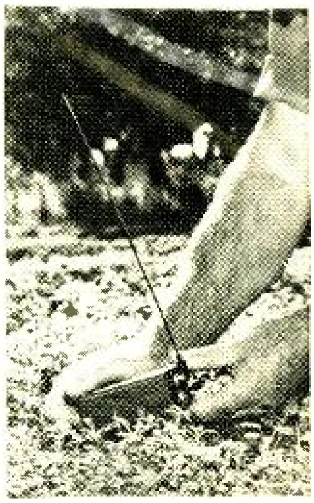
Now you can fit both channels of a stereo amplifier into a phonograph tonearm. Ed Francis provides complete details on a battery-operated stereo phonograph using two IC's.

SOLID-STATE TV

Transistor characteristics demand special types of circuits for TV. Contributing Editor Matt Mandl keeps you up to date with the latest solid-state TV servicing tips. Don't miss his fact-filled article in this issue.

NEW SENSOR 'HEARS' FOOTSTEP VIBRATIONS

Tred softly around this pocket-size security sensor. It was developed to detect vibrations from moving humans or vehicles up to 75 feet away and relay a warning to a distant monitor receiver. The electronic sensor, designed to prevent infiltration, can transmit a coded warning that



identifies its location from 1/5 to 5 miles, depending on terrain. A signal-processing filter system discriminates low-frequency vibration sources to minimize false alarms from low-flying aircraft, thunder and other sources. GT&E's Sylvania built the device for military applications.

OPTO-ELECTRONIC TV?

Whatever form large, flat color TV displays take in coming years, it's unlikely they'll be CRT's. (See January 1969, RADIO-ELECTRONICS, p. 33.) To a growing list of display devices with potential possibilities for flat-screen TV is added an opto-electronic device developed at Sandia Corp. Like many of the new displays, this one requires an x-y addressing circuit to generate a point of light—unlike TV's continuous sweep raster.

This new solid-state tech-

(continued on page 6)

LOOKING AHEAD

By DAVID LACHENBRUCH
CONTRIBUTING EDITOR

TV's future directions

Three important Government documents are helping to spell out the future of television. They are the FCC's new "notice of inquiry" on cable TV, its authorization for nationwide pay TV, and the report of the President's Task Force on Telecommunications.

The FCC's proposed rules governing cable TV (CATV) may have been designed to make broadcasters and cable operators happy, as has been alleged, but they immediately came under attack from both factions. Cable operators were particularly perturbed, calling the proposed rules a "freeze" on construction of new systems. Here are the commission's major proposals:

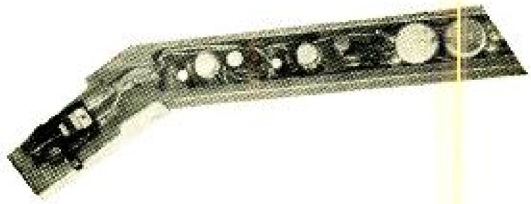
1. Cable systems in the nation's 100 largest markets (New York is No. 1, Terre Haute No. 100) would be required to get permission of the originating stations to carry signals of any stations more than 35 miles away.

2. Systems in smaller markets could import signals without permission, but only to bring in programs of the three networks, one independent station and one educational station—and these must be the nearest stations of

(continued on page 4)

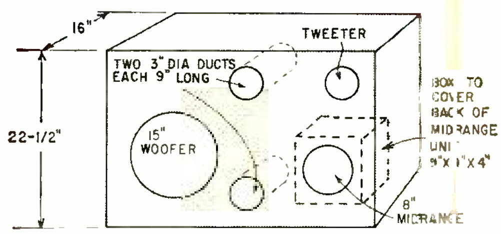
Radio-Electronics

March 1969 • Over 60 Years of Electronics Publishing



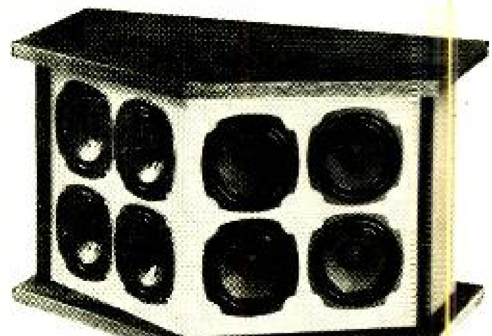
Portable stereo is a cinch. Just put two channels worth of IC amplifiers in the pickup arm.

see page 52



Need a speaker system? Here are complete plans for 16 different versions. Try one soon.

see page 44



No crossovers needed in this speaker system. See how and why it works. Full details by an expert.

see page 33

On The Cover
Hanging out of the Radio-Electronics logo are two JVC spherical speakers. Directly below are the three parts of a Bose stereo speaker system. At the bottom right is an inside look at the C-M electronic crossover.

AUDIO-HIGH FIDELITY-STEREO

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DEPARTMENTS

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LOOKING AHEAD

(continued from page 2)

their kind available. If CATV systems wish to bring in more channels, they must get permission from the originating stations.

3. CATV systems would be required to originate one channel of their own programing—but *only* one channel (except for such "automatic" programing as news and stock tickers, weather channels and the like). The commission left open the question of whether cable systems should be permitted to sell advertising time.

The proposed rules would not affect any existing cable systems. The commission specifically said it had no intention of taking any service away from anyone now being served by CATV. Although the rules are only "proposed" and will be the subject of many legal filings, and probably hearings, the FCC put into effect "interim procedures" which make the rules at least temporarily applicable to all new cable systems—beginning immediately.

Although at first glance the rules appear mild enough, cable TV interests, through their National Community Television Association, immediately attacked them as "bringing to a halt the further expansion of CATV."

The sleeper in the FCC's proposals is the phrase, "permission of the originating station." Since stations don't own the copyrights of everything they broadcast—for example, feature films—the permission isn't theirs to give. Some communications lawyers, in fact, insist it would be illegal for them to give permission. Thus, the proposed rules would, quite likely, amount to a ban on the importation of signals from more than 35 miles away into major television markets.

In the meantime, Congress is wrestling with a new copyright law which would clarify the copyright liability of CATV systems for programs they relay. Until a law is passed, the whole "permission" situation—and what it means—is completely muddled.

The FCC also started an inquiry into the long-term future of cable TV, including such questions as whether the same cables into the home ultimately will be used for two-way computer information, facsimile newspapers and the like—and who should be permitted to own these cables.

The President's Task Force

At almost the same time that the FCC was issuing its proposed CATV rules, excerpts from the report of the blue-ribbon Communications Task Force named by ex-President Johnson were being made public. They seemed to conflict with the attitude of the FCC. The Task Force took the view that cable TV held the most promise for supplying the nation with a diversity of communications to and from the home.

Among the near-future capabilities of CATV, as envisioned by the Presidential panel, are employment services (help-wanted ads), literacy training, preschool programs, preventive health programs, adult education, classroom instruction, shopping information, places to dine, classified ads, amateur drama, and so forth. Cable TV's tremendous channel-handling capacity, at a relatively low cost per channel, the Task Force said, makes it the most potent future force in communicating with the home.

But the Task Force also took note of CATV's copyright problems, and said they should be resolved by Congress without delay.

(continued on page 12)

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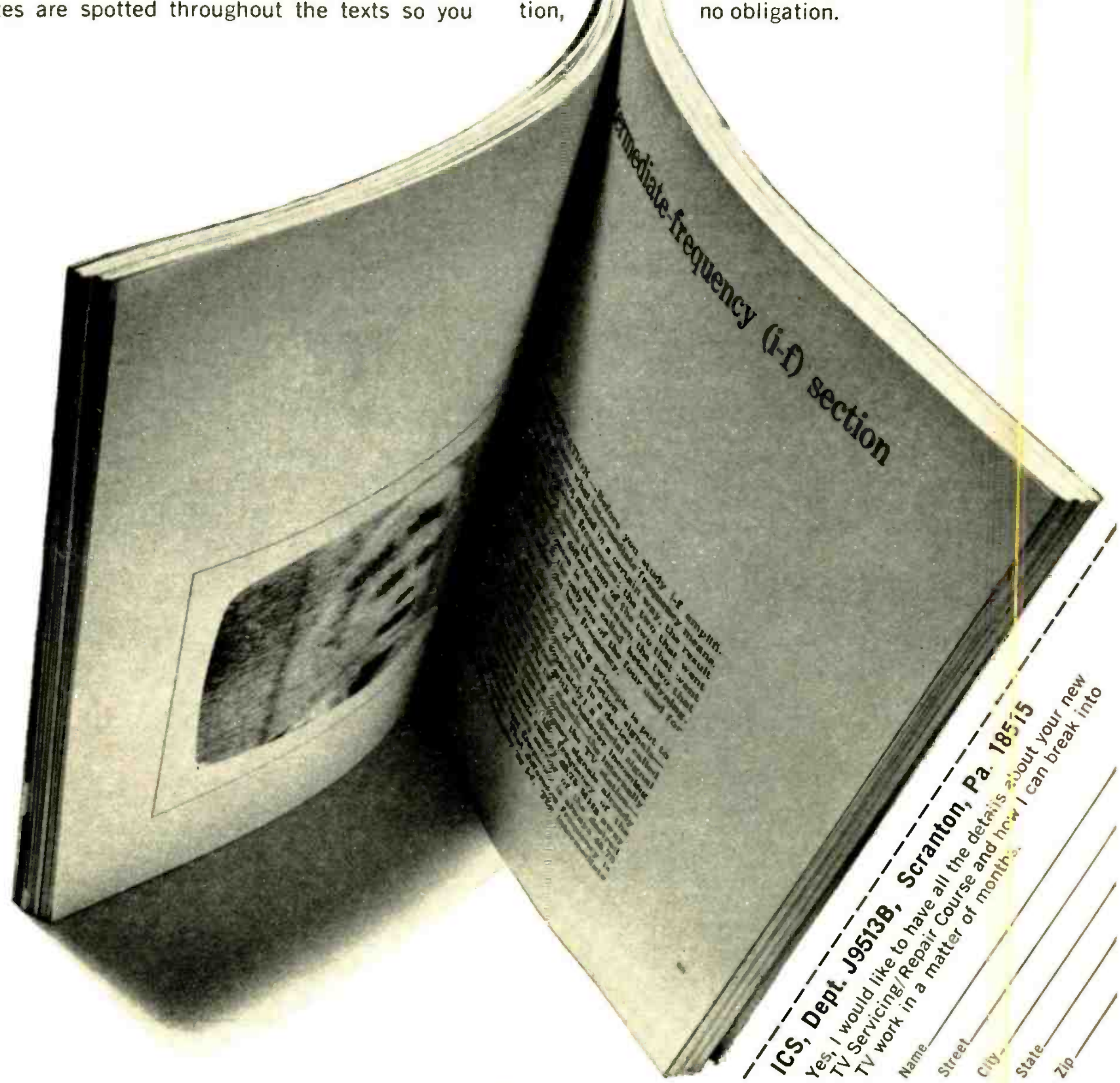

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OPTO-ELECTRONIC TV?

(continued from page 2)

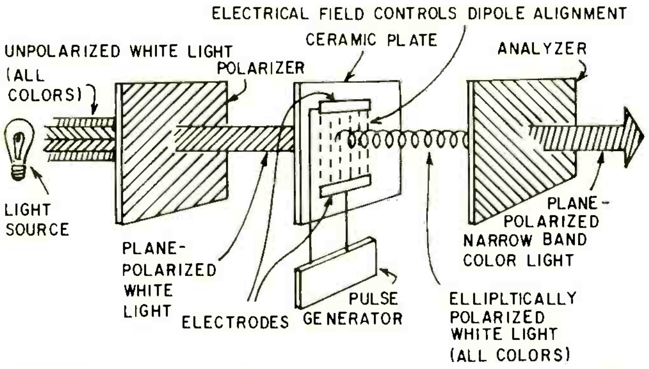
nique uses a three-element filter and a source of white light (see diagram). The light is filtered by the first polarizer so that it is traveling in a specific plane when it enters the center sheet. This element, the heart of the device, is a matrix of tiny transparent ceramic slices that can be individually addressed with voltage pulses. The material used is a ferroelectric ceramic (lead zirconate titanate), whose atomic dipoles can be rotated precisely with the appropriate applied voltage.

An electric field also causes this clear ceramic to become birefringent (objects appear double through it). This birefringence causes each wavelength of the plane-polarized light entering it to break into two wave planes—elliptically or helically polarized light. Specific colors or wavelengths of this light can then be selected by passing it through the last filter, the analyzer. The color of the resulting point of light will depend on how the polarized light is "twisted" as it passes through each ceramic slice.

So far, prototypes have contained only 100 ceramic cells deposited in ⅛ x 1/16-inch area. Blue colors are weak, and a black spot has been unattainable. If higher cell densities are achieved, the technique may permit projecting displays on screens, much as slide projectors show 35mm transparencies. The device was described in the Nov. 14, 1968, *New Scientist*.

PICK A SPEAKER

Looking for a hi-fi speaker? Why not build your own? We've got plans for 16 systems in this issue, with speaker price tags ranging from $20 to a Rolls Royce setup for over $300.



SEEING WITH SOUND

Optical holography is becoming more and more useful in industry and research, as you can see by the tire test described on these pages. Now researchers are also turning to acoustical holograms, made by replacing laser light beams with sound beams. Since sound waves penetrate matter better than do light waves, acoustical holography will permit "seeing" in 3D through liquids and solids.

A technique developed at Bendix Research Labs allows acoustical holograms to be made of moving objects. To record the sound waves, an arrangement similar to a TV camera is used, except a piezoelectrical plate is substituted for the optical, beam-scanning system in a TV camera CRT. Acoustic beams form an interference pattern on the outside of the piezoelectrical plate, and the pattern is converted to electrical pulses on the inside of the plate by a scanning beam. To reconstruct the image, the pattern is projected on a phosphorescent screen, photographed, and the original image reconstructed with laser light.

MORE COLOR IC's

Color TV circuits got a boost in reliability and a sharp cut in size with Zenith and

Motorola announcements of IC color demodulators.

Zenith's new IC, with a ceramic base and epoxy covering, plugs into a socket on 18 top-line sets (photo). The demodulator combines 19 transistors, 2 diodes and 24 resistors on a silicon chip less than 1/16-inch square.

The MC1325 is the IC device introduced by Motorola and was built for design flexibility. The R – Y : B – Y signal ratio, for example, can be modified by the addition of an external resistor.

LIMITS RAISED FOR SUPERCONDUCTIVITY

MURRAY HILL, N.J.—Transmission of large electrical currents over great distances through small-diameter cables came closer to economic reality with a recent development that has pushed

(continued on page 12)

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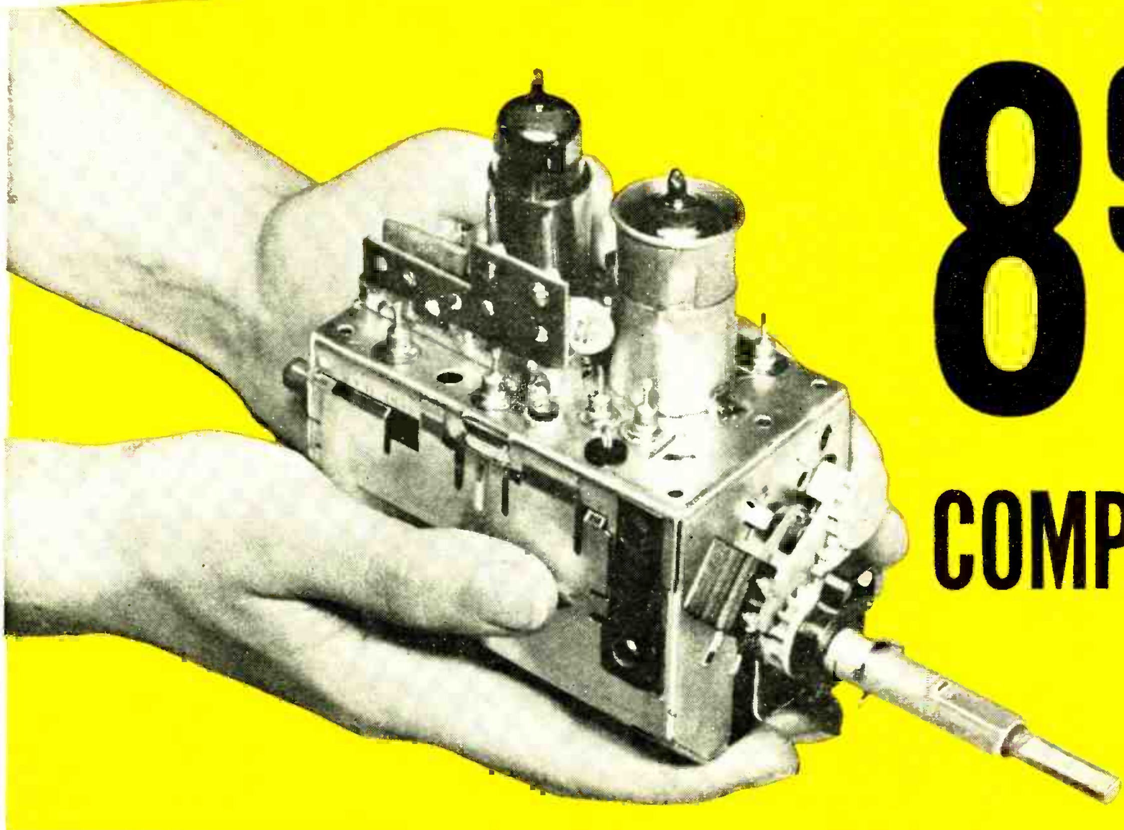

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CR6XL	Parallel 6.3v	2½″	12″	41.25	45.75	10.45
CR7XL	Series 600mA	2½″	12″	41.25	45.75	11.00
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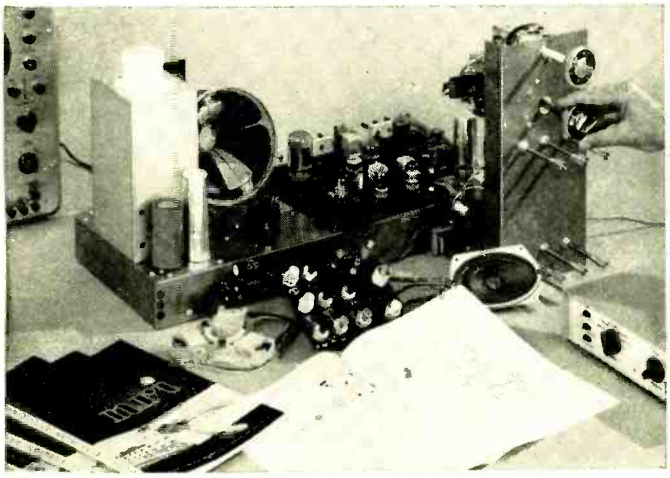

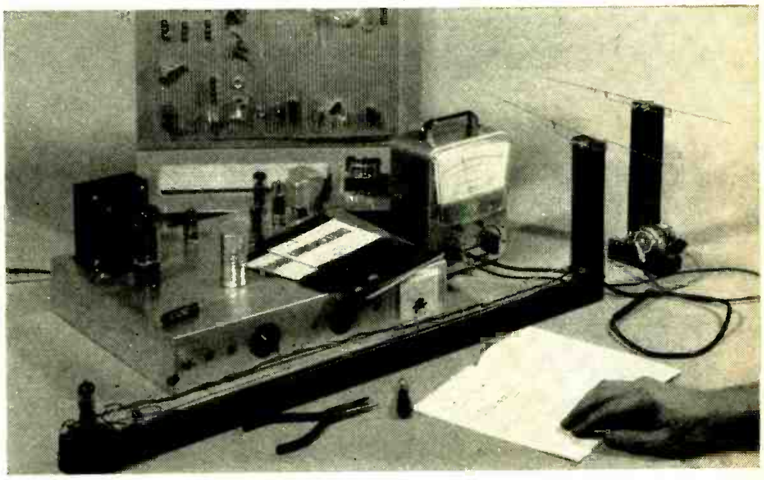

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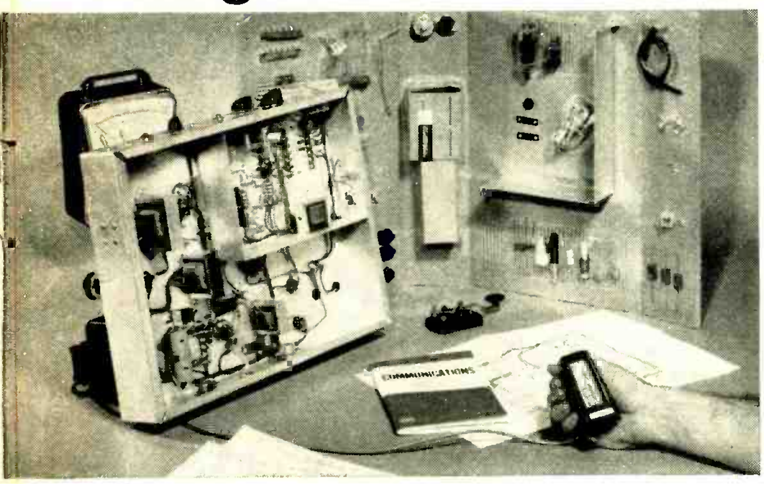

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LOOKING AHEAD

(continued from page 4)

—and pay TV

Ten years ago it would have made big waves. But when the FCC ended 15 years of deliberation by finally approving a nationwide system of pay TV, it created scarcely a ripple. Perhaps this was because every experimental pay-TV system so far has thrown in the sponge—the latest being the Zenith-RKO project in Hartford, Conn., which died Jan. 31, 1968.

Perhaps, too, it is because of the careful restrictions the commission placed on the see-for-a-fee operations it will permit. These circumscriptions, designed to protect conventional free TV, include:

1. The limiting of pay-TV operations to areas served by five or more stations, and then limiting pay operations to only one station in each area. Under these conditions, there would be a maximum of only 89 areas in the United States which could qualify for pay-TV stations.
2. Movies shown on pay TV, with a few exceptions, must be *less* than 2 years old.
3. Live sports events of the type shown on free TV within the preceding 2 years may not be shown—with the exception of events normally blacked out in a particular area, such as professional football games in the home team's area.
4. Series programs with regular casts are barred.
5. No commercials may be shown during pay programs.
6. Pay-TV stations must also offer free programs at least 28 hours weekly.
7. At least 10 percent of a station's annual pay-TV programing must be devoted to material other than movies and sports.

The FCC withheld judgment on whether it would permit pay TV via cable, but asked the public's views on the subject, in preparation for a future determination.

The Zenith-RKO experimental pay system in Hartford, meanwhile, was shut down after 6½ years—for several reasons, including the necessity of developing pay-TV decoders which will work with color programing. The station has now reverted to its regular free commercial TV operation. **R-E**

SUPERCONDUCTIVITY

(continued from page 6)

the temperature for superconductivity to above 20.7°K. (Zero degrees K or Kelvin represents the total absence of heat, an equivalent to −460°F.) When superconductivity occurs, materials lose all resistance to the passage of electric current.

Bell Labs scientist B. T. Matthias and co-workers raised the superconductivity level with a metallic combination of niobium, aluminum and germanium.

The earlier upper limit for superconductivity was thought to be 18°K. Now that this limit has been raised to 20.7°K, it is possible to use inexpensive liquid hydrogen to achieve superconductivity instead of the much more expensive liquid helium. The boiling point of liquid helium is 4°K whereas liquid hydrogen boils at about 20°K.

The new materials may also make it possible to produce magnetic fields with densities higher than those already achieved through superconductivity. In 1961 a 100,000-gauss field was produced with a niobium-tin alloy at Bell Labs. **R-E**

In the Shop . . . With Jack

By JACK DARR
SERVICE EDITOR

HOW TO SAVE COLOR CRTS

ONE OF THE HEART-BREAKING THINGS in color TV is the set which shows an odd-looking picture, with flesh tones a peculiar reddish tint, and a mess of other colors. If you turn the color control off, out goes the whole picture! There is obviously no video (Y) signal present—only the color.

Alternate symptom: screen is too reddish (bluish, greenish) on black-and-white, and this color can't be turned down. One gun is obviously running wide open—lots of speed but no control. It is biased full on and you can't cut it off with the normal controls.

This indicates one possible trouble: a heater–cathode short in one gun of the picture tube. To make sure, check it with a good color CRT tester. (There are certain chassis troubles that can imitate the same symptoms.)

Practically all color sets use a biased heater (Fig. 1). About 150 volts dc is taken from the B+ supply and applied to the color picture

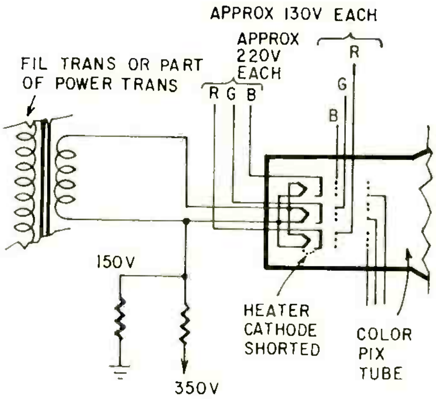

Fig. 1—Biased heater typically used in color CRT's operates from B+ supply.

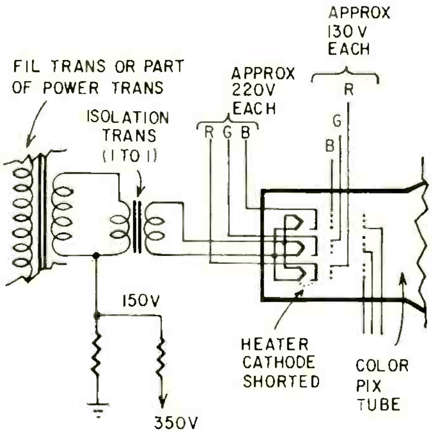

Fig. 2—Heater-to-cathode short (above) can be isolated with a 1:1 transformer.

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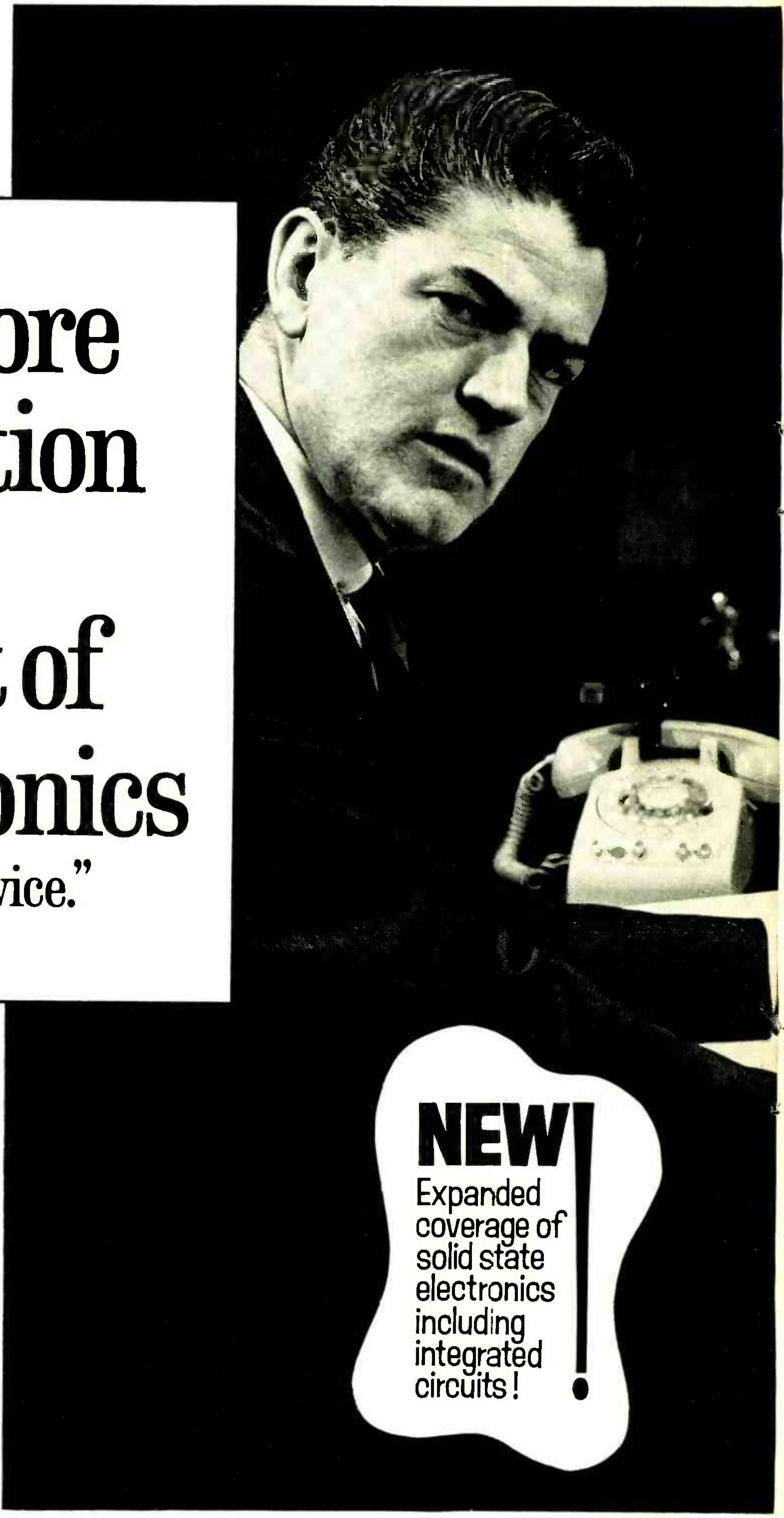
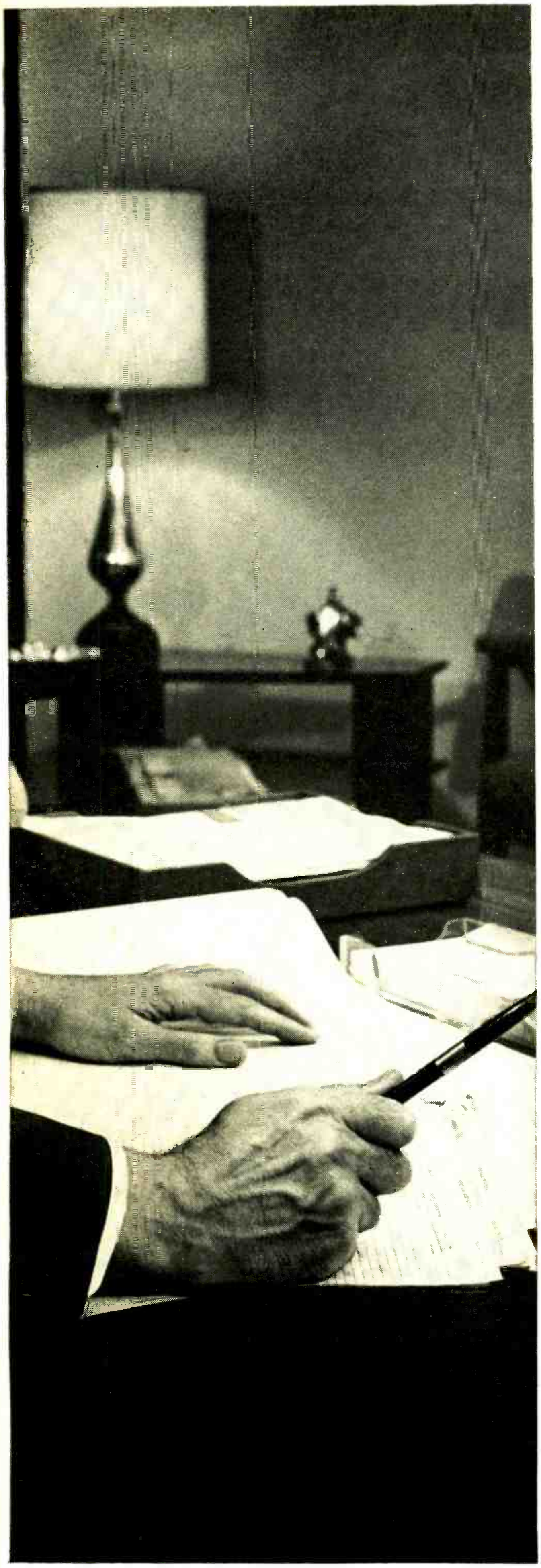




Isolation transformer by Perma-Power.

tube heaters and the h-v regulator (if it's a shunt regulator like a 6BK4, etc). This reduces the voltage stress between the heater and cathode to prevent this kind of short. The B+ supply has a very low impedance to ground, and the video signal is bypassed to ground through the filter capacitors.

With a heater–cathode short identified, we can forget this bias. The trouble has already happened.

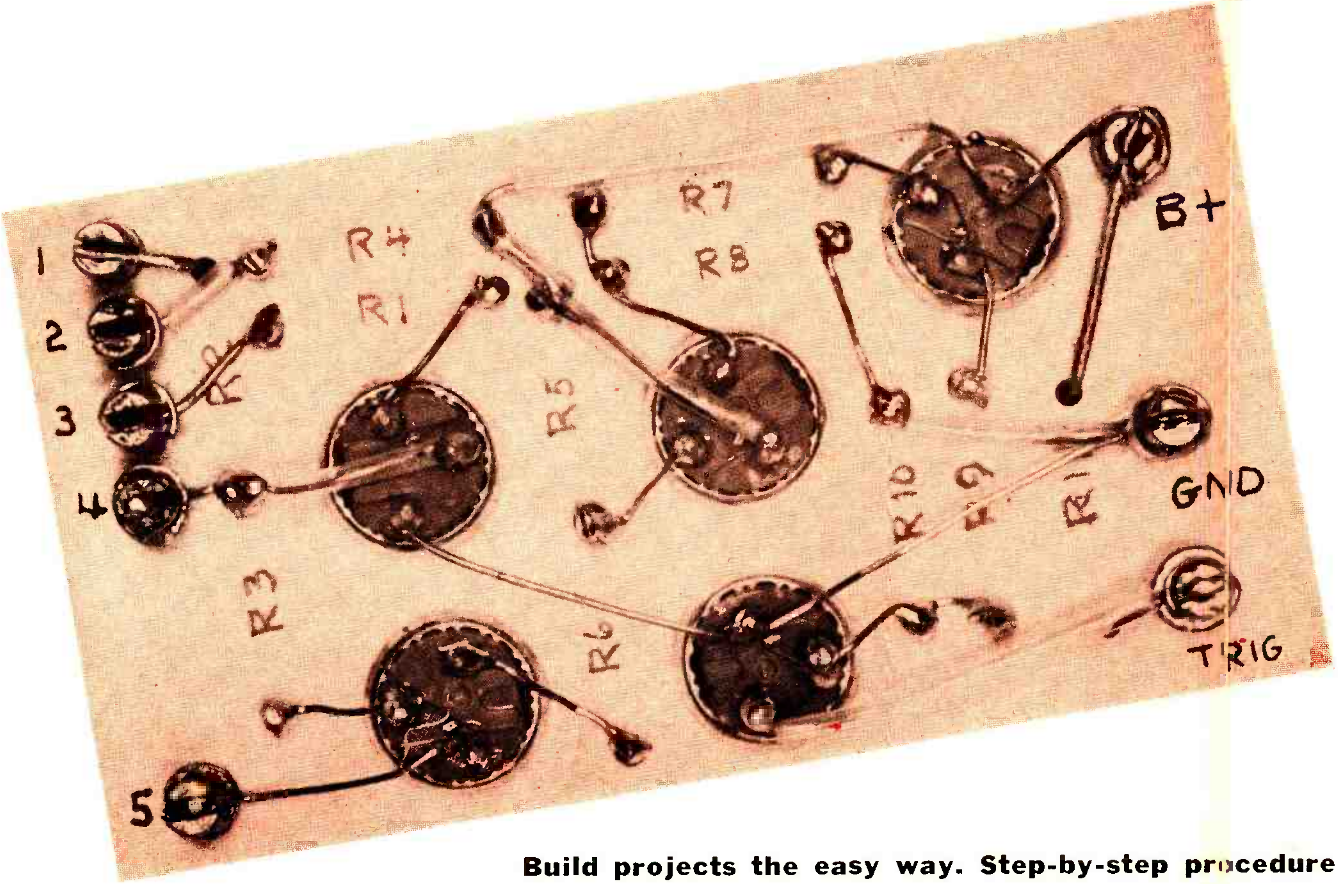
It is NOT a good idea to try blowing this type of short out with the rejuvenate function of the picture-tube tester. Other interelement shorts, yes. These are usually "particle" shorts, where a flake of material has gotten between two other elements. But a heater–cathode short could be due to a fracture of the heater's ceramic insulation, which could let the heater coil touch the cathode cylinder. Applying a shooting voltage to this just might blow out the heater!

There's a much simpler way to get rid of this short and save the picture tube. If you can *isolate* the shorted heater, you'll save the video. This can be done by adding a small 1:1 isolation transformer (Fig. 2). These look exactly like the familiar picture-tube brighteners, but they aren't. They do not raise the heater voltage, since in most cases this isn't necessary. They simply isolate the heater from the ground.

A typical unit is shown in the photo. This is installed just like a brightener by putting it between the picture-tube base and socket. The transformer shown is made for older 70° round tubes. Rectangular-tube units, with the small base, are available for the same price. Since this is something like 1/28th the cost of a new picture tube, the set owner is getting a real bargain. **R-E**

TIME SAVER

USE THE WIRED BOARD TECHNIQUE



Build projects the easy way. Step-by-step procedure shows you how to pack in seven components per square inch.

By ROBERT E. BROCK*

THE WIRED CIRCUIT BOARD TECHNIQUE IS FOR ALL ELECTRONIC HOBBYISTS, experimenters, technicians, engineers and designers who want to build a one-of-a-kind electronic project for their own use or to test a new idea. If offers the advantages of the etched board technique and eliminates virtually all its disadvantages.

Here are nine comparisons of these two techniques:

1. Wired board layout is easier to design because wire crossovers are possible (when one wire is covered by tubing). Foil paths cannot cross unless they are on opposite surfaces of the board.
2. There is no unusual heat problem when wires are soldered. Potentially serious and very significant heat problems exist when foil paths are soldered.
3. The wired circuit path is not fragile, while a foil path may be mechanically damaged very easily.
4. A wire conductor presents a somewhat lower resistance point-to-point than does foil because of its greater mil area.
5. Wired board layout permits a packing density of components exceeding that of etched board layout. At the same time it presents all the attributes of neatness, function and accessibility for point-to-point testing offered by the etched board design.
6. Defective or damaged components on a wired board may be removed and

* Ampex Corp., Redwood City, Calif.

replaced with ease and without hazard to the board. The hazards and difficulties of doing this with an etched board are well known.

7. The width of a wired path is only the diameter of the wire itself (or that of the tubing at crossovers). The foil path width is always greater (occupies more board area). Individual wire paths may be as close as their insulation permits without any possibility of bridging (or shorting) from one to the other. The possibility of bridging one foil path to another while soldering is always present.
8. While both the wired and the foil techniques permit the use of transistor sockets and terminal pins, the ease and flexibility of determining the best socket orientation is far greater with the wired technique.
9. The wired-board blank may be drilled and assembled as soon as the layout is ready. The etched-board blank must be etched before it is drilled, and this drilling is a hazard in itself.

My first test of the wired board idea was building and testing an experimental triggering device. Its circuit (see Fig. 1) included six panel controls, and circuit connections had to be provided on the board for them. One of the controls (switch S1) supports four capacitors.

The board layout (Fig. 1) delivers a packing density (counting eight terminal pins) of seven components per square inch. The drilling pattern (Fig. 1) was made from the layout by tracing the exact locations and identities of components through carbon paper onto the under-surface of the blank board.

Components template

The components template (Fig. 2) in ludes cutout areas which, when traced, produce exact-si.e outlines of ½-, 1- and 2-watt resistors, of a transistor socket and a typical terminal pin. It also includes small guide holes near the ends of each resistor outline, to precisely locate resistor-lead drill holes. The transistor-socket template hole provides a circle whose diameter is the major diameter of the socket clamping ring.

You can make a components template of clear acetate sheet (0.010"–0.025"). Scribe the cutout areas and center lines by placing the acetate over the illustration of Fig. 2. Use a sharp blade to trace lightly each straight line that crosses the length and width of the template area. These lines mark the lateral and longitudinal center lines of the resistors, and the centers of the holes that outline the transistor socket and the terminal pin. Also lightly trace the short cross lines near the ends of the resistor outlines; these locate the holes for the resistor leads.

Carefully trace the outlines of the resistors very heavily (but do not cut through). Then remove the acetate, and place it on a sheet of cardboard to cut out the resistor outlines. Use a 15/32" drill at the socket hole location, a 5/32" drill at the terminal pin hole and a 3/64" drill for the two holes for each resistor outlines.

Finally, trace the scribed boundary lines of the template with the knife to cut out the finished template. If you have worked carefully, the sides of the template will be precisely parallel, the ends exactly perpendicular to the sides, and all edges will be smooth.

Layout technique

Preparing a full-size layout requires some planning to produce efficient component placement. Unless the shape of the board is affected by the space in which it must fit, the layout should occupy a square or rectangular area of minimum size. The following are useful suggestions to keep in mind when preparing a layout:

1. Identify components that will not be mounted on the wired board. These include all panel controls and indicators (potentiometers, switches, etc.), input and output receptacles, the power transformer (if any), physically large capacitors and components that must be heat-sink-mounted.
2. Make an initial layout of the wired board underside. While making the layout, provide a terminal pin for the connections the external components will require to circuit points on the board. One terminal pin will often represent a junction point of two or more externally mounted components.
3. Because the board-mounted components are invisible from the underside of the board, their outlines should be drawn with dashed lines, which serve to establish space requirements and the centers of drilled holes.
4. As drawn, the wire paths may be only representative. Actual wired paths may instead follow the most direct route between circuit points.
5. Give careful consideration to the orientation of all components and transistor sockets with respect to their circuit connection points. Identify each component by its schematic reference number, and number or identify each terminal pin.

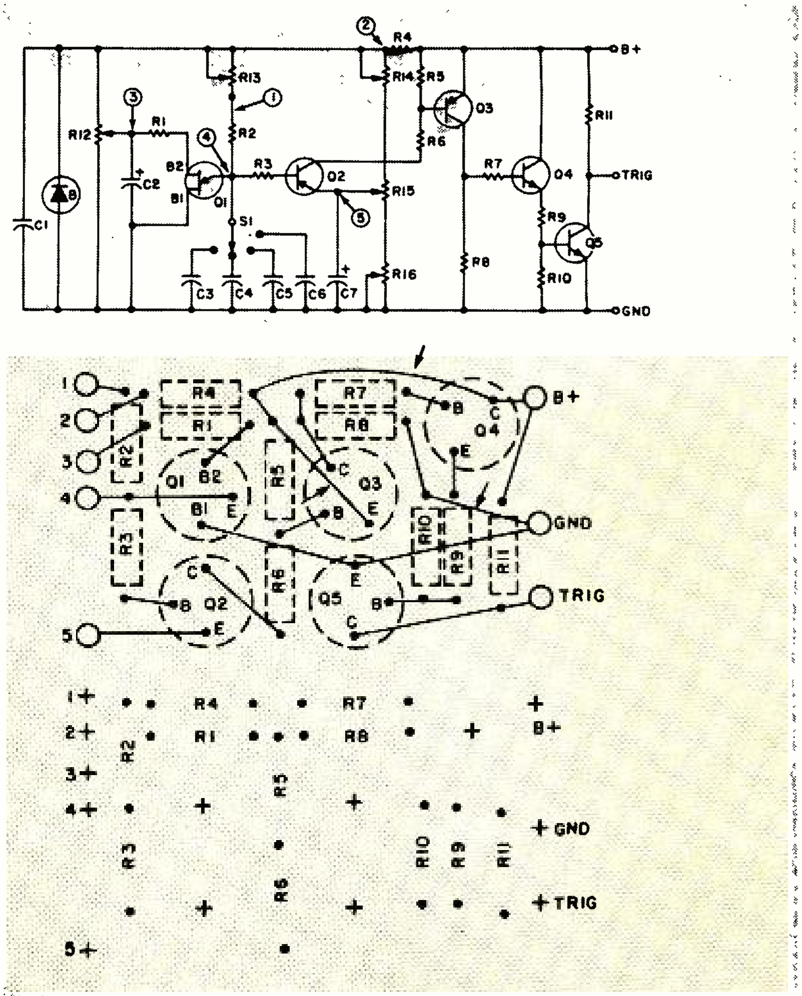


Fig. 1—Circuit of experimental triggering device (top). Numbered arrows are terminals in layouts below. Full-size layout of wiring board (center). (Arrows indicate insulated wire.) Drilling template (bottom) for under side of board.

6. Having made and checked the initial layout against the schematic, study it to determine how it can be reduced to occupy a minimum of board area. Think in terms of repositioning or reorientation of components to reduce the size of unused board areas.
7. Make a new layout that reflects the improved packing density planned in (6). Remember that the wire paths may cross each other (if tubing is used at crossover points), and that the paths may be directly under any of the components (except perhaps the transistor sockets). Capacitors or resistors associated with switches should be mounted on them, external to the board. Small capacitors and diodes should be connected to terminal pins (on top of the board), and dressed to a vacant board area where possible.

Unless the number of 1-watt resistors represents 22% (or the number of 2-watt resistors represents 12%) or more of the total number of resistors, it is usually possible to place an average of seven components (counting terminal pins) per square inch of board. In any case, the packing density achieved can equal or exceed that of a comparably well-designed foil-path board.

Wired-board construction

After completing the components layout and marking the locations of holes to be drilled, position the layout on the under side of a sheet of 1/16" plain phenolic or fiberboard. Fasten it in position temporarily with short lengths of masking tape at the top and sides. Then insert a sheet of carbon paper (carbon side down) between the layout and the board. The series of photos across the bottom of pages 25 and 26 illustrates the text that follows.

Use a dull-pointed stylus to mark the location of each hole to be drilled (Photo A). Each resistor requires two

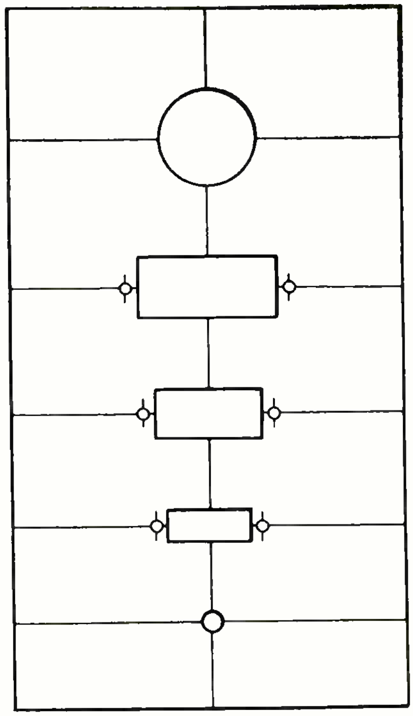


Fig. 2—Template for drawing exact size component outlines.

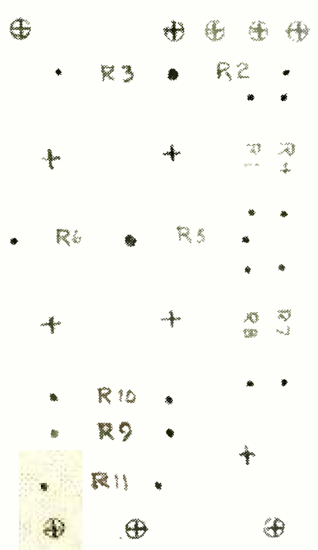


Photo A—Drill holes are transferred to back of blank board used for the wired board layout. Tape the completed component layout (Fig. 1) to the underside of circuit board with carbon paper. Trace each drill hole and schematic number of the resistors. Spray board with fixative to prevent smudging pencil markings.

Photo B—Drill holes for the components, sockets and terminals next. In-line resistors need only one hole. Its size is determined by resistor wattage (see text for hole size). If tracing was made on a larger piece of board, cut the board to finished size now. Leave adequate margins for chassis-mounting holes.

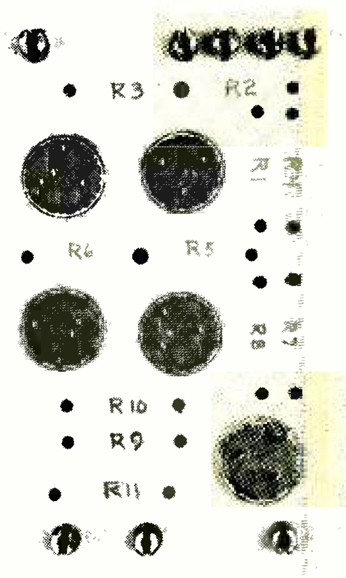


Photo C—Install sockets and terminal pins next. Make sure that socket pins are oriented to correspond with pin positions in the layout. Similarly, install terminal pins so their slots line up with the connections to be made in the circuit. The fourth pin of the sockets has been clipped off as it is not needed in this circuit.

such holes. Be sure to mark both, and mark only the schematic code of the resistor. Do not draw the resistor outline. Mark the center of each transistor socket location, and draw in each terminal pin, and marking its assigned number or other identification.

Lift up the layout and the carbon paper, and determine that every hole to be drilled is marked and every component identified. Then remove the layout and the carbon paper, and apply a light spray of a fixative such as Krylon or lacquer to the board surface to prevent smudging the marks.

The wire holes drilled for each resistor should be 1/16″ diameter and the hole for each transistor socket 3/8″. The hole for each terminal pin should be its diameter as measured with a micrometer (to assure a firm pressed fit when installed).

Drill only one common hole to connect two in-line resistors (Photo B). The common-wire hole for two in-line ½-watt resistors should be 5/64″ diameter; for two 1-watt resistors, 3/32″; for two 2 watt, 7/64″.

Install the transistor sockets with their bases protruding through the under surface of the board, and orient them to the positions shown for the C–B–E leads in the layout. Similarly install the terminal pins, orienting their slots (if any) to be in line with their connections to the wired circuit (Photo C).

Use No 22 AWG tinned soft bare copper wire to make all direct connections between transistors and terminal pins. Solder the connections to the socket terminal. Solder connections to terminal pins only if no other underside connections are to be made to that terminal pin.

If the layout includes several junctions with power buses (such as "+" volts or ground), make and solder the terminal connection, and extend the bus in readiness for component junctions as you encounter them (Photos D, E and F).

Wiring suggestions

Here are several useful rules to follow in wiring the board:

1. Use No. 22 AWG tinned soft bare copper in all circuit paths that do not include any 1-watt or 2-watt resistors.

Connections of External Components to Wired Board (Experimental triggering device)

PIN IDENTITY	CONNECTIONS TO EXTERNAL COMPONENTS
1	Bottom of R13
2	Tops of R12, R13, R14, Cathode of diode, C1+
3	Wiper of R12, C2+
4	Wiper of switch S1
5	Wiper of R15, C7+
GND	Bottom of R16, common of C3, C4, C5, C6, C7-, C1-, Anode of diode, bottoms of R12, and R16 (with wiper)

2. Use No. 20 AWG (or two pieces of No 22 AWG in parallel) in circuit paths to 1-watt resistors. Use No. 18 AWG (or three pieces of No. 22 AWG) in circuit paths to 2-watt resistors, and in all power- and negative-return buses connected to 1- or 2-watt resistors or to the collectors of power-switching or power-amplifier transistors.
3. Use the resistor leads for all direct connections to terminal pins and, where possible without splicing, to all transistor socket connections.
4. Prepare each resistor for mounting on the board by bending both leads at right angles. Mount each resistor by pushing its leads through its predrilled holes in the circuit board. If one lead is to be the only connection made to a given terminal pin or transistor terminal, bend it flush with the board surface in the direction of the connection, make the connection, and solder it.
5. If any resistor lead makes a junction with one or more components, cut it off, leaving about 3/16″ protruding from the under side of the board. Proceed with the point-to-point wiring by wrapping the connecting wire one or two tight turns around the resistor lead (snug to the board) and soldering it. Then snip off any of the lead length that protrudes from the soldered connection, and continue to the next connection point. **R-E**

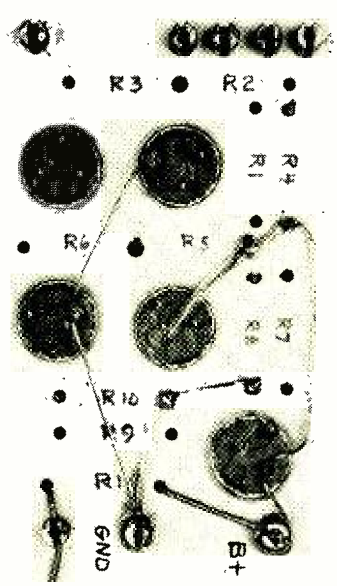


Photo D—Power buses (B+ and GND) are connected and soldered. Resistors R4, R5, R8, R10 and R11 are installed during this step. Note the use of tubing to protect against shorts at cross-connection points.

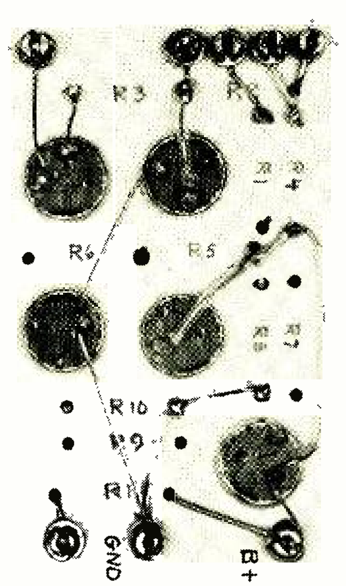


Photo E—Connections between terminal pins and components are completed. Resistors R1, R2 and R3 have been added for this step. More tubing is used for insulation wherever insulation is needed.

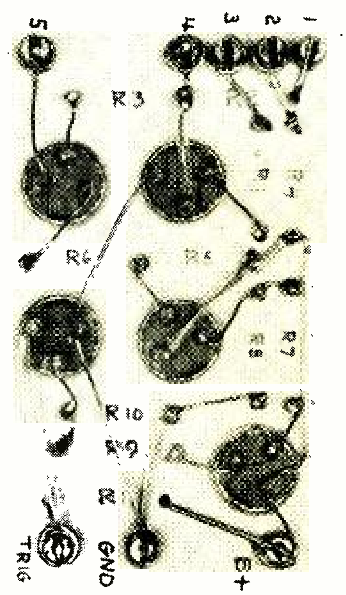


Photo F—Resistors R6, R7, and R9 are added, and all connections between terminals, sockets and components are completed. The board is now completely assembled and ready to be put to work.

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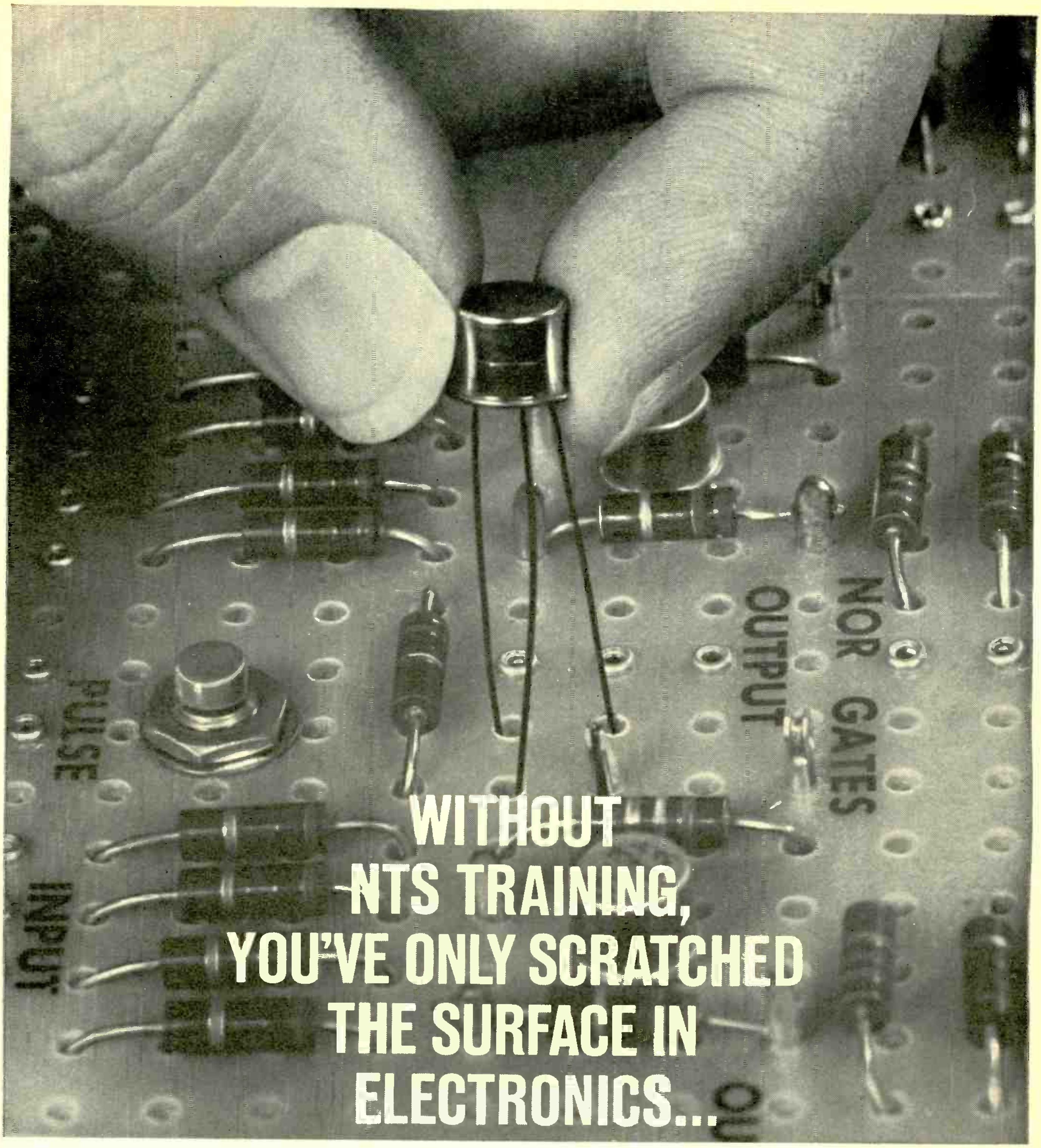

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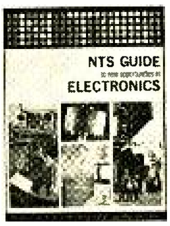

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Crossover Showdown—

Crossovers, Electrical or Electronic?

by **NORMAN H. CROWHURST**

THIS QUESTION ISN'T EASY TO ANSWER. THE QUESTION ISN'T as easy as a question ought to be, because what's on the questioner's mind may not coincide with what the answerer thinks he's answering. How's that?

Really, here are several questions, wrapped up together, and to answer them properly, we must separate them. What most people probably think of is whether the frequency separation, associated with crossovers, should be performed before or after power amplification. Label that question 1.

Then there's the matter of whether the correct overall power level is maintained throughout the frequency response, and which form achieves the more successful separation, as far as distortion-free performance is concerned. That's a more involved question, but we'll label it question 2, for the time being.

Before or after power amplification?

The big reason for using multi-way speakers, which creates the need for crossovers, is avoiding intermodulation between frequencies in different parts of the audio spectrum. Intermodulation comes in two major forms: 1. Lower frequencies combined with higher frequencies can modulate the latter, creating a gargly effect. 2. More than one higher frequency may intermodulate, between themselves, creating a buzz at the difference frequency, which is lower.

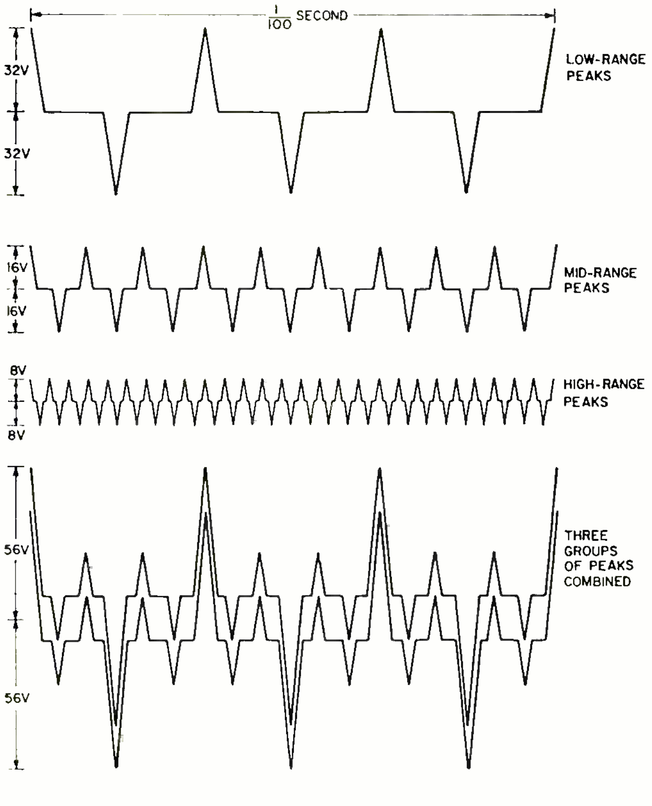

Fig. 1—Stylized representation of signal peaks in a three-way system. You can see how the total peak power required is more than double the sum of the individual peak powers required.

Keeping the segments of the audio spectrum separate avoids the gargly effect, because the high frequencies go to a different unit, and thus aren't modulated by the lower frequency. It also avoids the buzz effect, because the higher frequencies are reproduced in a unit that won't reproduce the lower-frequency buzz generated between them.

But really, one big power amplifier is better than two or three smaller ones, isn't it? Not necessarily.

Let's say we have a three-way system, where the bass unit may handle 32 watts, the mid-range 8 watts and the tweeter 2 watts. All are 16-ohm impedance units. One argument suggests that power never comes to all the units at the same instant, so a 35-watt amplifier should suffice.

The more usual notion would add up 32 + 8 + 2, which makes 42 watts, and we conclude that a 50-watt amplifier should be plenty big enough.

Let's consider a simplified signal containing peak signals in each range, of maximum amplitude for that range. Power ratings are based on the average power in a single sine wave. So peak power is twice the rated value. Waveforms add, whether they're sine waves or more complicated musical compositions.

A peak power of 64 watts at 16 ohms calculates to 32 volts peak. A peak power of 16 watts at 16 ohms is 16 volts peak. And 4 watts peak at 16 ohms is 8 volts peak. If one amplifier handles all three, there will be points where all three waveform peaks will momentarily add, although on average, they won't.

For example, if the frequencies at which peaks occur are 300, 900 and 2,700 respectively, then 3 times every 0.01 second (10 msec) in each polarity, the three waveforms will momentarily add. For the rest of the time, they won't (Fig. 1).

But 3 times each 10 msec, the amplifier must handle the equivalent of 32 + 16 + 8 volts peak (not watts). So to handle the peaks at these moments, the amplifier must be capable of handling 56 volts peak, which represents 196 watts peak, or a rating of 98 watts.

This is more than double the sum of the individual powers, which was 42 watts. If you use separate amplifiers, they could be rated at 32, 8 and 2 watts, respectively, quite satisfactorily. But if you use a single one, it must be rated at 98 watts to handle the same overall signal. That's quite a difference. What it amounts to is that those three smaller amplifiers can produce as much total sound as a single 100-watt amplifier handling the whole signal.

This additive effect aggravates the intermodulation problem. Even though the single amplifier may be re-

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The Many Ways To Go

A New Approach to Speaker Design

by ERIC ROSENFELD*

MOST MODERN LOUDSPEAKER DESIGN EFFORT CONCENTRATES on designing a box containing several loudspeakers pointed at the listener. The intent is to design loudspeakers with flat frequency response when measured on axis in an anechoic environment and having wide dispersion at all frequencies.

Which direction to realism?

As the art of speaker design advances it becomes more and more difficult to determine the true fidelity of a loudspeaker. Anyone who has compared modern speaker systems is aware of the subtlety of differences between high quality systems. In spite of these loudspeakers' similarity to each other, most people realize that their sound is a far cry from the experience at a live concert.

If there were no technological problems in designing a loudspeaker system, how should it be designed for maximum fidelity? Would a box with flat frequency response on axis and high dispersion provide the ultimate in fidelity? To answer these questions we must take a closer look at the reproduction process. Let's take our ears first.

What we don't know

Life would be simpler if we could model what happens when an acoustic vibration reaches the ear causing sound to be perceived by the brain. Unfortunately our understanding of the hearing process is still very poor. We know certain very rudimentary characteristics of hearing such as the threshold of hearing at different frequencies. We have some idea of what cues enable the ear to determine the location of a sound source. Our understanding of more complicated phenomena such as how the brain utilizes various cues to determine the location of a sound source, or even more important, how the brain is able to separate one sound from many are still deep mysteries.

Without knowing what characteristics of sound are important in music reproduction, and without knowing what types of errors or distortions are inaudible, there is only one course to take.

Difference experiments are the way

Listen to the sound with and without the coloration or distortion and see if the difference can be heard. If you hear a difference it must be attributed to the distortion or coloration. If there is no audible difference, the distortion or coloration is unimportant. In setting up such an experiment there must be absolute similarity among all other parameters. Otherwise the cause of any difference detected cannot be determined.

Let us look at how a difference experiment could be used to determine whether some part of a music reproduction system is introducing a significant amount of distortion. The experiment must be designed so that when the person listens to the two samples to be compared, the only difference would be the variation caused by the part of the system under test. This means that even the levels of the two signals, and the background noise of the two signals must be the same at the time of the comparison. If all things are held equal, then any audible difference must be due to the added distortion.

To test a speaker for distortion, this technique might be applied in the following manner. First a recording of the sound reproduced by the loudspeaker is made while a record is played by the loudspeaker. The amplifier driving the speaker and the tape recorder recording level control are set so that neither the amplifier nor the tape recorder is overloaded. A second recording of the same program source

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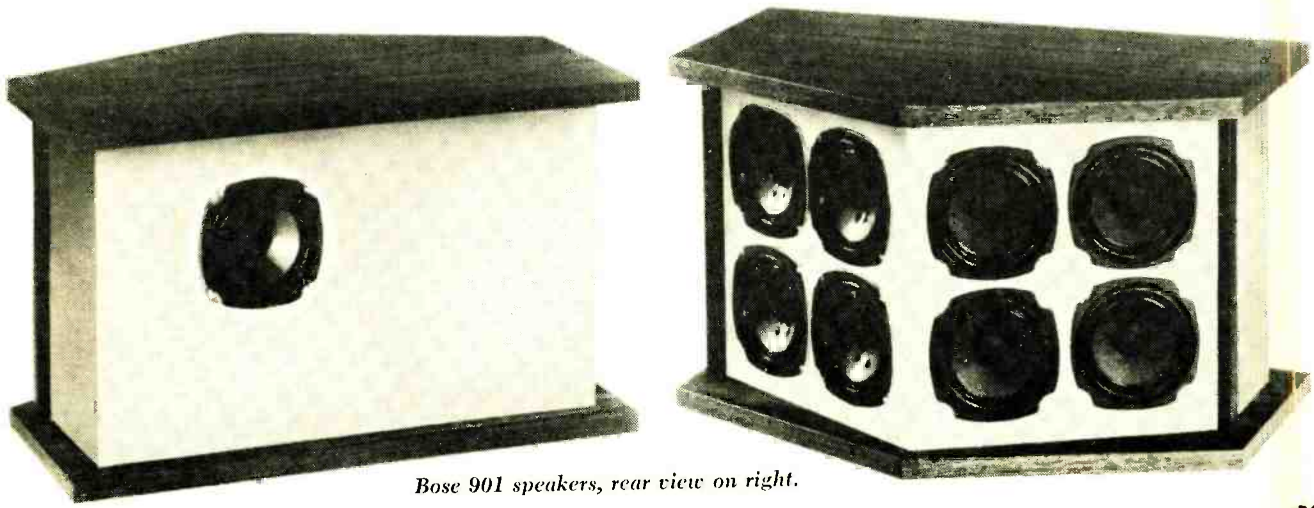
*Technical staff, Bose Corp., Natick, Mass.



Bose 901 speakers, rear view on right.

latively free of intermodulation distortion at its lower levels, any amplifier produces large slices of distortion, both harmonic and intermodulation, any time its peaks run into overload.

So choosing a 50-watt amplifier, based on merely adding the separate powers required, means that the momentary 200-watt peaks, that should have a 100-watt amplifier to handle them, will produce a large amount of intermodulation distortion, concentrated in those short moments, 3 times every 10 msec in the illustration used.

Here is another disadvantage. Suppose you do use a 100-watt amplifier, to be sure you have the peak power available. Now you have an average power of 100 watts available, too. If the system is turned up too high in level, all the units can receive twice the power for which they are rated. Or one of them could sometimes get the full 100 watts, which is even worse. This definitely endangers the units: they could be damaged or burned out.

So trying to make a single power amplifier feed a multiway system really puts us between the devil and the deep blue sea. That pretty well answers the before-or-after power amplification question. Now we come to the more involved question.

How steep the rolloff?

This has always been a question, even before electronic crossovers came into the picture. Really it relates to certain qualities about loudspeaker unit frequency response. Speakers for use in a multiway system are designed to handle their own frequencies well, but should not be given frequencies outside their own range.

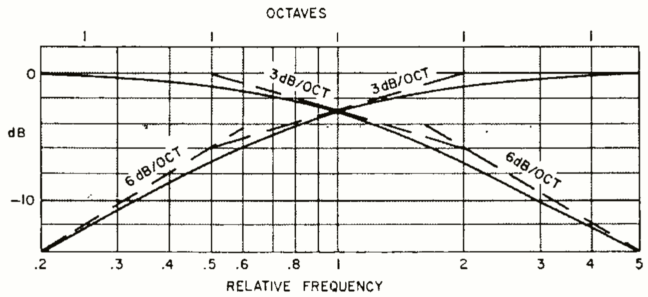


Fig. 2—Frequency response of simple RC (series and shunt) rolloffs, when they are used as crossovers.

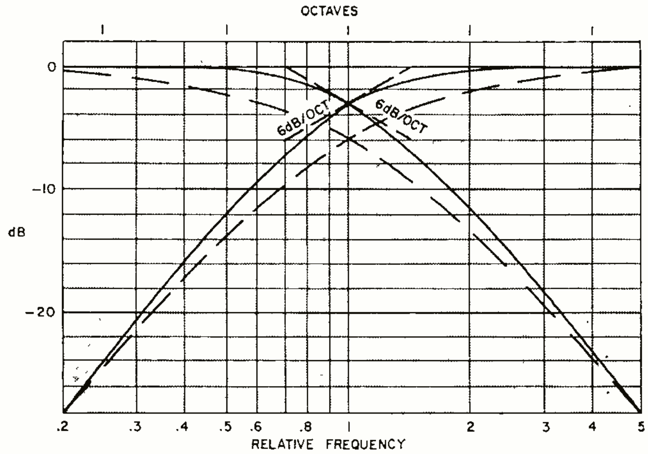


Fig. 3—Correct 12-dB/octave response (solid-line curves) and the effect of combining two 6-dB/octave responses (shown as dashed-line curves).

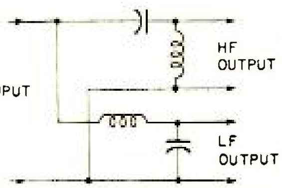


Fig. 4—Circuit for electrical crossover filter. Each element has a reactance of 1.414 times the terminating impedance, at crossover frequency. When correctly terminated, it yields the true 12-dB/octave response.

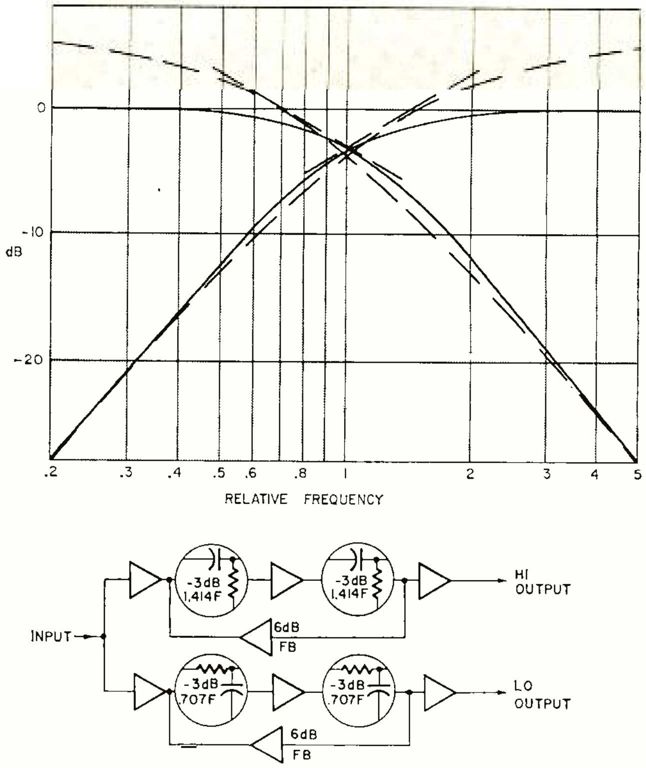


Fig. 5—Getting correct 12-dB/octave response with feedback. Dashed-line curves indicate response before feedback is applied. The block diagram indicates the essentials of this method.

The basic RC rolloff (Fig. 2) produces a 6-dB/octave ultimate slope. At the crossover frequency, each output receives half-power, or is 3 dB down, and the slope is 3 dB/octave. An octave one side or the other of crossover frequency, one unit is 1 dB down and the other is 7 dB down; not a big differential, nor is it rapidly made.

The better speaker units will work with only such 6-dB/octave crossovers. But some should really have at least 12-dB/octave crossovers. This response is not just the 6-dB/octave response doubled (Fig. 3). If it was, the method would be simple: just use two of them. A better way to view the 12-dB/octave response is as the simple response squeezed into half the frequency range (on a log scale).

Thus we could tabulate the difference between the responses in this way:

Frequency (times crossover):		0.25	0.5	0.707	1	1.414	2	4
		db response						
6 dB/octave:	LF unit:	— 0.25	— 1	—1.75	—3	—4.75	— 7	—12.3
	HF unit:	—12.3	— 7	—4.75	—3	—1.75	— 1	— 0.25
12 dB/octave:	LF unit:	— 0.017	— 0.25	—1	—3	—7	—12.3	—24
	HF unit:	—24	—12.3	—7	—3	—1	— 0.25	— 0.017

If you put together two 6-dB/octave networks, the attenuation at crossover will be 6 dB, and the total power from the two units is —3 dB at this frequency. There is a dip in the overall response, and the slope doesn't change much more rapidly than the single unit.

The only way to get a correct 12-dB/octave rolloff

(continued on page 36)

is made with the amplifier gain driving the speaker boosted, and the recorder gain reduced so the level of this recording is the same as the first recording. The two recordings are synchronized and compared in an A-B comparison. When the two recordings are compared, any difference must be caused by the distortion added when the speaker was driven at the higher level.

Using this technique it is possible to determine the importance of any distortion added by the speaker at higher levels. This type of experiment allows the investigator to determine the importance of distortion or any other variable only by comparing two things for a difference, rather than trying to determine which of two different things sounds better.

Fidelity from many small speakers

Using controlled difference experiments, different approaches to the problem of music reproduction can be tested.

Exactly this type of test was used to prove that many small speakers in a single enclosure, when used with proper electronic equalization, introduce no *audible* coloration or distortion to the sound reproduced through them.

To perform a difference experiment we must have another system which is identical to the test system except that this standard of comparison must not contain any of the defects of the test system. If we had a standard speaker design one might wonder why we were fooling around with another speaker which wasn't as good.

Just as it is possible to simulate an ideal amplifier having unity gain by a straight piece of wire, it is possible to simulate the performance of a spherical source (a source that emits spherically shaped waves) containing no coloration or distortion. With careful measurements we can simulate, with the aid of a computer, what a microphone would record when placed in a room with a spherical source being played.

Once a recording has been made of the computer-simulated spherical speaker as it would sound in a given room, the experimental speaker can be placed in the same room. A microphone is placed in the room, and a recording is made of the real speaker. The simulation of the spherical speaker is done so the characteristics of the real and simulated rooms, the positions of the real and simulated speakers, and the positions of real and simulated microphones are identical. Thus these variables cannot contribute to any differences detected.

If the recordings match up so closely that is is impossible for the recordings to be audibly distinguished, we know that we have developed a technique for reproducing a sound without coloration or distortion. If our test speaker does not sound the same as the simulated speaker we know only that more work must be done to develop a better approximation to the simulated loudspeaker.

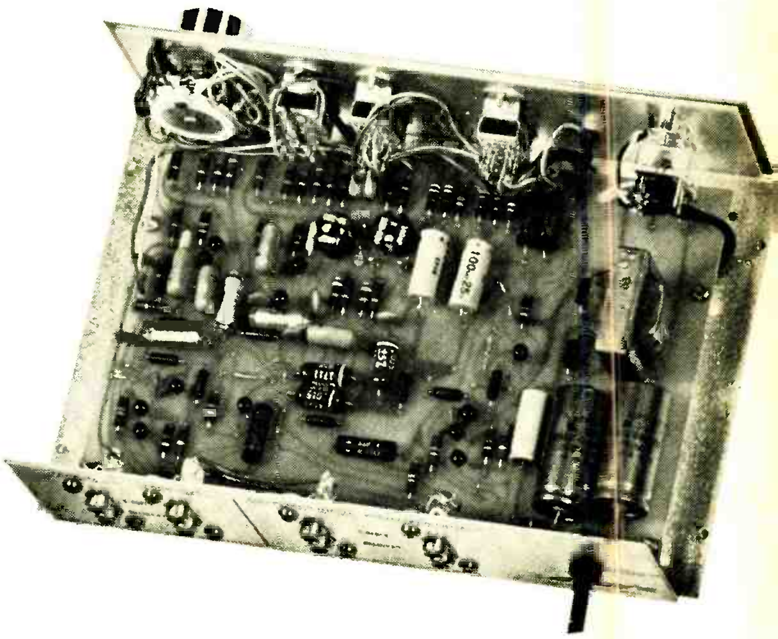
The proof is in the pudding

Just such a series of experiments was done by Prof. Amar G. Bose of M.I.T. at the Research Laboratory of Electronics, M.I.T.[1] In these experiments a computer simulated the performance of a spherical loudspeaker in the corner of a room. Using a speaker system containing many small speakers driven by a signal that had been passed through an electronic equalizer, he was able to produce recordings that were audibly indistinguishable from the recordings of the computer-simulated spherical speaker.

The speaker system consisted of twenty-two identical speakers mounted on the surface of an eighth of a sphere. This system was placed in the corner of the same room that was measured for the computer-simulated speaker. When measurements were made it was found that, as expected, the entire array of twenty-two speakers did not display any of the imperfections of the individual speakers.

Why bother to equalize?

The difference in response between the real and simulated speakers versus frequency was a smooth curve without the audible imperfections of the individual speakers. Any irregularities expected from the cone resonances of the individual loudspeakers averaged out. If one small speaker were playing alone, such irregularities would have been noticeable.



Resurgance in electronic crossovers is typified by the new unit from C-M. The imported device permits the hi-fi system owner to select the exact crossover frequency he desires to use.

This was an important observation. It meant that an electronic euqalizer could be inserted into the amplifier chain before the real loudspeaker to compensate for the difference. Such an equalizer would contour the signal spectrum fed to the speaker so any coloration introduced by the speaker is cancelled. Such compensation would not have been possible if there were sharp irregularities with characteristics that might vary with time or environment. This instability of characteristics would be expected in conventional speakers where only a few speaker elements are used to reproduce each frequency band. Here, since cone resonances do not average out, they introduce irregularities that vary greatly from unit to unit and with time. The overall frequency response of such a system can be corrected, but the effects of cone resonances, responsible for coloration in some speakers, could not be corrected practically.

When the simulated speaker and the real compensated

(continued on page 36)

[1] *On the Design, Measurement, and Evaluation of Loudspeakers* by Amar G. Bose, presented at the 35th convention of the AES.

is either to use the correct electrical circuit (Fig. 4) feeding the loudspeaker units direct, thus putting the crossover after power amplification, or to use the RC stages with feedback to provide the equivalent interaction (Fig. 5).

A number of manufacturers, aware of the advantage of separating the frequencies before the power amplification, have advertised electronic crossovers. An incidental advantage to manufacturers is that it sells more power amplifiers! But up to date no commercial equipment has been made available that produces the correct response for 12-dB/octave (or steeper) rolloffs.

I have written articles giving design data from which

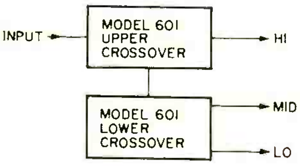


Fig. 6—How to use two CM Laboratories model 601 electronic crossovers to set up a three-way system.

one can be built (item 5 below), but to date they have not been made commercially available.

However, one quite useful unit has recently made the scene. In performance, it does no better than a simple RC crossover, yielding 6 dB/octave. But it does provide considerably greater flexibility in use than any simple RC network could.

This is the C-M Labs Model 601 Electronic Crossover. Its advantage over simple circuits is that it has seven "element" frequencies for the crossover: 100, 200, 400, 800, 1,600 3,200 and 6,400 Hz. These are selected by slide switches. Thus 2,000 Hz can be made up as 1600 + 400, or 3,500 Hz as 3,200 + 200 + 100.

With this arrangement, 127 crossover frequencies are possible, at 100-Hz intervals from 100 to 12,700 Hz.

The electronic circuits are used to provide isolation between elements, and freedom from distortion over this wide range of control. The unit has zero voltage gain (output same level as input) using an input of 100,000 ohms and an output for connecting to 10,000 ohms or higher, from a 600-ohm source. It has a level control for each output. The units may be cascaded to achieve three-way crossover (Fig. 6).

Making a 12-dB/octave network involves applying some 6 dB of negative feedback (minimum) around two RC rolloffs in cascade. As the feedback will be different from each output, the input needs buffering, so the feedback affects only the channel over which it is applied.

Input and output should be buffered so that impedance termination does not radically affect response. Modifying the feedback and rolloff points, and adding further rolloffs without feedback, can synthesize 18-dB/octave crossovers, but responses this sharp are apt to spoil transient performance.

A good choice rests between the 6 dB/octave, which the C-M Labs Model 601 provides in great variety, or 12 dB/octave, which you'd have to make up for yourself at the moment. In another article, I'll give data and details of aligning the circuit to obtain correct response for a transistorized version. R-E

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*Radio-Electronics, December 1957, contained one such article.

speaker system were judged in carefully controlled A-B comparisons, no difference could be detected by the most skilled listener on any type of program material. This experiment proved that when a multiplicity of small speakers is used with proper electronic equalization, there need never be any coloration or distortion from such a system.

Where to from here?

Having a proven technique for reproducing sound without coloration or distortion we have solved only one facet of the problem of sound reproduction. Now we must look at the rest of the problem.

Most people are interested in listening to performances which, if attended live, would usually be held in a large room or hall. There are certain characteristics of large rooms which particularly concern the person trying to reproduce such a performance.

As with a source of light, in open space, the intensity of a sound source falls off with distance. However, if we measure the intensity of the sound produced by a source in a room, beyond a certain distance from the source, the sound level remains relatively constant. This phenomenon is caused by the reflections of the sound by the walls. After a certain distance from the source is reached, the sound results almost entirely from reflections off the walls. If the room is irregularly shaped, the intensity of the sound resulting from these reflections will be almost completely independent of position. If the room is regular in shape (such as the average living room, with parallel walls) then reflections produce standing waves which will account for most of the sound energy that reaches the listener in a room. To realize the importance of the reinforcement of the original sound produced by reflections on a room, talk softly to a person across a room, then talk to a person across the same distance outdoors away from large reflecting objects. Your voice will be significantly weaker outdoors. Outdoors your voice will not be reinforced by reflections as in the room.

For a good seat in a concert hall the ratio of direct to reflected sound might be on the order of one to eight. The direct sound, while weaker than the reflected sound, is not completely dominated by the latter. This is important—the direct sound is responsible for some of the clarity and directionality of the sound.

This knowledge of reflected sound should influence speaker design in two different ways. First, the designer should control the relation between the direct and reflected sound emitted by the speaker. Second, new criteria must be used to serve as a guide to the speaker designer because of the importance of evaluating the performance of speakers as they are actually used in a room where the listener hears both direct and reflected sound.

The intensity of the reverberant sound in a room is determined by the total sound radiated in all directions by the speaker. Therefore, methods for measuring the the total sound radiated by the speaker must be developed. Current speaker measurements in anechoic chambers do not reveal this aspect of a speaker's performance. More difference experiments must be done to determine more accurately how the reverberant sound in a room affects the quality of the sound we hear.

The new state of the art

By recognizing the importance of reflected sound, and the use of a multiplicity of a small loudspeakers with electronic equalization, a new step forward has been made in the design of loudspeaker systems. R-E

Experiment with

10 Emitter-Coupled Circuits

by ROBERT L. PETROWSKY

THE BASIC PRINCIPLE OF EMITTER coupling is used in a large number of highly useful circuits. They are divided into two classes, linear and switching. First we'll look into how emitter-coupled circuits work. Then we'll present ten practical circuits for you to try.

A basic emitter-coupled circuit is shown in Fig. 1. Note that common-emitter resistor R3 is much larger than R1 and R2 or the internal emitter impedances of transistors Q1 and Q2. Resistor R3 is usually 1,000 to 10,000 ohms; R1 and R2 are 50 to 100 ohms, and the internal emitter impedances are 10 to 50 ohms. (R1 and R2 eliminate transistor unbalances and increase input impedance. However, they are often eliminated, since they do reduce circuit gain.) Emitter supply voltage V_{EE} is also much larger than base input voltages V_{B1} and V_{B2}.

As a result total current through both transistors is constant and depends on common-emitter resistor R3 and emitter supply voltage V_{EE}. (Constant current $= I_K = V_{EE}/R3$.)

This constant current is split between Q1 and Q2 in a proportion which depends on the difference in base voltages, $\Delta V_B = V_{B1} - V_{B2}$. ΔV_B is called the differential input voltage. A graph showing the emitter current of each transistor versus the differential base voltage is in Fig. 2.

It shows that emitter currents always add up to constant current I_K, which is 1.5 mA here. When the differential input voltage is zero (i.e., when base voltages are equal), emitter currents of Q1 and Q2 are equal at half the constant current (point P).

As the differential input voltage increases from zero to about 50 mV, the curve is linear. Linear emitter coupling operates in this region (between points B and C). As the differential input exceeds 50 mV, the curve becomes nonlinear. Between 100 mV and 200 mV, one transistor is cut off and the other transistor conducts the constant current. This is the switching class of emitter coupling (between points A and D). So, the basic circuit is linear for signals up to 50 mV and a switch and limiter for inputs above 150 mV.

When the circuit is used in a linear mode, it is called a differential amplifier. It is adaptable to gain-controlled amplification of dc, audio, video and high frequencies into the vhf region. Linear integrated circuits (IC's) for various applications including operational amplifiers for analog computing and special circuit functions are built largely around differential amplifiers.

When used in a switching mode, the circuit is called an emitter-coupled switch and is responsible for emitter-coupled logic (also called current-mode or current-switching logic). It eliminates transistor storage time and

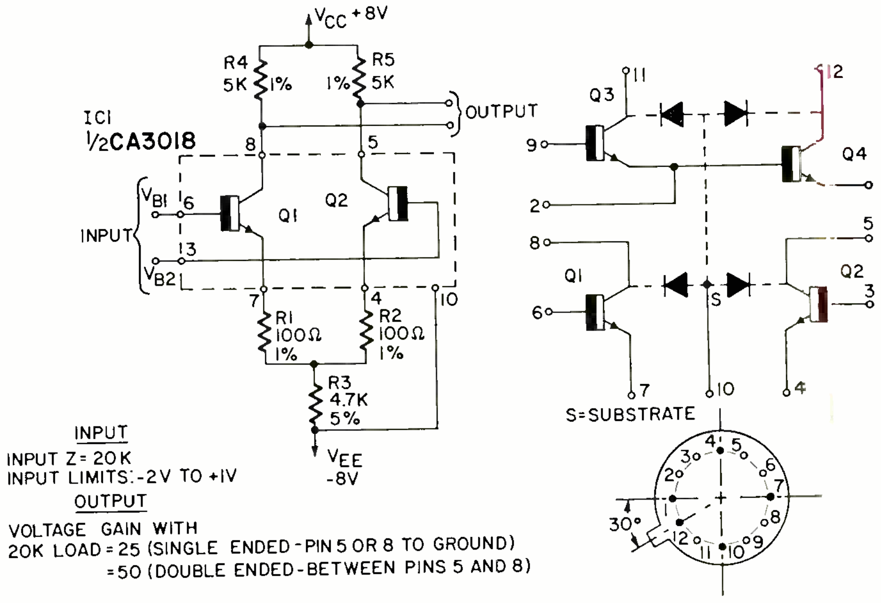


Fig. 1—Basic emitter-coupled differential amplifier is suitable for audio, video or dc. Total current through Q1 and Q2 is constant, but splits between them depending on the difference between the base voltages (ΔV_B).

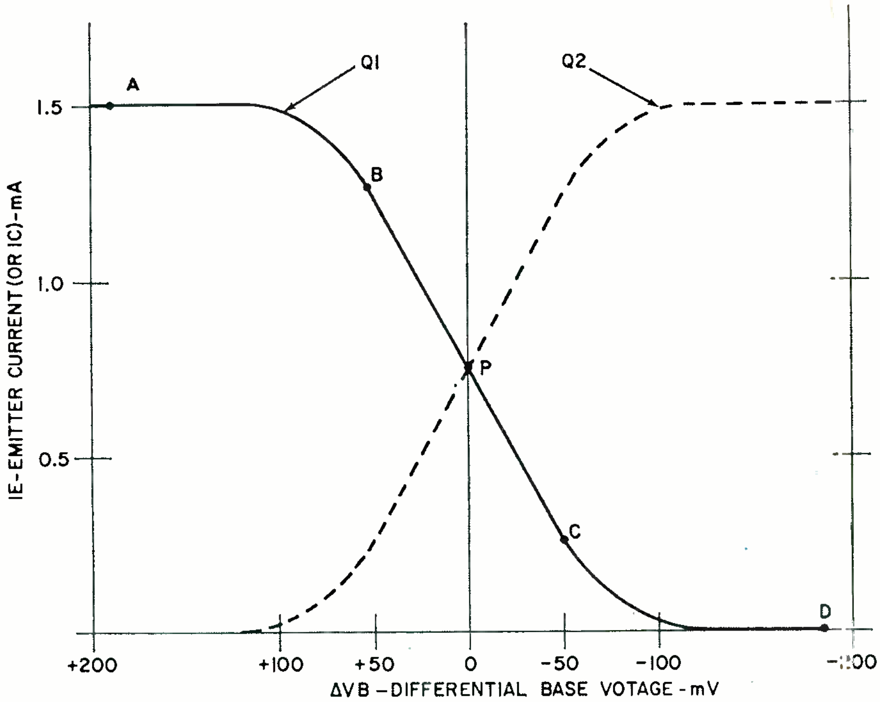


Fig. 2—Graph of Q1's and Q2's emitter current against changes in their base voltages shows emitter currents always total 1.5 mA. Circuit of Fig. 1 is a linear amplifier for signals up to 50 mV (points C to B). Between 150 and 200 mV, one transistor cuts off and the other carries the full current.

implements some of the highest-speed gates, flip-flops, one-shots and Schmitt triggers.

Three differential amplifiers

A general-purpose differential amplifier was shown in Fig. 1. It has a 20,000-ohm input impedance and a voltage gain of 50 for dc, audio and video. Base input voltages must be restricted to the +1-volt to −2-volt range.

A big drawback of differential amplifiers is the need for expensive matched transistors to prevent circuit unbalances. With IC's it is possible to get a pair of matched transistors along with two transistors with a common base and emitter terminal in one TO-5 can. The RCA CA3018 transistor array is a working available unit.

An unwanted dc level or noise voltage common to both inputs of a differential amplifier is called a common-mode voltage. The amplifier's ability to reject a common-mode voltage and amplify only the differential input voltage ($\Delta V_B = V_{B1} - V_{B2}$) depends on how good a constant-current source R3 and V_{EE} make. Making R3 and V_{EE} larger makes for a better constant-current source and improves the common-mode rejection. However, R3 and V_{EE} soon reach impractical sizes.

A solution to this is shown in Fig. 3, where the common-emitter resistor and emitter supply are replaced by transistor Q3. Since a transistor's collector is an excellent constant-current source, the common-emitter resistor has effectively been increased to a very large value without increasing emitter supply voltage V_{EE}. The noise rejection of the differential amplifier in Fig. 3 is much better than that of Fig. 1.

By modifying the circuit of Fig. 3, you get gain control. Returning to Fig. 2 for a moment, you can see that the constant current determines the slope of the curve in the linear region. If the constant current is increased, the slope of the curve also increases. For example, if instead of a constant current of 1.5 mA as shown, the constant current was 3 mA, the slope would double.

The slope of the curve represents the transconductance of the amplifier. The gain is the collector load times the transconductance. Therefore, you can change the gain of the amplifier by simply changing the constant current. (See Fig. 4-a).

Constant-current transistor Q3 varies the current supply. Bias resistor R6 returns to a control voltage instead of 8 volts. Various control terminal voltages and the corresponding circuit gains are in Fig. 4-b. Independent emitter resistors R1 and R2 of Figs. 1 and 3 have been eliminated, since they reduce the gain-control effect as well as overall circuit gain.

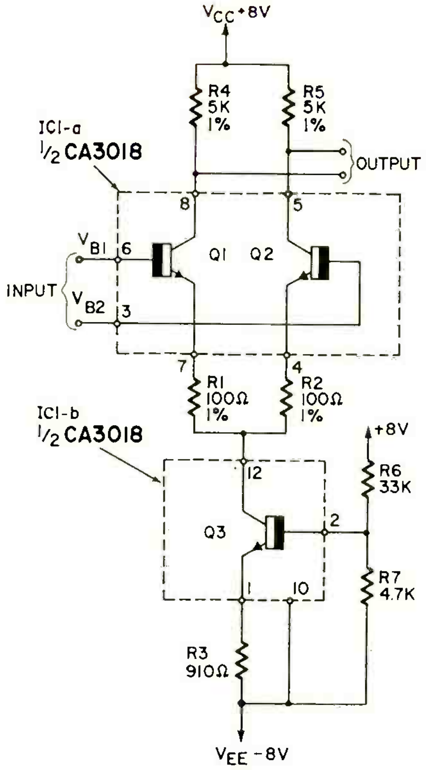
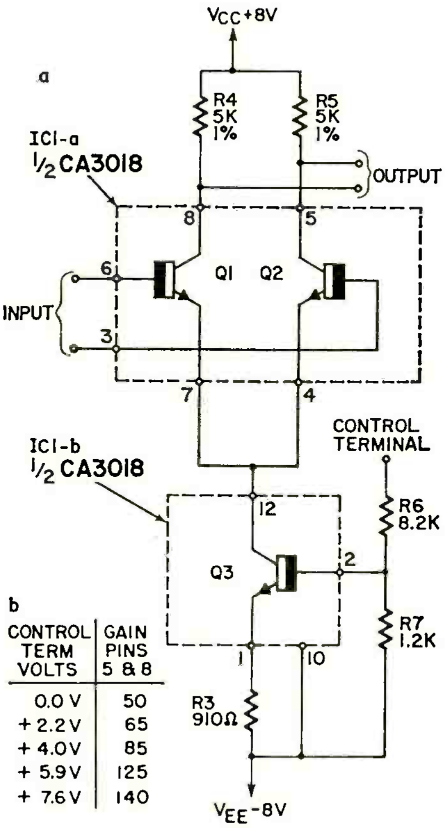


Fig. 3—Modification to circuit in Fig. 1 reduces common-mode voltage (noise) of the inputs. Q3 is a constant-current source, effectively increasing R3 to high value.



CONTROL TERM VOLTS	GAIN PINS 5 & 8
0.0 V	50
+2.2 V	65
+4.0V	85
+5.9V	125
+7.6V	140

Fig. 4-a—Change in differential amplifier gain is accomplished by varying bias of Q3, which alters Q1-Q2 current. b—Control voltage effect on circuit gain.

Operational amplifier applications

One of the most useful applications of differential amplifiers is as operational amplifiers (see RADIO-ELECTRONICS, May 1968, for general theory on operational amplifiers). Originally used in analog computers, operational amplifiers are being used to generate all kinds of special circuit functions.

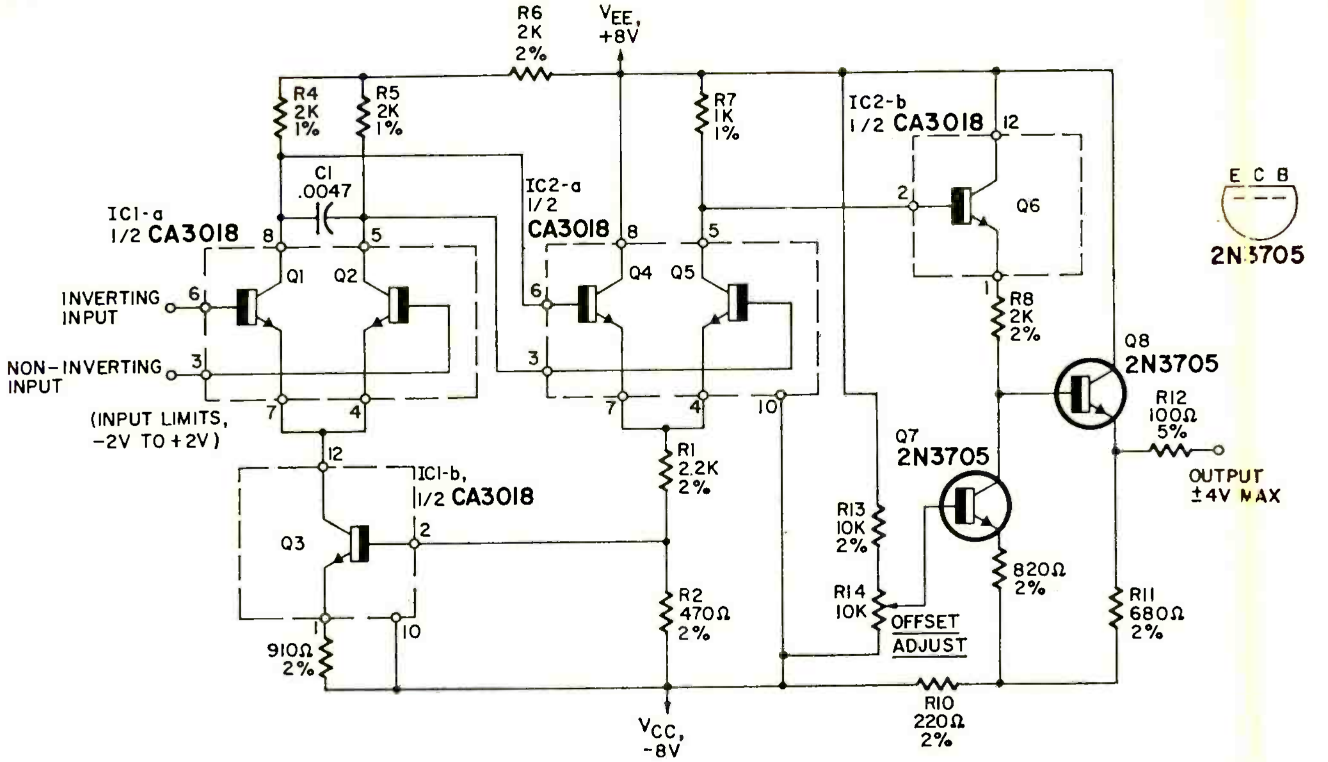
Two cascaded differential amplifiers make up the operational amplifier of Fig. 5 which provides a gain of 600. In the first stage a transistor current source rejects common-mode voltages. The effect of common-mode voltages is further reduced by feedback from the common-emitter resistor (R1 + R2) of the second differential amplifier to current-source transistor Q3 of the first stage.

The output at Q5's collector is an amplified version of the differential input voltage but is riding on a +6-volt dc level. Transistor Q6, an emitter follower; Q7 a current source, and Q8, the output emitter follower, act as a level translator and amplifier with a gain of 2. Q7 shifts the output dc level to ground by the drop of its constant current across R8. Offset adjust R14 sets the bias on Q7 and consequently the current supplied to R8. To set this control, ground both amplifier inputs and measure the output voltage. Set R14 so that the output reads exactly zero volts.

Transistor Q8 via emitter resistor R10 (in common with Q7) provides a gain of 2 and a low output impedance. Overall circuit gain is 1200 and output impedance is 150 ohms.

This unit will cost about $9 for parts. Most resistor tolerances are 2% to keep dc levels and the maximum plus and minus output level swings the same. Wider tolerance resistors will degrade the amplifier's performance. Building this amplifier, and using it in the circuits of Figs. 6 through 9, gives a good grasp of operational amplifier techniques. Most of these amplifiers are similar in design, although an additional differential amplifier stage is usually used.

A voltage follower is shown in Fig. 6. This circuit transforms a high-impedance source to a low-impedance source. It is useful when you do not want to load a source such as a reference battery. A mercury battery, with long shelf life, provides an accurate 1.35 volts. You get long life too, since



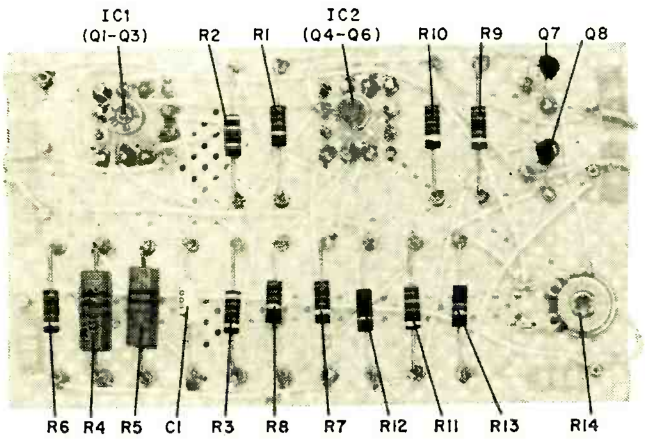


Fig. 5 (photo and drawing above)—Operational amplifier is formed with two IC amplifiers. Transistors Q7 and Q8 are connected to the IC (Q1-Q6), for gain of 1200. The +8 and −8V terminals should be marked V_{CC} and V_{EE} respectively.

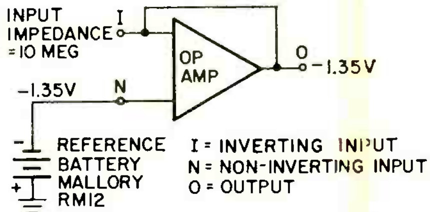


Fig. 6—Used as a voltage follower, the CA3018 provides a very high input impedance and low battery drain. Application prevents loading of reference battery.

voltage-follower battery drain is negligible. Feedback increases the amplifier's effective input impedance to around 10 megohms.

In any feedback amplifier runaway oscillation is possible. This occurs because an amplifier shifts phases as well as increases signal amplitudes. The higher the frequency the greater the phase shift. If feedback has a wide enough bandwidth, phase shift back to the input at some frequency reaches 360° and the circuit oscillates.

The voltage follower is most susceptible to oscillation since all the output is fed back to the input. To correct this situation we use phase compensation with specially placed RC networks to reduce the amplifier's gain at higher frequencies.

The phase compensation is simply capacitor C1 placed across the output of the first stage (see Fig. 5). As frequency increases, gain decreases, so there is less than unity gain for frequencies shifted 360°. The 3 dB frequency of this circuit is about 100 kHz.

A voltage comparator which provides a +4V output when the input, E_{IN}, is below a certain comparison level and zero volts when the input is above a certain comparison level is in Fig. 7. By changing the ratio of R1 and R2 and by changing the reference voltage, E_{REF}, the comparison level can be adjusted.

$E_{OUT} = 4$ volts when E_{IN} is less than $-\frac{R1}{R2}E_{REF}$.

$E_{OUT} = 0$ volt when E_{IN} is greater than $-\frac{R1}{R2}E_{REF}$.

An analog adder, elementary in analog computers, is in Fig. 8. Its output is the inverted sum of the three input voltages. R4 is again for drift compensation.

An interesting precision low-level rectifier for accurately rectifying low-level ac signals (in an ac millivolt meter, for example) is shown in Fig. 9. The intrinsic diode drop prohibits ac-

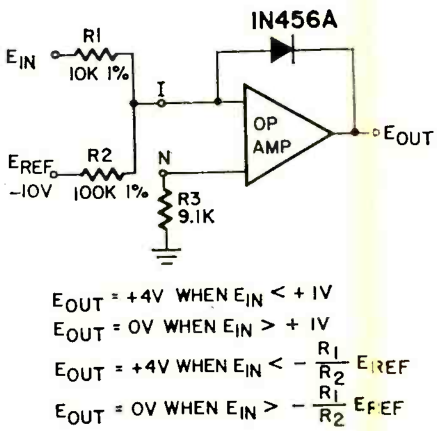


Fig. 7—Clamped voltage comparator use of an operational amplifier. Output is 4 volts when input is below a specified comparison level, and 0 volts when input is above a certain comparison level.

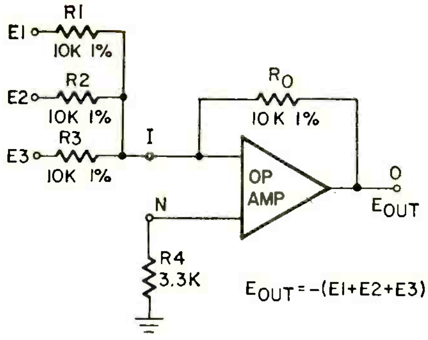


Fig. 8—Operational amplifier used as an adder to sum analog voltages. Output is the inverted sum of input voltages. R4 provides drift compensation.

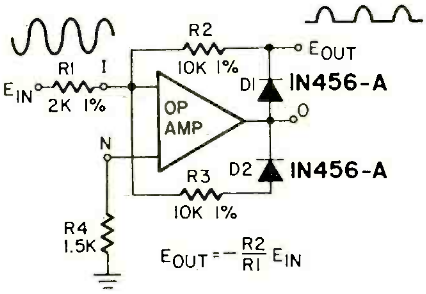


Fig. 9—Precision low-level rectifier can be used in ac millivolt meter. The op amp output is positive on the negative excursion, causing D1 to conduct through R2. On positive cycle, D2 conducts.

curate rectification with diodes at millivolt levels.

On the negative input excursion, E_{IN}, the operational amplifier output, goes positive, causing diode D1 to conduct through R2. On the positive input excursion D2 conducts through R3. The output at the junction of R2 and D1 is an accurate half-wave rectification of the input. It is also amplified and inverted in phase.

$$E_{OUT} = -\frac{R2}{R1} E_{IN} \text{ (half-wave)}$$
$$= -5\, E_{IN}$$

R4 again is used in the circuit for drift compensation.

Two logic circuits

Up to now we've been dealing with linear mode of emitter coupling where the output voltage is proportional to the input. In the switching mode the constant current supplying the emitters goes through one side of the circuit and the other side is cut off.

An emitter-coupled gate circuit is shown in Fig. 10. If both E1 and E2 are 1 volt, Q1 and Q2, which represent one side of the circuit, are cut off and the constant current flows through Q3. If either E1 or E2 is -1 volt, the constant current flows through the Q1, Q2 side of the circuit, Q3 being cut off.

The levels at the collectors are shifted by D1, R1 and R2 or D2, R3 and R4 so that the output levels are either -1 volt or $+1$ volt. These voltage levels (logic levels) are typical of emitter-coupled logic and Fig. 10 is a basic building block for logic circuits. This circuit can be directly cascaded with others like it or made into a flip-flop.

It is an AND gate for positive inputs and an OR gate for negative inputs. Since the output is from transistors, it is actually a buffered (amplified) AND or OR gate. Since complementary (opposite-phase) logic signals are available at opposite collectors, it is a NAND or NOR gate too, depending on how it's used.

Its single greatest advantage is its high speed. Collector loads are chosen so that the transistors do not saturate. This eliminates transistor storage time, a major factor which slows saturated logic circuits. The transistors used (2N2258's) are specially made for emitter-coupled logic circuits.

The gate in Fig. 10 and the Schmitt trigger of Fig. 11 have no storage times, and rise and fall times of about 5 nsec. The Schmitt trigger is used as a square-wave generator by driving it with a sinusoidal input up to 50 MHz, or as a level detector. When input E_{IN} goes positive, Q1 turns on. R2 is set so the circuit through R5 switches to Q2. As E_{IN} drops below zero, Q2 turns off and Q1 turns on. R2 is set so the circuit switches at zero volts. **R-E**

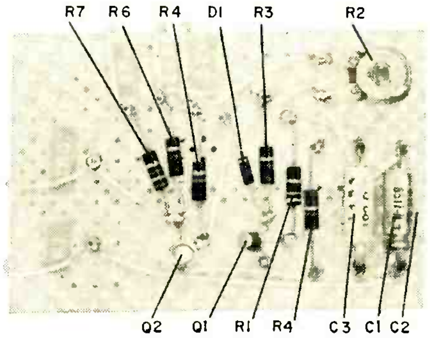


Fig. 11, photo (and drawing below right)—Emitter-coupled circuit used as a Schmitt trigger. Sinusoidal inputs up to 50 MHz produce a square wave output.

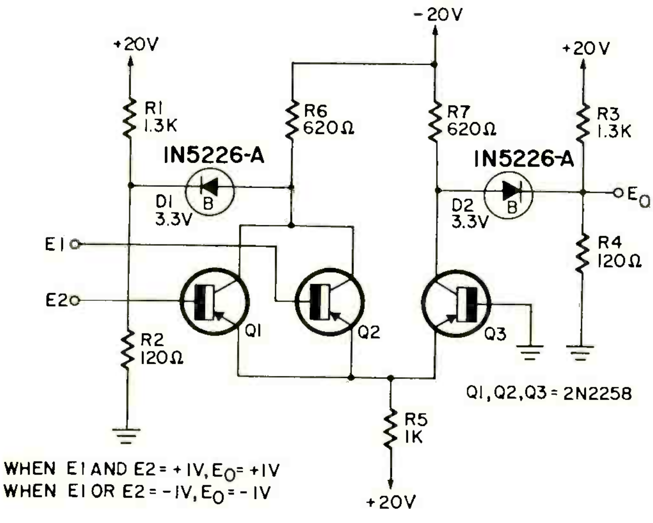
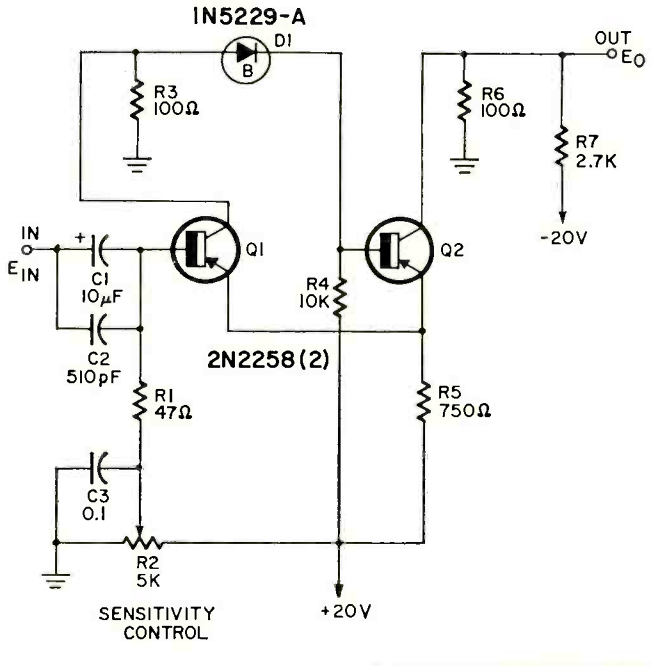


Fig. 10—Switching mode operation of emitter-coupled circuit uses cutoff portion of transfer curve (see Fig. 2). Voltage inputs at E1, E2 determine the high-speed logic mode of the circuit.



In-Circuit Testing Techniques

SYLVANIA TECHNICAL STAFF

The video section of a typical TV chassis uses a two-stage amplifier (see Fig. 1). The first stage (emitter follower) provides a high impedance to the video detector output. The audio i.f. at 4.5 MHz as well as video for the agc keyer are taken off here. Wide video response is improved by dc coupling to Q212's base. The test point is handy for checking detected signals prior to amplification. The gain of this stage is adjusted with R244, which compensates for transistor gain variation. This in turn adjusts the bias at Q210 via the dc coupling voltage division of bias potentiometer R242, R240, R250, and the 15-volt bus. The collector circuit provides low-frequency video to the agc keyer for developing agc. The collector of Q212's video output provides video to the picture tube and the sync separator.

Since forward bias for Q210 is adjustable and its emitter is coupled to the base of Q212, the video output, the adjustment also affects the condition of Q212. When the i.f. stages provide an output the detector conducts on negative peaks and passes through the base biasing resistors of Q210. This causes a drop in opposition to the biasing voltage, thereby reducing stage conduction. The effect of this voltage opposition must be removed to adjust the video bias control accurately. Too low a setting will cause limiting of picture highlights and too high a setting will cut the gain of the system.

In servicing, signal injection or an rf probe and signal tracing are used to locate the defective stage. The specific technique will vary with the technician and the equipment available. Preliminary voltage checks on these stages may even eliminate the need for further signal tracing.

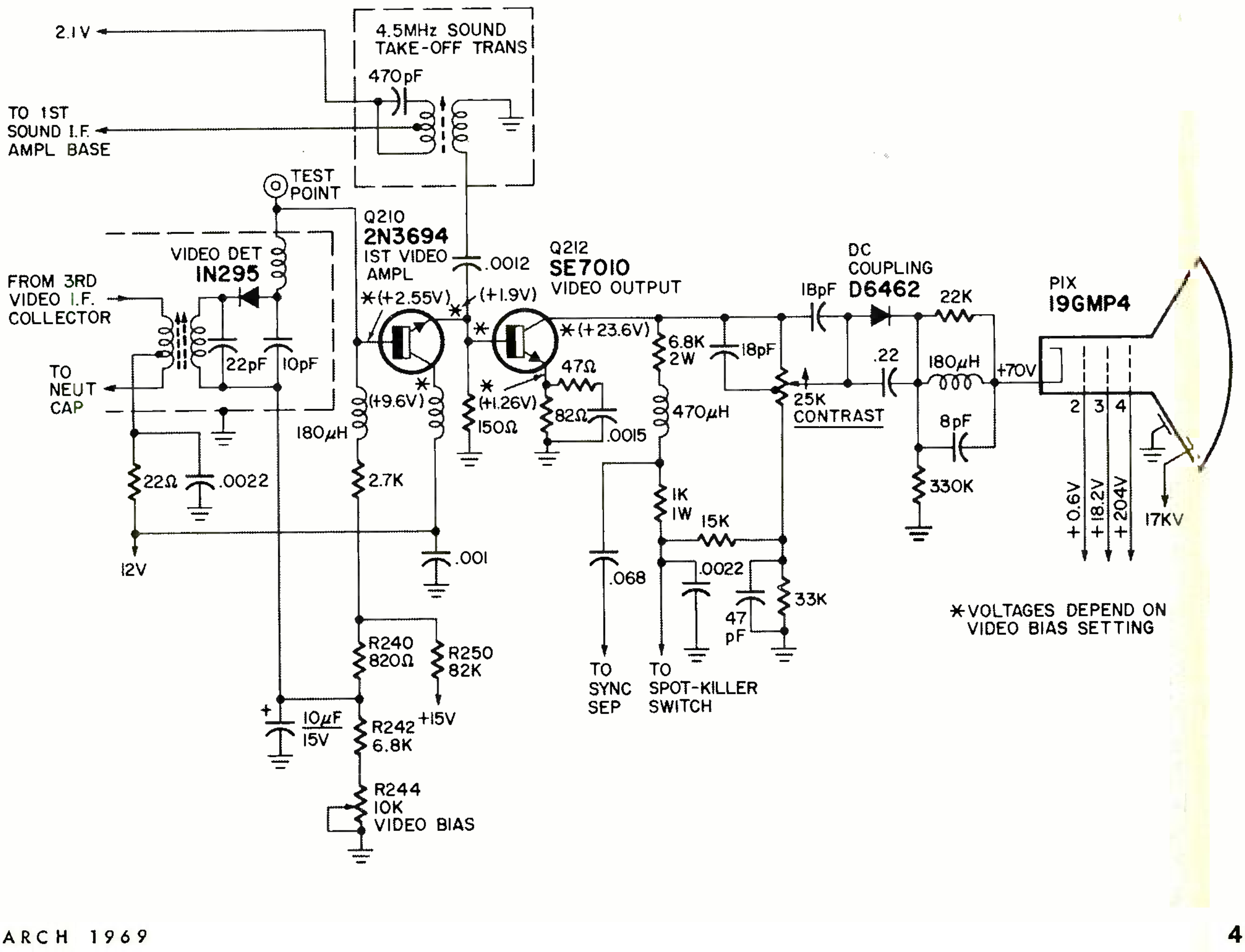
Once the defective stage or stages have been located, they can be analyzed by evaluating dc voltages.

Voltage measurements will disclose many circuit defects that may have upset the normal currents in these stages. The base and emitter voltages should be carefully checked and compared to the schematic with no signal voltages present. (The tuner is set for no-signal input by rotating between channels, and the no-signal bias should remain on the i.f. agc bus.)

The collector voltage may also provide important clues, for example, 12 volts is indicative of a nonconducting stage. Components such as open collector resistors or shorted capacitors may also affect voltage readings.

In-circuit testing

In-circuit transistor testing techniques are applied to the i.f. transistors by monitoring the transistor collector voltage. If it is lower than the supply voltage (12 volts), the transistor is conducting. Then, while monitoring the col-



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lector voltage, short the base and emitter together. Collector voltage should rise toward the supply voltage, indicating that the transistor can be turned off (zero forward bias). Compare the collector voltage to the voltage specified on the schematic. Either a high or a low reading indicates a malfunction in the stage. If collector voltage is normal, go to the next stage and, if the collector voltage does not rise toward its supply voltage, analyze that stage to determine the cause.

If voltage measurements do not disclose the defect, check components that affect ac or rf operation but have little or no effect on bias or dc voltages.

Signal injection may help locate the faulty stage. Use an AM signal generator set at band center and modulated with 400-Hz audio. Apply the signal between base and ground, starting at the third i.f. and working back toward the tuner input. As you move the generator toward the i.f. input one stage at a time, less generator output should be required to provide the same output signal on the scope or CRT. **CAUTION: Just touch the base of the transistor. Be sure you do not short it to the collector.**

Since shorted capacitors would have been detected during the voltage analysis, check now for open capacitors. This is easily done by temporarily paralleling the suspected capacitor with one of about the same value and an equal or higher voltage rating. With the tuner set for a local channel, the effect of bridging in the new capacitor can be seen in the picture. Be sure that the capacitor being placed in parallel with the suspected one is approximately the same value.

The last area to suspect during i.f. analysis is alignment. Unless i.f. alignment cores are misadjusted, the probable effect will be poor performance rather than complete absence of picture. Do not attempt realignment unless you are certain that there are no defective components that might be causing the problem.

Key measurements in transistor circuits will generally lead you to the fault. Readings with an ohmmeter tend to be less valuable than voltage readings. If service literature is not available, there are some rules of thumb to use.

Signal injection is valuable for locating a faulty stage. Simply insert the signal at a collector and lower the volume or contrast until the audio or picture signal is minimal. Move the injector to the base and the volume or picture "interference" will improve in proportion to the gain increase.

Very-low-impedance stages (such as the i.f. input) may show a deceptive lack of improvement because of the load these circuits impose on the signal injector.

Here are some rules of thumb for troubleshooting transistor circuits.

Always put the negative lead on the n-element when measuring at the emitter junction.

Emitter-junction bias is most easily measured directly between the base and emitter.

Normal bias on *germanium* transistor amplifiers is 0.2 to 0.4 volt.

Normal bias for *silicon* types is from 0.4 to 0.8 volt.

Bias measurements may vary but large variations call for further investigation.

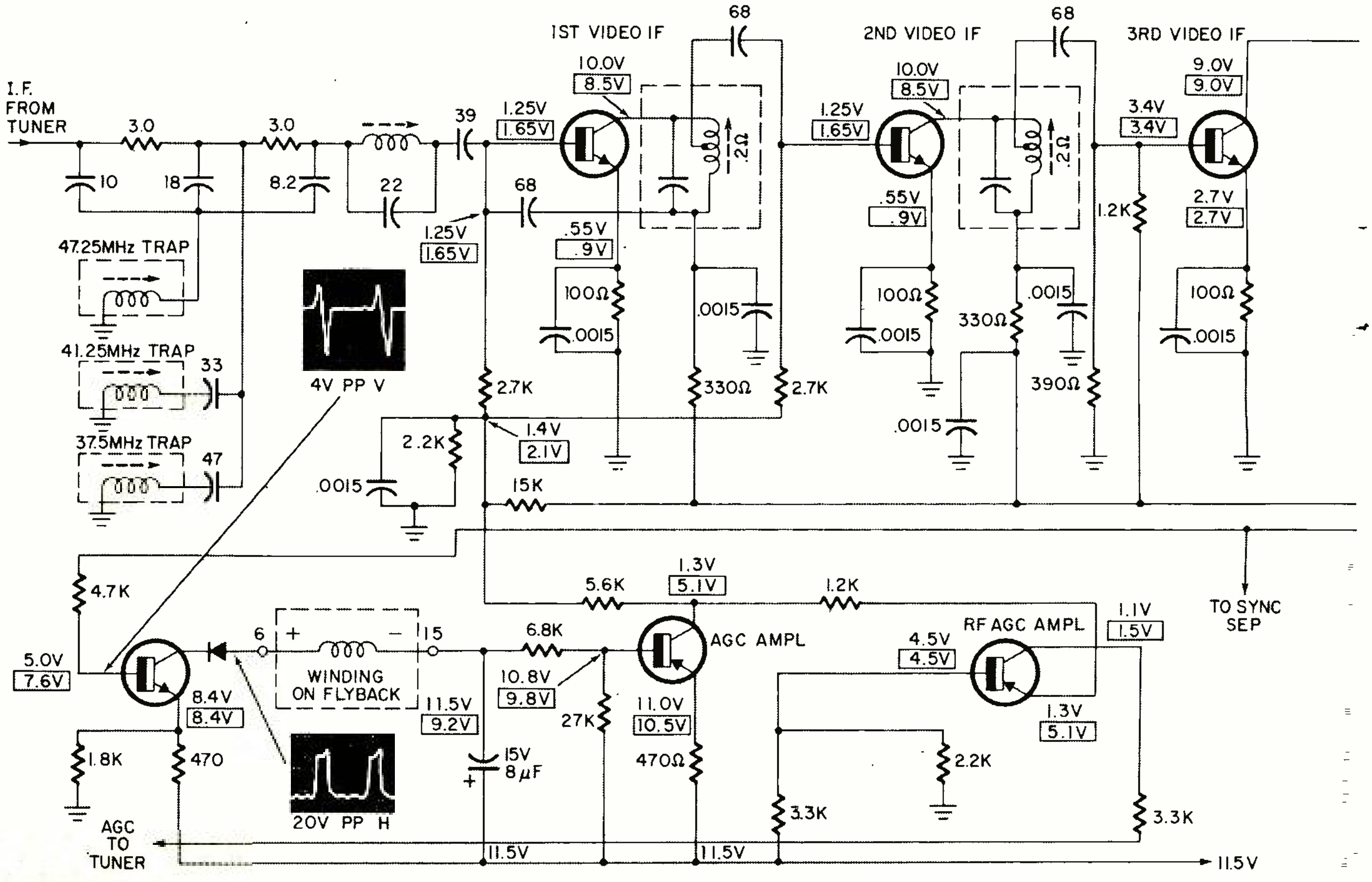
Transistors can generally be checked with an ohmmeter as follows:

A. PNP—Put the negative meter lead on the base. Connect the positive lead to the collector and then the emitter. The meter should show a low resistance.

Reverse the leads by putting the positive lead on the base. The meter should show a high resistance to both emitter and collector.

B. NPN—The meter should show low resistance from emitter and collector

(2)



with the positive lead on the base. With the negative lead on the base you should read a high resistance.

At least two leads must be disconnected from the circuit to check a transistor accurately with an ohmmeter.

Remember to reverse leads when making resistance checks. The reading should be the same both ways. A different reading probably means a transistor junction is affecting your reading.

Small-signal transistors generally have 1 to 5 current in the emitter circuit.

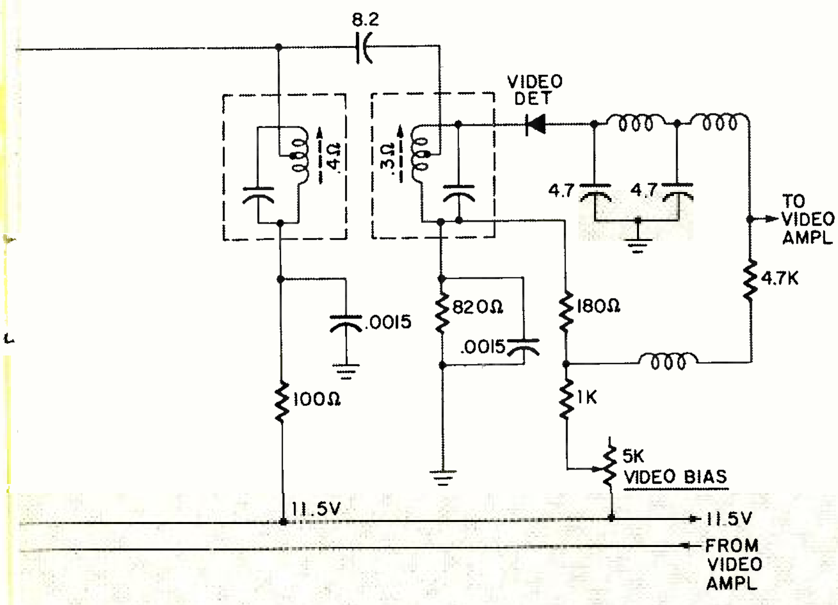
The voltage across the emitter resistor should be about the same as the resistor value in K ohms if 1ma is being drawn through it. For example: A 4,700-ohm resistor will drop 4.7 volts at 1 of current.

These are general rules. There are exceptions in almost every set.

Troubleshooting the video i.f.

To judge the performance of the i.f. system take a look at the video waveform at the video detector load resistor with a good scope. The waveform should be of proper amplitude and the sync pulse should represent 25% of the total signal amplitude. If this signal is incorrect, the problem could be in the video i.f., agc, video detector or first video amplifier stage.

The possibility of the agc system (Fig. 2) being a source of trouble should be investigated first, depending, of course, on the symptoms available. Begin by removing any agc developed by the set and inserting a bias supply. A source of positive agc bias can be obtained by connecting a 30K resistor to the 50K potentiometer between the plus 11.5 volt bus and chassis. Connect the arm of the potentiometer to the i.f. agc buss. This makes available a variable positive agc voltage which can be set to any desired value. With the tuner off channel and no input signal to the set adjust the bias so the i.f. noise signal will not change the video amplifier control bias. Set the video bias under no-signal condition to about 2 volts (or as specified in the service data). The video bias should be able to swing above and below its nominal value by at least 0.5 volt. If this is not possible, there is trouble in the video stages. Connect a scope to the base of the first video amplifier and see if a bias adjustment will produce a noise output. If it does, the trouble is probably in the agc system and should be investigated. If no output is obtained then the fault is probably in the video i.f. stages or the video detector. If an output is seen on the scope but there is no snow on the screen, check the video amplifiers.



Isolating the stage can be difficult or easy depending on what is causing the trouble. A few preliminary checks may make it easy. Measure the collector voltage on all the affected stages to determine if one is low, high, or missing entirely. Frequently, several "suspect" stages are supplied from the source and all may be without power. If all the stages have proper collector voltages, there are two ways to go. The easiest way will depend upon experience with the problem.

The third and proven way is signal injection. Starting at either end of the circuit under suspicion, inject the proper type signal into the base and collector of each stage. When the signal disappears (or appears going toward the input) you have located the defective stage. Note that the output (which can be observed on the CRT or by listening to the speaker) gets stronger as you approach the front end.

If you are familiar with the set under test, direct measurements of each stage provide another approach. Experienced technicians generally make two preliminary checks on each stage and then proceed to the next. Since the suspected stages are usually few and often easily located, these checks are done rapidly.

Measure emitter-junction bias first. This is easily and accurately done by placing the meter leads directly between the emitter and base. Proper polarity for the bias and the meter leads is easily determined.

The proper voltage across the emitter junction in a transistor will be the same in almost all cases. All silicon transistors will have about 0.7 volt and all germanium types will have about 0.2 volt. This is true for both npn and pnp types.

After detecting an incorrect voltage, evaluate the circuit and determine the reason. Incorrect emitter-junction bias almost always means a faulty transistor. If the bias voltage is high, the transistor will often be bad though perhaps from another cause.

If the bias seems to be normal, measure base and emitter voltages separately. Even with proper bias the transistor may not be drawing enough current. A good rule of thumb is that all transistors in a given section will draw about the same current.

Low voltage, low current and the resultant low heat will make components in transistor sets last longer. They will generally have as good a life as most resistors. The electrolytics (used profusely in transistor equipment) will probably be most troublesome and the transistors should be suspected along with all the other components. **R-E**

You can build these

16 Speaker Enclosures

by ABRAHAM B. COHEN †

DESPITE THE QUANTITIES OF LOW-COST, ASSEMBLED LOUDspeaker systems on the hi-fi market, do-it-yourself projects are still very popular. If you're planning such a project, your choice of a loudspeaker enclosure should take several factors into account: performance, cost, size, appearance and expandability.

The speaker system should be installed in the room where your family does most of its "living," and the space available in this room will influence your selection.

The table below and the following figures describe 16 enclosures whose construction information was supplied by six leading loudspeaker manufacturers. The enclosures selected vary in size and may be installed in room dividers, hung from walls, inserted in alcoves and placed on counters or desks. Larger enclosures, which are regaining some of their early popularity, may be built as floor furniture pieces.

To simplify construction, the manufacturer's original *external* design is not included. The builder can select the enclosure's exterior appearance to match room furniture. Several of the systems shown are expansible or include adapter boards. This permits either an 8-, 12- or 15-inch speaker, for example, to be installed without major changes in the enclosure.

Expansible systems minimize obsolescence, enabling you to increase the audio "fullness" of the system as your budget permits.

Optimum performance will be obtained only if the proper lumber is carefully assembled. Here are a few construction tips.

Plywood of ¾-inch thickness should be heavily glued at all mating surfaces. When joints are clamped or screwed together, surplus glue should seep out along its entire length. Small glue blocks are often used to reinforce interior edges of the panels. Apply glue to surfaces between the blocks and panel, and secure the blocks to both panels with screws.

Bass-reflex and infinite-baffle enclosures must be especially rigid to avoid distortion and loss of bass response. Use at least four good-sized screws along *each* edge of the rear panel. At least 1 inch of sound-insulation material should be applied to all interior surfaces in any enclosure. Large panels may require diagonal cross-braces to minimize vibrations, and a cross-strut can be used *between* large surfaces.

Make sure the speaker mounting panel is very flat, especially where the speaker is mounted. If possible, make the front panel thicker than the others.

If wood screws are used to mount the speaker, drill small guide holes and drive the screw in carefully. A better method of speaker mounting is with machine bolts and T-nuts, which are pressed into a hole in the baffle board.

Avoid grille cloth material that is acoustically opaque, as this will ruin high-frequency response. The cloth should be loosely woven—at least 50% of its area should be open space. Tighten and secure the cloth to the *back* side of the panel. **R-E**

SYSTEM	FIG.	WOOFER	MIDRANGE	TWEETER	ENCLOSURE TYPE	CU. FT.	DIMENSIONS	MANUFACTURER	PRICE SPEAKER(S) ONLY*
DOUBLY EXPANDABLE SYSTEM	1	← 12 →			TUNED DUCT	7.4	35" x 24" x 16"	UNIVERSITY SOUND	$ 20
BASS EXPANSION	1	15	(12 →)		TUNED DUCT	7.4	35" x 24" x 16"	UNIVERSITY SOUND	$115
TREBLE EXPANSION	1	15	12	HORN	TUNED DUCT	7.4	35" x 24" x 16"	UNIVERSITY SOUND	$155
DOUBLY EXPANDABLE SYSTEM	2	← 8 →			TUNED DUCT	3.4	29" x 19" x 12"	UNIVERSITY SOUND	$ 20
BASS EXPANSION	2	12	(8 →)		TUNED DUCT	3.4	29" x 19" x 12"	UNIVERSITY SOUND	$ 45
TREBLE EXPANSION	2	12	8	CONE	TUNED DUCT	3.4	29" x 19" x 12"	UNIVERSITY SOUND	$ 60
2 SPEAKER - 2 WAY	3	(15 →)	(← HORN)		BASS REFLEX	7.5	36" x 23" x 17"	ALTEC-LANSING	$150
3 SPEAKER - 2 WAY	4	2(15 →)	(← HORN)		BASS REFLEX	16.0	40" x 36" x 21"	ALTEC LANSING	$240
3 SPEAKER - 3 WAY	5	15	8	HORN	TUNED DUCT	4.35	28" x 21" x 14"	UNIVERSITY SOUND	$160
3 SPEAKER - 3 WAY	6	15	8	CONE	TUNED DUCT	5.75	31" x 22" x 16"	UNIVERSITY SOUND	$140
1 SPEAKER - 2 WAY INTEGRATED	7	(15 →)		CONE(2)	INFINITE BAFFLE	4.65	22" x 22" x 18"	BOZAK	$100
2 SPEAKER - 3 WAY	7	15	8	CONE(2)	INFINITE BAFFLE	4.65	22" x 22" x 18"	BOZAK	$155
2 SPEAKER - 2 WAY	8	(12 →)		HORN	BASS REFLEX	3.4	24" x 19" x 14"	ALTEC-LANSING	$ 90
3 SPEAKER - 2 WAY	9	2(8 →)		HORN	INFINITE BAFFLE	2.7	26" x 14" x 14"	ALTEC-LANSING	$105
3 SPEAKER - 3 WAY	10	15	8	CONE	TUNED DUCT	7.3	34" x 29" x 14"	JENSEN	$130
2 SPEAKER - 2 WAY	11	12	8	HORN	TUNED DUCT	1.8	25" x 14" x 10"	JENSEN	$100
4 SPEAKER - 3 WAY	12	2(12)	8	CONE(8)	INFINITE BAFFLE	8.7	41" x 25" x 16"	BOZAK	$320
2 SPEAKER - 2 WAY	13	(8 →)		HORN	TUNED DUCT	1.25	24" x 14" x 7"	ELECTRO-VOICE	$ 50
2 SPEAKER - 2 WAY	13	(12 MECHANICAL →)		HORN	TUNED DUCT	4.00	28" x 18" x 15"	ELECTRO-VOICE	$ 70
3 SPEAKER - 3 WAY	13	15	HORN	HORN	TUNED DUCT	13.00	50" x 34" x 15"	ELECTRO-VOICE	$155
2 SPEAKER - 2 WAY	14	(10 →)		HORN	TUNED DUCT	2.3	21" x 16" x 13"	J. B. LANSING	$170
2 SPEAKER - 2 WAY	14	(12 →)		HORN	TUNED DUCT	2.3	21" x 16" x 13"	J. B. LANSING	$190
2 SPEAKER - 2 WAY	14	(15 →)		HORN	TUNED DUCT	2.3	21" x 16" x 13"	J. B. LANSING	$220
2 SPEAKER - 2 WAY	15	(10 →)		HORN	INFINITE BAFFLE	1.5	23" x 11" x 11"	ALTEC-LANSING	$ 95
2 SPEAKER - 2 WAY	16	(15 →)		HORN	15" PASSIVE RADIATOR	5.75	35" x 24" x 13"	J. B. LANSING	$345

† From *Hi-Fi Loudspeakers and Enclosures*, by Abraham B. Cohen, Hayden Book Co., Inc., Copyright © 1956, 1968.

*Add cost of enclosure and, for multiple-speaker systems, crossover networks. Manufacturers can provide crossovers and details.

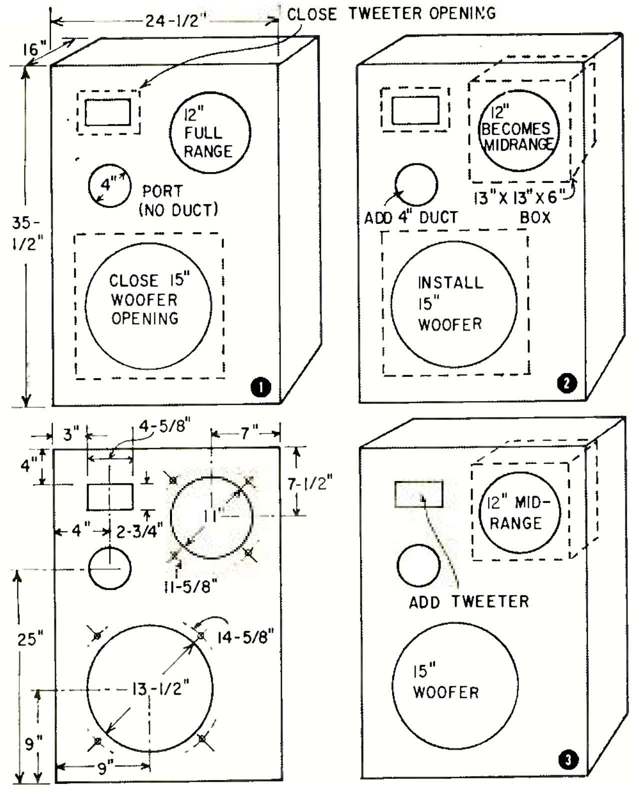


Fig. 1—A doubly expandable, tuned-duct University system. Start with 12" model M12 wide-range speaker (1). Add 15" C15HC woofer to extend bass response (2), and a HF206 tweeter (3). Note boxing of 12" speaker and duct.

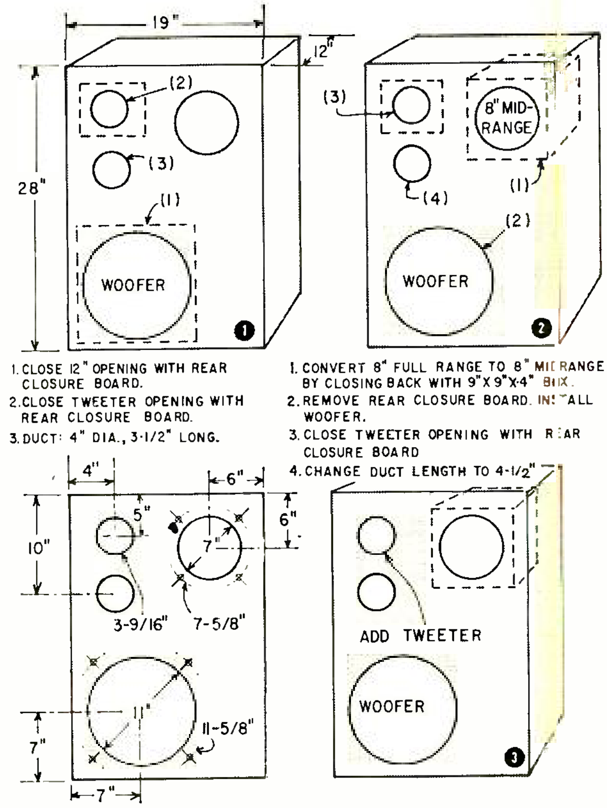


Fig. 2—Another University system, similar to Fig. 1, starts with an 8" M8D wide-range speaker (1), using a duct. If a 12" M12 woofer is added (2), duct length is changed. The addition of MS tweeter (3) extends response of system.

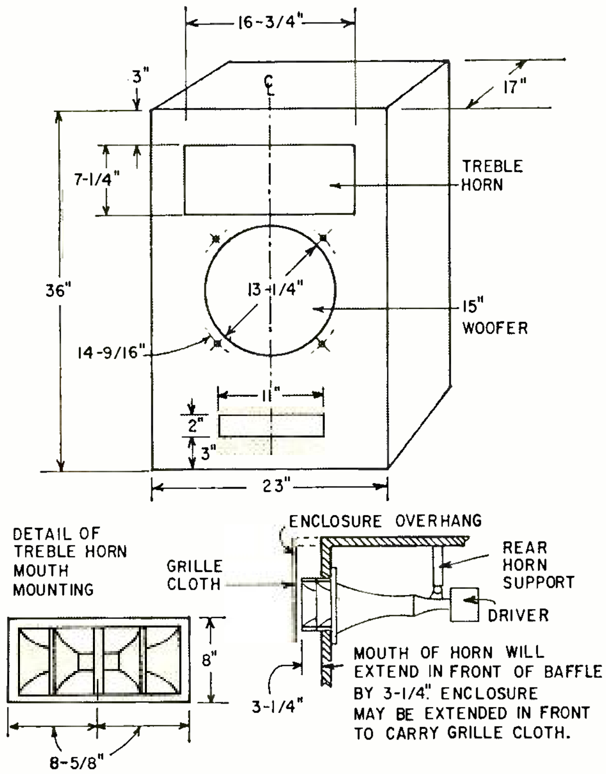


Fig. 3—A 2 speaker-2 way Altec-Lansing bass reflex system. Use a 15" 416A woofer, 811 treble horn with a 806A driver.

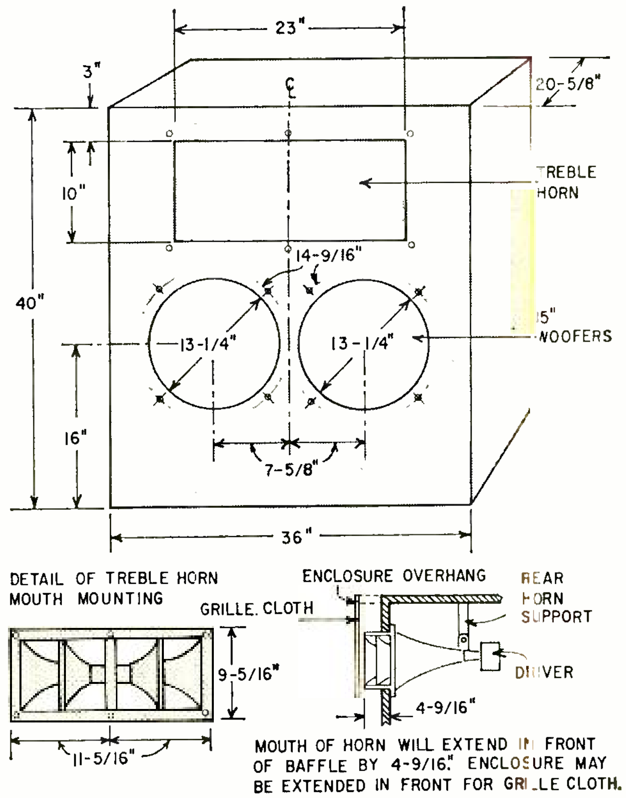
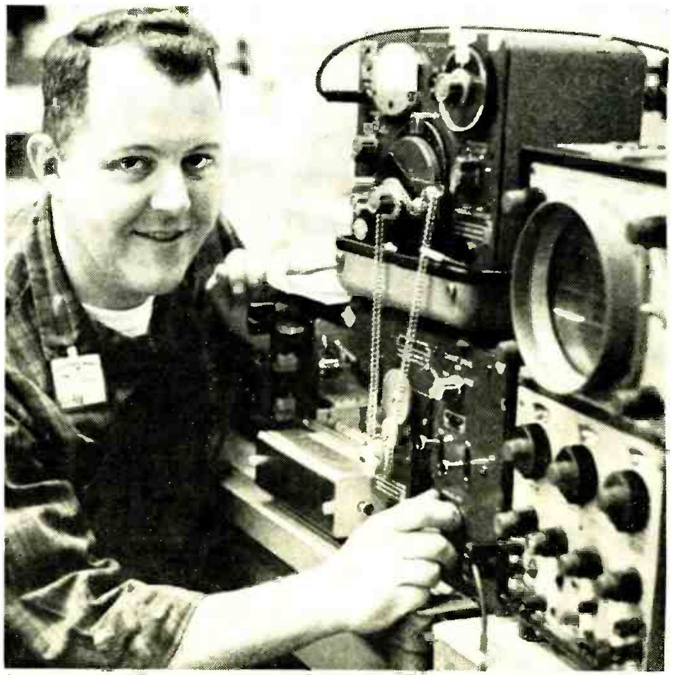


Fig. 4—This infinite baffle Altec-Lansing system uses two 416A woofers. Use 511B treble horn with 802D driver.

One of our students wrote this ad!

Harry Remmert decided he needed more electronics training to get ahead. He carefully "shopped around" for the best training he could find. His detailed report on why he chose CIE and how it worked out makes a better "ad" than anything we could tell you. Here's his story, as he wrote it to us in his own words.



Harry Remmert on the job. An Electronics Technician with a promising future, he tells his own story on these pages.

By Harry Remmert

AFTER SEVEN YEARS in my present position, I was made painfully aware of the fact that I had gotten just about all the on-the-job training available. When I asked my supervisor for an increase in pay, he said, "In what way are you a more valuable employee now than when you received your last raise?" Fortunately, I did receive the raise that time, but I realized that my pay was approaching the maximum for a person with my limited training.

Education was the obvious answer, but I had enrolled in three different night school courses over the years and had not completed any of them. I'd be tired, or want to do something else on class night, and would miss so many classes that I'd fall behind, lose interest, and drop out.

The Advantages of Home Study

Therefore, it was easy to decide that home study was the answer for someone like me, who doesn't want to be tied down. With home study there is no schedule. I am the boss, and I set the pace. There is no cramming for exams because I decide when I am ready, and only then do I take the exam. I never miss a point in the lecture because it is right there in print for as many re-readings as I find necessary. If I feel tired, stay late at work, or just feel lazy, I can skip school for a night or two and never fall behind. The total absence of all pressure helps me to learn more than I'd be able to grasp if I were just cramming it in to meet an exam deadline schedule. For me, these points give home study courses an overwhelming advantage over scheduled classroom instruction.

Having decided on home study, why did I choose CIE? I had catalogs from six different schools offering home study courses. The CIE catalog arrived in less than one week (four days before I received any of the other catalogs). This indicated (correctly) that from CIE I could expect fast service on grades, questions, etc. I eliminated those schools which were slow in sending catalogs.

FCC License Warranty Important

The First Class FCC Warranty* was also an attractive point. I had seen "Q" and "A" manuals for the FCC exams,

*CIE backs its FCC License-preparation courses with this famous Warranty: graduates must be able to pass the applicable FCC License exam or their tuition will be refunded in full.

and the material had always seemed just a little beyond my grasp. Score another point for CIE.

Another thing is that CIE offered a complete package: FCC License and technical school diploma. Completion time was reasonably short, and I could attain something definite without dragging it out over an interminable number of years. Here I eliminated those schools which gave college credits instead of graduation diplomas. I work in the R and D department of a large company and it's been my observation that technical school graduates generally hold better positions than men with a few college credits. A college degree is one thing, but I'm 32 years old, and 10 or 15 years of part-time college just isn't for me. No, I wanted to *graduate* in a year or two, not just *start*.

If a school offers both resident and correspondence training, it's my feeling that the correspondence men are sort of on the outside of things. Because I wanted to be a full-fledged student instead of just a tagalong, CIE's exclusively home study program naturally attracted me.

Then, too, it's the men who know their theory who are moving ahead where I work. They can read schematics and understand circuit operation. I want to be a good theory man.

From the foregoing, you can see I did not select CIE in any haphazard fashion. I knew what I was looking for, and only CIE had all the things I wanted.

Two Pay Raises in Less Than a Year

Only eleven months after I enrolled with CIE, I passed the FCC exams for First Class Radiotelephone License with Radar Endorsement. I had a pay increase even before I got my license and *another* only ten months later. I'm getting to be known as a theory man around work, instead of one of the screwdriver mechanics.

These are the tangible results. But just as important are the things I've learned. I am smarter now than I had ever thought I would be. It feels good to know that I know what I know now. Schematics that used to confuse me completely are now easy for me to read and interpret. Yes, it is nice to be smarter, and that's probably the most satisfying result of my CIE experience.

Praise for Student Service

In closing, I'd like to get in a compliment for Mr. Chet Martin, who has faithfully seen to it that my supervisor knows I'm studying. I think Mr. Martin's monthly reports to my supervisor and generally flattering commentary have been in large part responsible for my pay increases. Mr. Martin has given me much more student service than "the contract calls for," and I certainly owe him a sincere debt of gratitude.

And finally, there is Mr. Tom Duffy, my instructor. I don't believe I've ever had the individual attention in any classroom that I've received from Mr. Duffy. He is clear, authoritative, and spared no time or effort to answer my every question. In Mr. Duffy, I've received everything I could have expected from a full-time private tutor.

I'm very, very satisfied with the whole CIE experience.

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Every penny I spent for my course was returned many times over, both in increased wages and in personal satisfaction.

Perhaps you too, like Harry Remmert, have realized that to get ahead in Electronics today, you need to know much more than the "screwdriver mechanics." They're limited to "thinking with their hands"...learning by taking things apart and putting them back together...soldering connections, testing circuits, and replacing components. Understandably, their pay is limited—and their future, too.

But for men like Harry Remmert, who have gotten the training they need in the fundamentals of Electronics, there are no such limitations. As "theory men," they think with their heads, not their hands. For trained technicians like this, the future is bright. Thousands of men are urgently needed in virtually every field of Electronics, from two-way mobile radio to computer testing and troubleshooting. And with this demand, salaries have skyrocketed. Many technicians earn $8,000, $10,000, $12,000 or more a year.

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Circle 28 on reader service card

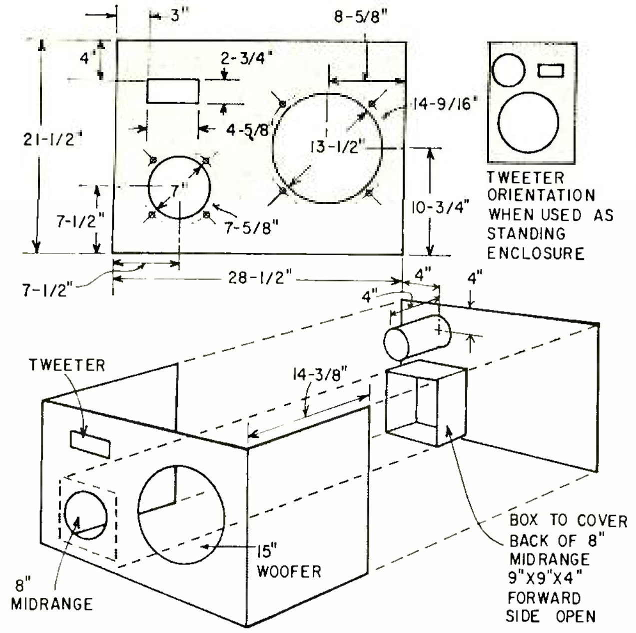


Fig. 5—Here's a 3 speaker-3 way, rear duct tuned University system. Components are a 15" C15W woofer, C8M midrange and HF206 tweeter. Duct diameter should be 4".

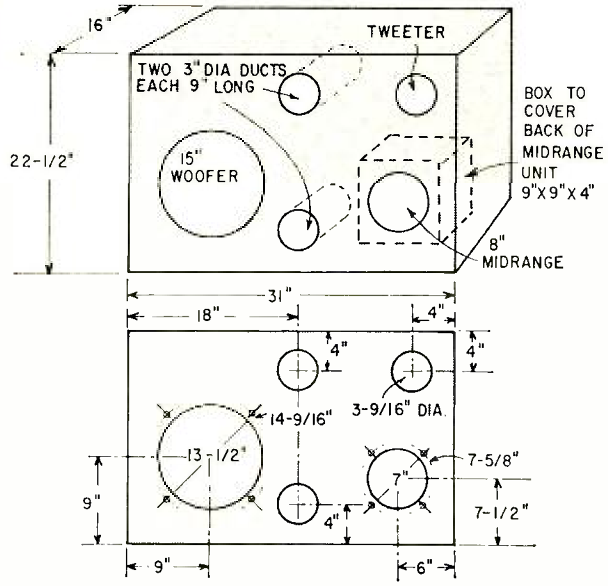


Fig. 6—Another 3 speaker-3 way, duct-tuned University system using two 3" diameter ducts. Use a C15HC woofer with C8M midrange and T202 tweeter. Box the midrange.

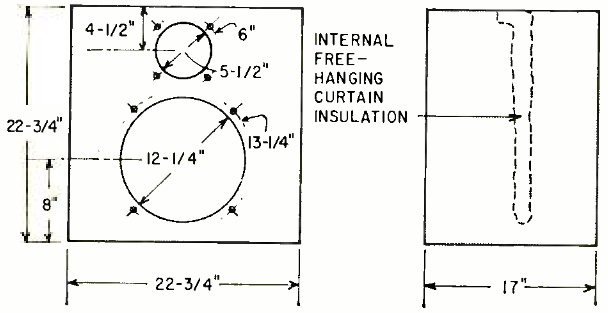


Fig. 7—Bozak 2-speaker (integrated 2-way system using 15" B207B coaxial with 5½" opening closed. For a 2-speaker 3-way system, add a B209B in 5½" opening.

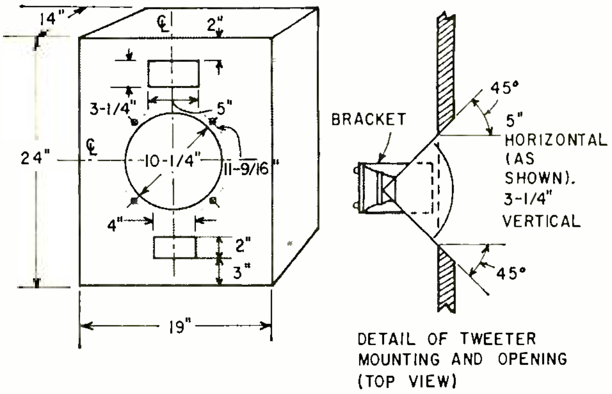


Fig. 8—A bass-reflex, 2 speaker-2 way system using Altec-Lansing components. Use a 12" model 414A woofer and a 3000H horn-type tweeter. Mount the tweeter as shown.

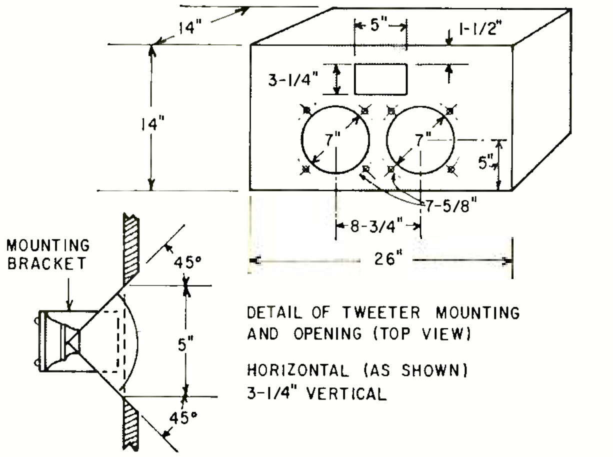


Fig. 9—This infinite baffle, 3 speaker-2 way Altec-Lansing system uses two 8" 755 woofers and a 3000H tweeter.

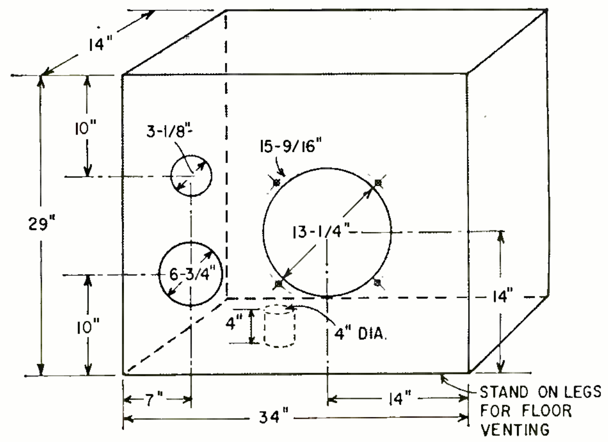


Fig. 10—Bottom-duct, 3 speaker-3 way Jensen system using 15" W15-IF woofer, ME-20 midrange and TE-40 tweeter.

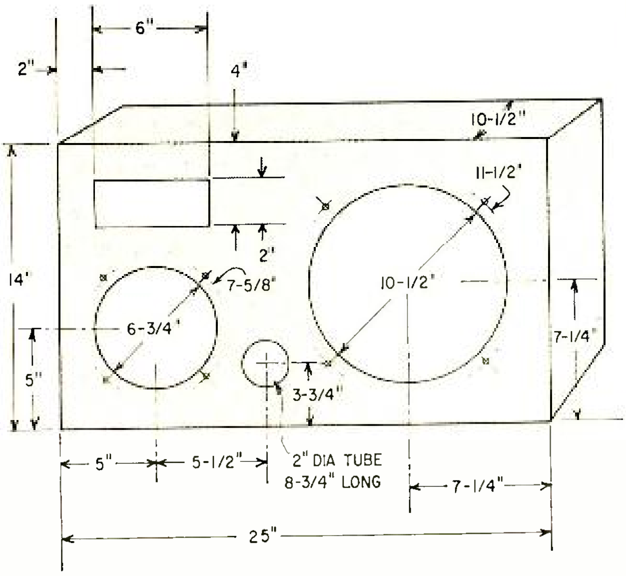


Fig. 11—A Jensen 2 speaker-2 way duct-tuned system. Components: W12-NF woofer, MQ8-U midrange, TH-20 tweeter.

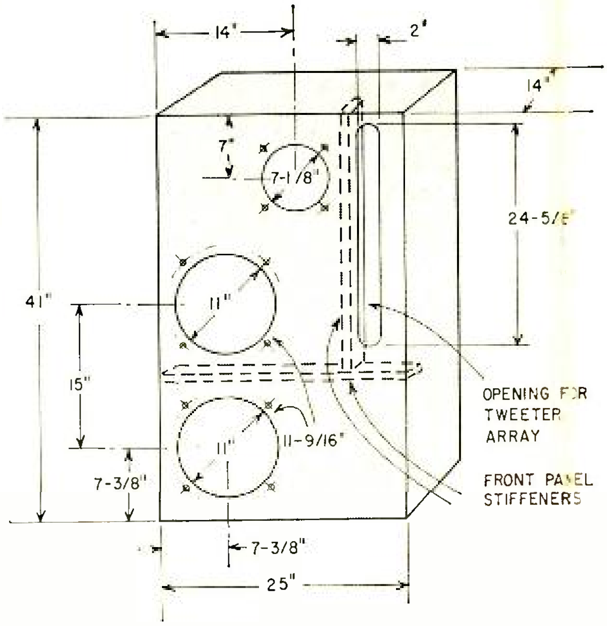


Fig. 12—A 4 speaker-3 way Bozak infinite-baffle system. Use B199A woofers, a B800A midrange, 4 pr. B200Y tweeters.

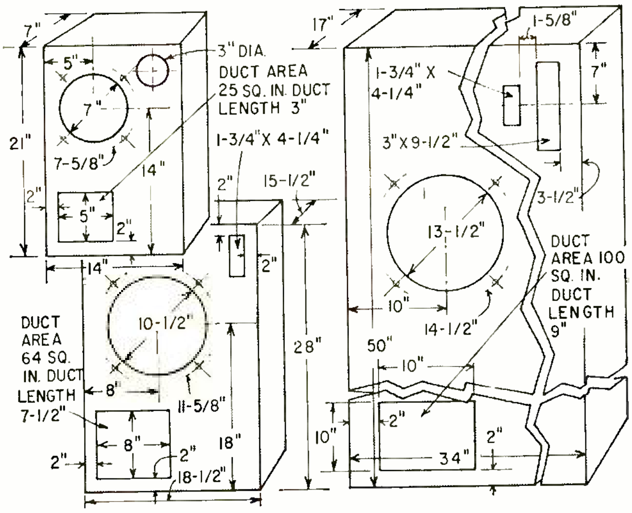


Fig. 13—Three different Electro-Voice tuned-duct systems. Smallest enclosure has an LS8 woofer and HF1 tweeter. Second largest system uses an SP12B woofer and T35 tweeter. Large enclosure uses SP15B woofer (with whizzer), a 8HD midrange speaker with T25A driver and model T35 tweeter. All three speaker systems are easy to put together.

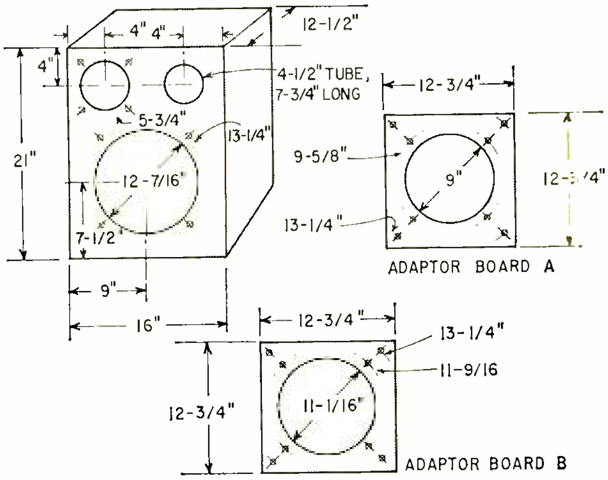


Fig. 14—Basic enclosure for this J. B. Lansing tuned-duct system will take three woofers. For 10" setup use adaptor board A over main woofer opening with an LE10A woofer and LE175DLH tweeter. Expand system with a 12" D123 woofer and LE175DLH tweeter (use board B). Use main woofer opening with 15" LE14A and the same tweeter.

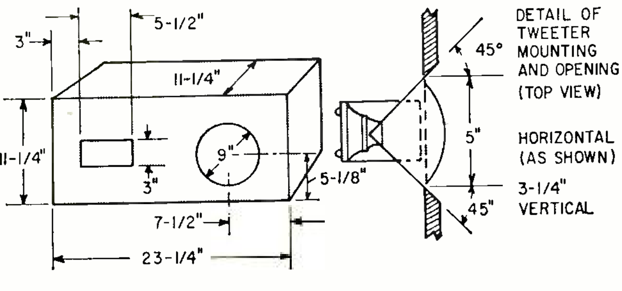


Fig. 15—This is a Altec-Lansing infinite baffle system (2 speaker-2 way). Use a 406B 10" woofer, 3000H tweeter.

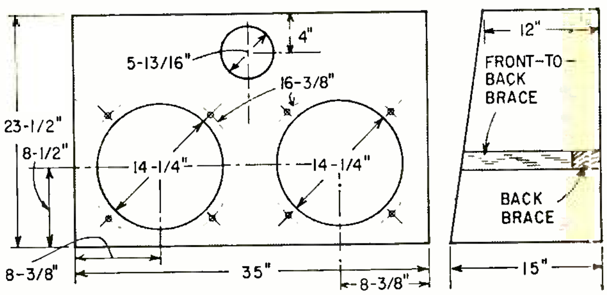


Fig. 16—A J. B. Lansing 2 speaker-2 way system using 15" LE15A woofer, PR15 passive radiator, HL91-LE85 tweeter.

IC STEREO AMPLIFIER IN A PHONO ARM

Portable stereo phonograph uses IC amplifiers and battery-powered turntable

by ED FRANCIS*

NOW, THROUGH THE USE OF SPACE-AGE INTEGRATED circuits (IC's), it is possible to come up with a complete solid-state stereo phonograph of reasonable quality with all electronics built into the tone arm. The only external items are a 6-volt lantern battery, two speakers and a battery-powered turntable. Total cost should be about \$40, depending upon the cartridge selected. Despite the relatively low cost, this unit will outperform many \$50 to \$100 stereos while providing enough volume for you *and* your neighbors.

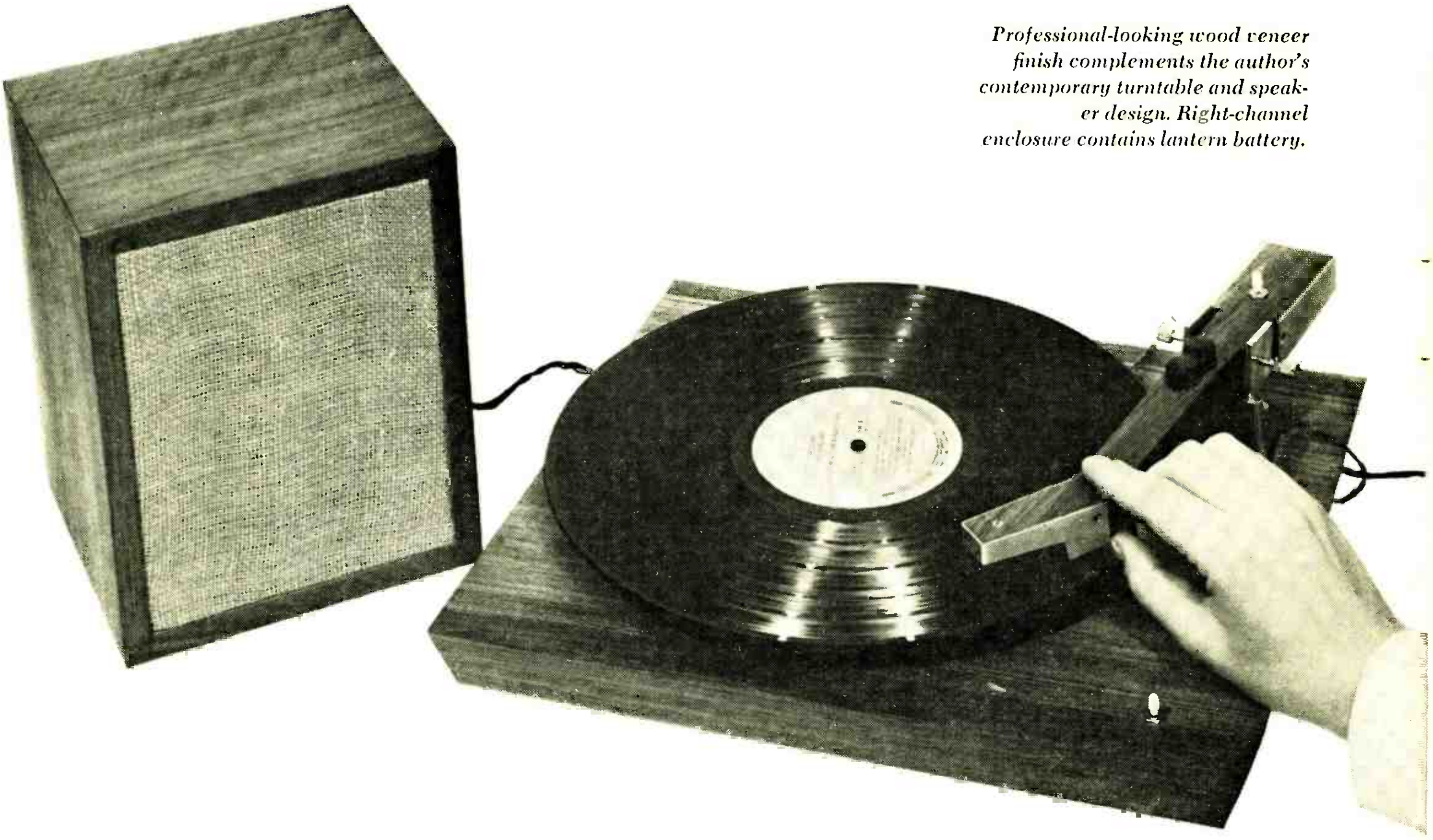
The heart of the stereo is two RCA CA3020 IC's. For simplicity, no output transformers are used. The amplifier outputs are fed directly into 130-ohm center-tapped speakers. The speakers are oval 3" x 5" units designed specifically for use with the CA3020. Because the speakers are not husky hi-fi types, low-frequency response is somewhat limited. This could be improved by using a pair of good output transformers and higher-quality speakers.

A lever-operated cam gently raises and lowers the arm for convenient operation. Virtually any turntable will work.

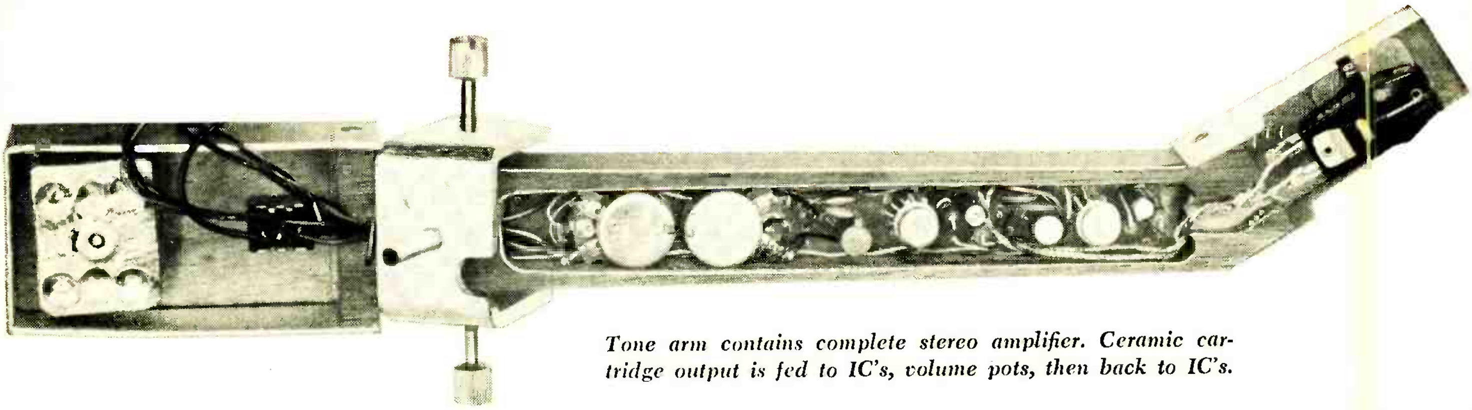
How it works

The stereo cartridge picks up A- and B-channel program material, generates an audio voltage and feeds it to the respective amplifier input. Because a high-output ceramic cartridge is used, the signal is fed through 100,000-ohm dropping resistors, since only 40 mV is required to drive the CA3020's to full output.

The signal continues through coupling 5-μf capacitors to the amplifier input stage, an emitter follower. From the emitter follower the signal goes to the volume control, passes through another coupling capacitor and



Professional-looking wood veneer finish complements the author's contemporary turntable and speaker design. Right-channel enclosure contains lantern battery.



Tone arm contains complete stereo amplifier. Ceramic cartridge output is fed to IC's, volume pots, then back to IC's.

goes back into the amplifier. The signal undergoes the standard phase-splitting process in preparation for push-pull operation. The amplifiers require either a center-tapped output transformer or a high-impedance, center-tapped loudspeaker. The amplifier circuit is in Fig. 1.

Construction

Construction is neither critical nor difficult. However, considerable attention must be given to many small details. The first part of the job involves woodwork and is simplified considerably if a bandsaw and router are available. The arm is cut from ¾-inch walnut stock (Fig. 2). With the aid of a router, clean out the under side of the arm to make room for the dual-amplifier circuit board. This cutout should be about ⅝ inch wide by 5¾ inches long and about ⅝ inch deep.

Bearings are ⅛-inch diameter 1-inch drill rod with 45° V-groove cups turned into each end. These V-grooves are supported or engaged by the pointed ends of captive nut thumbscrews (Newark 26F362 55¢ ea.).

After sanding the arm thoroughly, press the bearing rod into a slightly undersized hole drilled at location B. The arm support yoke consists of ⅛ inch by 1 inch aluminum bar stock bent into a U-shape, drilled and tapped for the thumbscrews. The swivel bearing is simply a 6-32 machine screw threaded into a short length of thin-wall brass tubing.

The mating portion of the swivel bearing consists of a ¼-inch stove bolt drilled out to accept the thin-wall brass tubing. Thread this stove bolt bushing into the walnut arm support. Since the outside of the bushing is threaded, arm height can be adjusted simply by turning the bushing in or out of the wooden arm support.

Connectors for the speakers are mounted on the arm support, and consist of two transistor sockets. Old transistors are used for plugs. Drill a ⅜-inch hole completely through the arm support base, and mount one socket in each end of the hole. Drill a vertical 5/32-inch hole into the side of the ⅜-inch socket hole to pass small-wire connections from the amplifiers in the arm down to the socket connectors for both audio and dc power. If you don't want to tackle the arm, use a conventional one and mount the amplifier under the motor board.

Shrouds surrounding the cartridge and counterbalance compartments are made of soft aluminum, and are drilled and fastened to the arm with No. 2¼ FH wood screws. Finely fitted shrouds are made best by first hand-fitting full-size paper patterns to the arm.

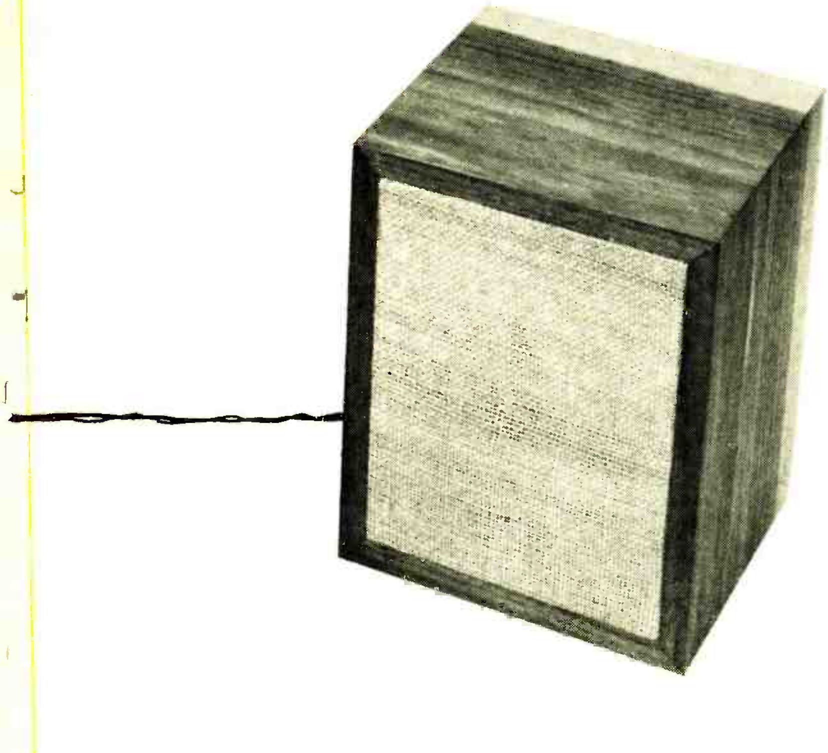
Although the counterbalance compartment was originally designed to house a 9-volt battery, I found it much more practical to use a lead counterbalance and put a 6-volt lantern battery inside one of the speaker enclosures.

A ⅝ x 5¼-inch circuit board is large enough for the amplifiers and the dozen or so components required to complete the unit. A full-size pattern of the foil side is in Fig. 3.

The two ⅝-inch diameter volume controls are wired into the circuit with standard 28-gauge stranded phono cartridge wire.

I used a ceramic stereo cartridge with 0.5-volt output. Since the amplifiers require less than 40 mV for full output, a 100,000-ohm series resistor restricts the cartridge's output. However, the CA3020 amplifier has a 50,000-ohm input impedance, which is quite compatible with many magnetic cartridges, the result being a somewhat lower output.

Except for the 510,000-ohm bias resistor, none of the external components are critical. However, their val-



*Department of Industrial Technology, Illinois State University, Normal, Ill. 61761

ues will affect the frequency response. Sticking fairly close to the values specified will assure a wide response (actually much wider than what the speakers will reproduce).

When soldering the IC's into the circuit heat-sink each lead. Also leave the leads full length. Use 28 gauge stranded phono cartridge wire to complete the connections from the circuit board to the volume controls. Connections to the cartridge are made with shielded phono wire. Be sure to dress these leads neatly, to prevent shorting the shields to components on the circuit board.

The 130-ohm center-tapped speakers are designed specifically for use with the CA3020's and eliminate the need for output transformers. You could also use a pair of 125–130-ohm output transformers to match standard low-impedance speakers.

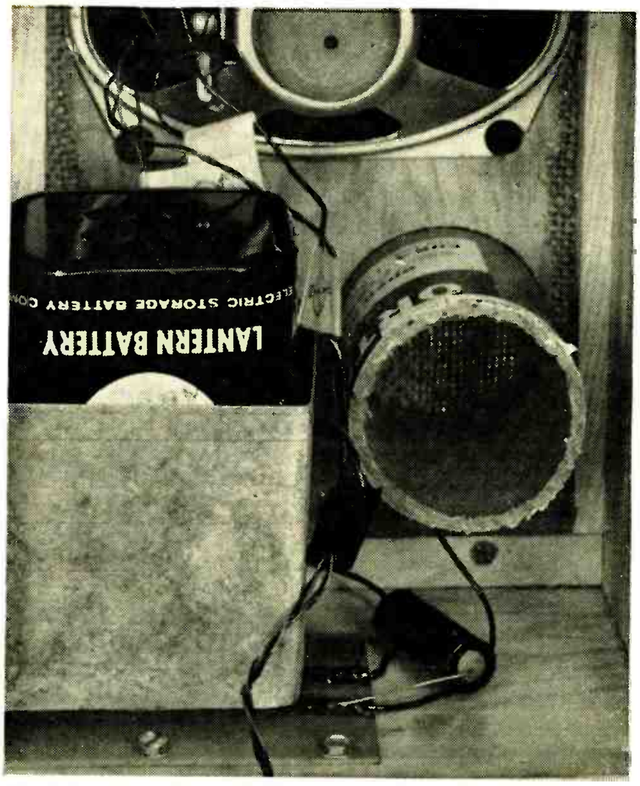
Ducted-port enclosures seem to improve speaker performance. They are made from ½-inch plywood and are covered with a suitable grille cloth. Walnut veneer will finish the job. Enclosure sides, tops and bottoms should be securely fastened with glue and finishing nails or screws. The outside dimensions are 7 x 9 x 6½ inches.

The fronts are cut about ⅛ inch undersize to allow for stretching the grille cloth around their sides. An opening for the ducted port is located near the speaker and off to one side. Its exact diameter is determined by the outside diameter of the tubing used. The approximate duct size is 2 inches in diameter by 3 inches long.

Before mounting the speakers and covering with grille cloth, paint the fronts flat black to disguise the speaker cone. When ready for installation, fasten the enclosure fronts to the frame from the inside with small cleats and wood screws. Connecting leads for the speakers are made from 28-gauge stranded phono cartridge wire. For one speaker, three wires are required. Because one enclosure houses the power supply, four conductors are required. I found a battery holder with contacts for the spring terminals to be quite convenient. A printed-circuit contact board located at the bottom of the battery holder that allows the battery to be inserted without regard to polarity—no mistake can be made—is shown in Fig. 4.

Subminiature speaker plugs to match the transistor sockets are made from old transistors. Simply grind off the top, clean out the contents and solder in the speaker wires. For additional strength and strain relief, fill the transistor plugs with cement after connections are made and tested. The speaker enclosure containing the battery has four leads and of course requires a four-contact transistor plug.

Although the on-off switch is located on the arm, you may find it more convenient to mount it on the front of the "power enclosure," or possibly combine both amplifier switch and turntable switch in a double-pole unit located on the turntable base.



Ducted-port enclosures helps response from the 130-ohm center-tapped speakers designed for use with the CA3020 IC. PC contact board (beneath battery) insures correct polarity.

The turntable base is made of plywood and wood stripping, and is covered with walnut veneer. A set of short legs will give the base a pleasing "floating effect."

Virtually any turntable will work. However, a battery-powered version makes the unit completely portable. Just add batteries, battery holder and a switch to power the turntable.

Be careful when locating and mounting the amplifier arm. You may have to level the arm support with shims. Proper tracking pressure is recommended by the cartridge manufacturer and is set by properly locating the slotted counterbalance. To set desired arm height adjust the pivot bushing in the arm support base.

The arm-lifting cam is supported by a small bracket made from a length of 3/32-inch diameter stainless-steel brazing rod. Make final cam adjustments after completing the arm and turntable assembly.

The IC stereo is quite efficient, and the battery delivers many hours of operation. The smoothly operating cam lifter will save records from shaky hands. Obviously, the arm should be lifted before adjusting the volume or balance. **R-E**

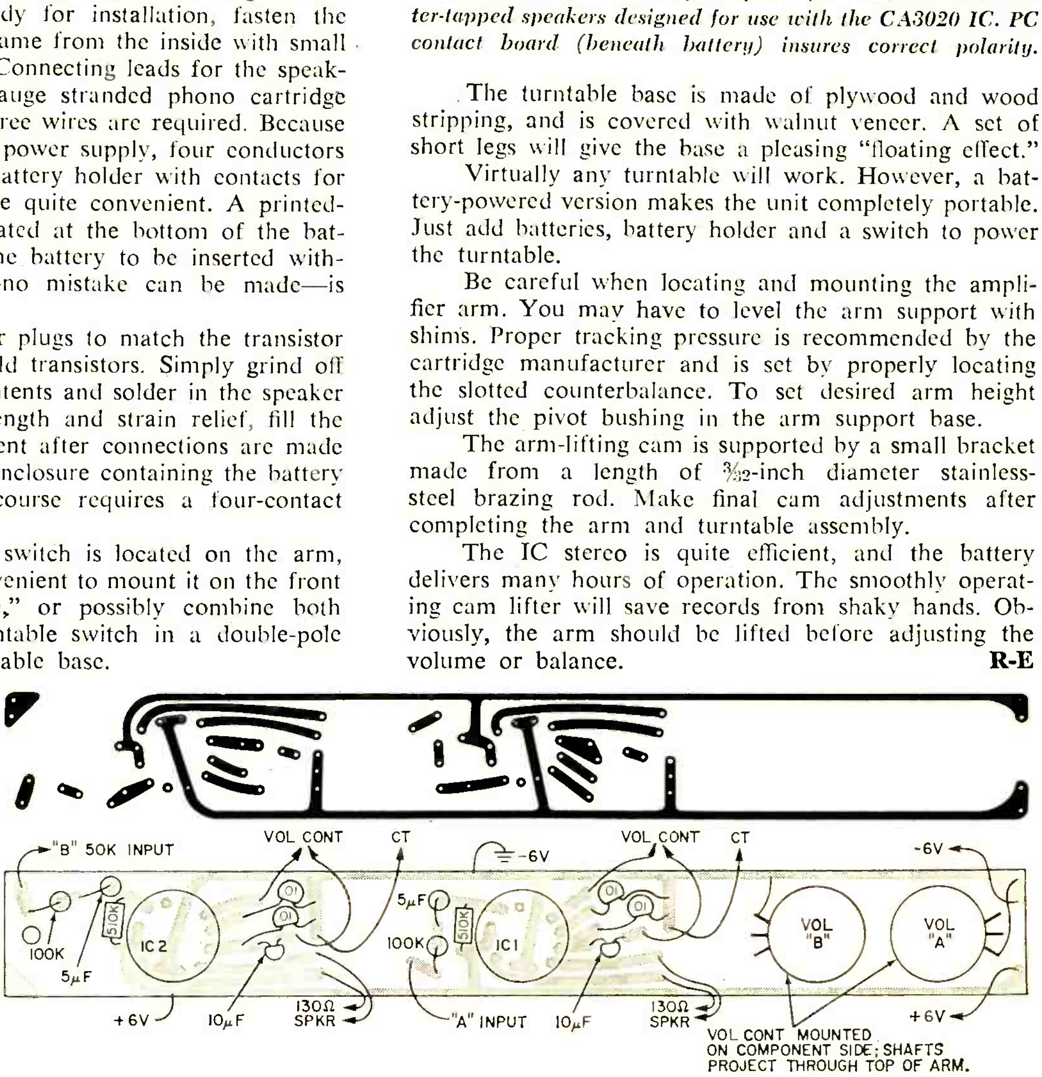


Fig. 3—Full-size PC pattern (top) and component placement from the foil side. Volume-control shafts project through top of arm. Make external hookups with phono wire.

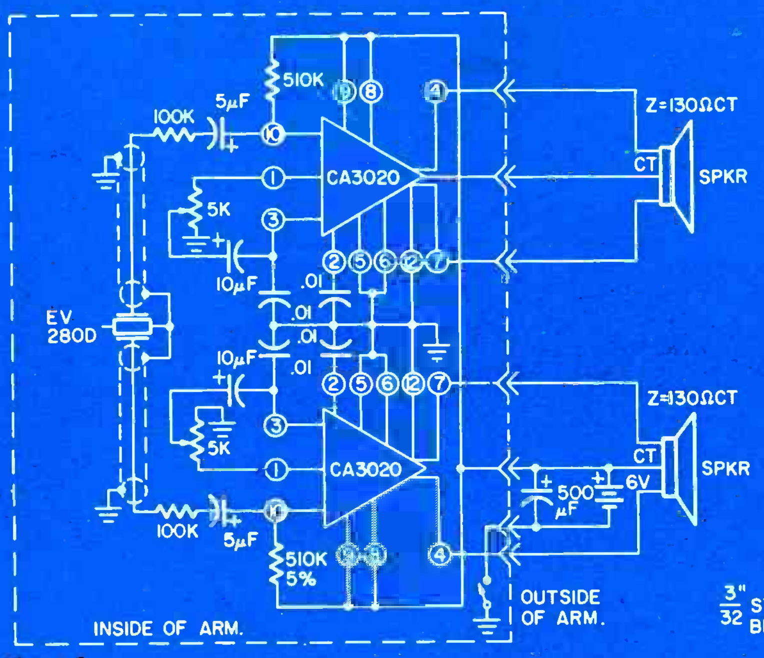


Figure 1

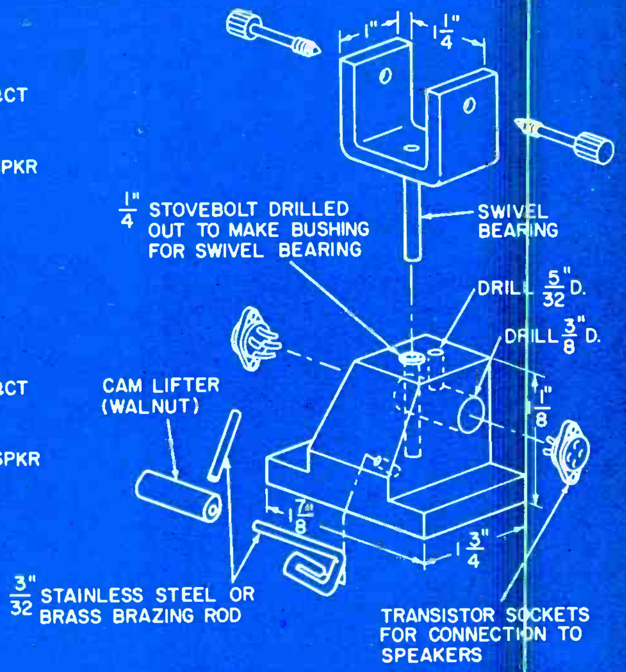
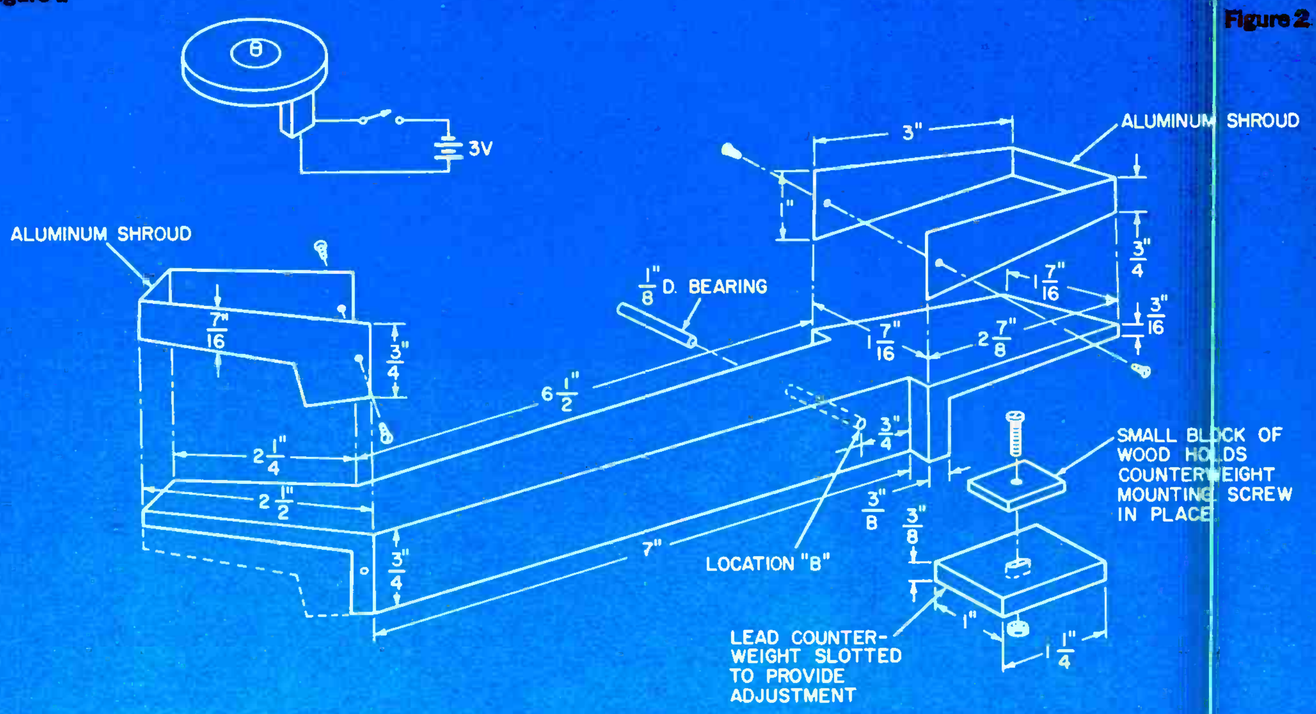


Figure 2



PARTS LIST

All resistors ½-watt 10% unless noted
2—510,000 ohms, 5%
2—100,000 ohms
2—potentiometers, 5,000 ohms, ⅝" dia. max, with long shaft

Capacitors
2—5 µF, 10 V, electrolytic
2—10 µF, 10 V, electrolytic
4—0.01 µF, disc ceramic

Miscellaneous components
2—CA3020 Integrated circuit (RCA)
2—spst toggle switch
2—speaker, 130 ohms, ct (RCA #111113)
1—stereo phono cartridge, 0.5-V output
1—turntable
1—6-V lantern battery

Miscellaneous hardware
2—transistor sockets
1—⅜" x 5¼" circuit board
1—2" x 3" circuit board
Miscellaneous hardware

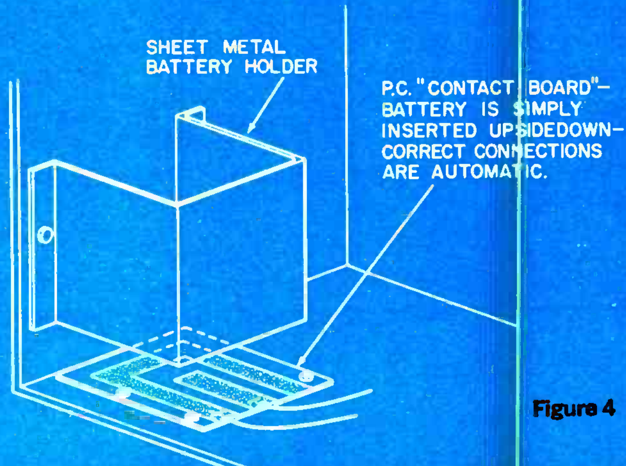
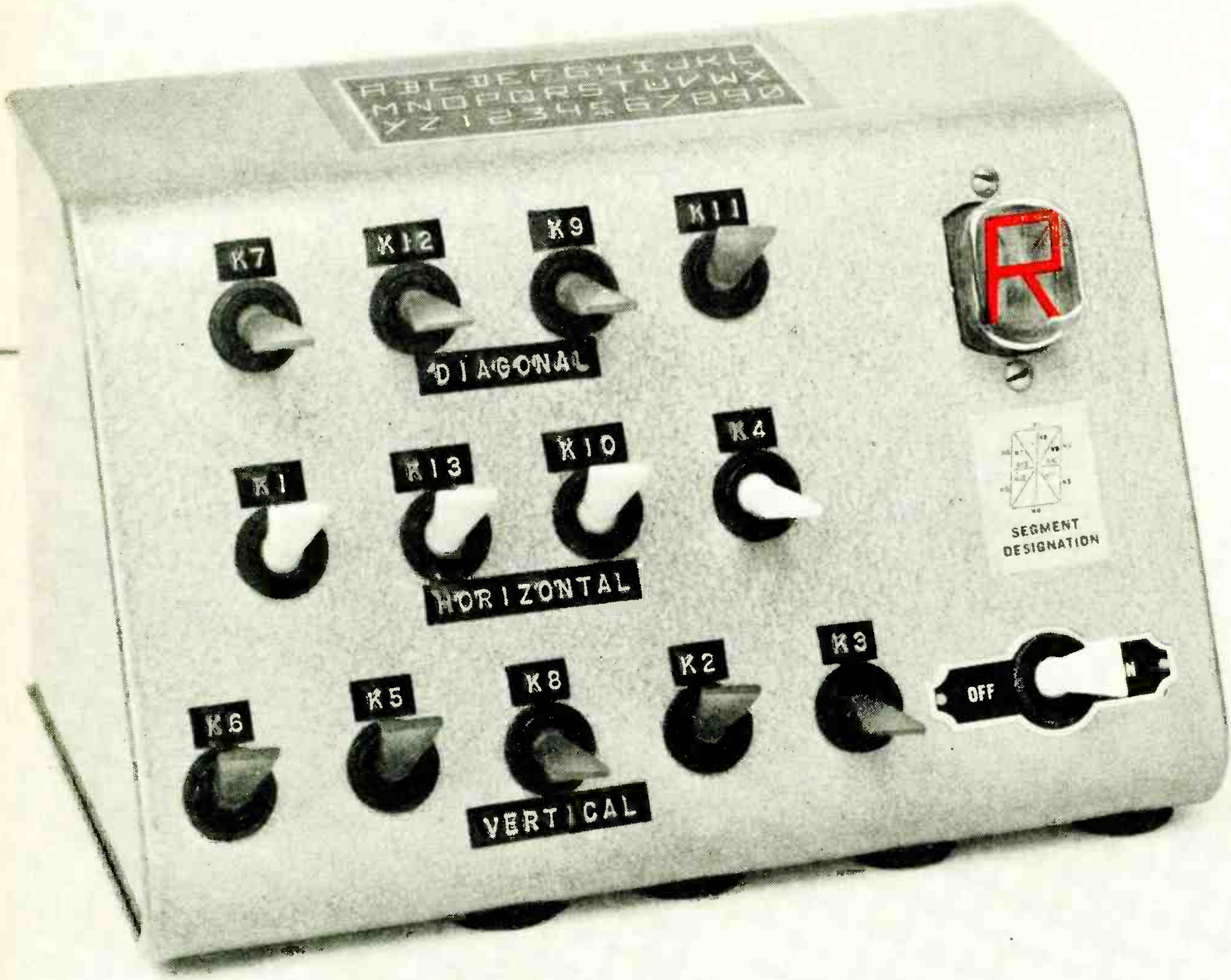


Figure 4



ALPHANUMERIC FUN

by **KEN GREENBERG**

Nifty Nixie demonstrator teaches youngsters ABC's. You'll have a ball too

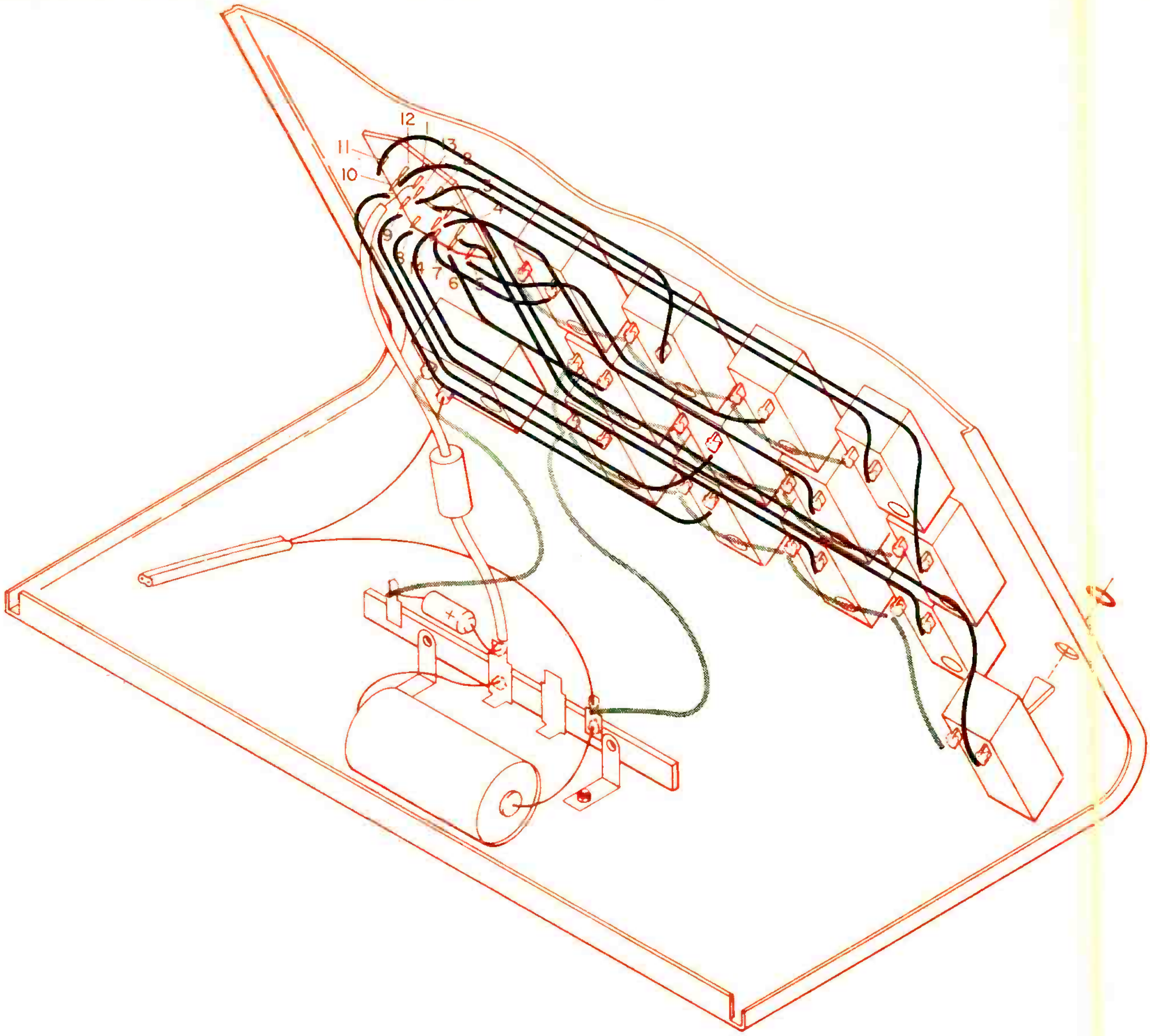
PRINTING LETTERS AND NUMBERS ON THE FACE OF a vacuum tube is fascinating. It can also be educational for preschoolers. Here is a simple circuit that uses the least expensive alpha-numeric readout (Nixie) tube available without the costly and complicated tube driver circuit.

The Burroughs B-5971 Nixie tube will display individually each letter of the alphabet and numbers 0 through 9. The tube contains 13 cathode segments and a common anode. Apha-numeric characters are formed by applying a negative voltage (with respect to the anode) to the appropriate combination of cathode segments. In the circuit described here, each cathode is switched on or off with its own spst switch.

The circuit diagram (Fig. 1) shows a simple half-wave power supply consisting of D1 and C1. Approximately 160 volts dc (no load) is supplied to the tube anode through series anode resistor R1. The maximum anode and cathode current for the B-5971 is under 20 mA, so any silicon or selenium rectifier of this or higher current rating can be used for D1.

The B-5971 and its SK169 socket are available ($16.75 and 90¢, respectively) from Burroughs Corp., Electronic Components Div., P.O. Box 1226, Plainfield, N.J. 07061. Free on request, Burroughs will send you its Bulletin 1141 in which all the technical details of the B-5971 are given.

To make the finished project professional-look-



BOX WITH A NIXIE

ing and colorful, I used Cutler-Hammer colored-handle Designer Line switches and housed the unit in a Bud 7″ sloping-panel cabinet. Using slide switches, the circuit can be made at less cost.

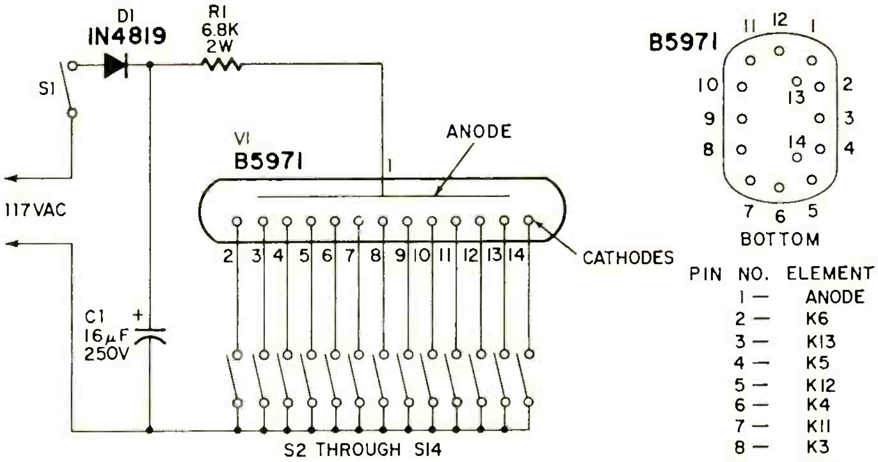
The construction of all the letters and numbers is detailed in Fig. 2. The arrangement of the individual-cathode segments is shown in Fig. 3. Both should be pasted onto the cabinet face for reference. The schematic (Fig. 1) shows the tube pin numbers and the cathode segment connected to each pin. The pictorial diagram shows complete construction details of the unit I assembled.

Mount the switches in three rows: one row of five controlling the vertical segments; one row of four for the horizontal segments, and one row of four for the diagonal segments. Label rows and switches to show segments they control.

When the unit is used as a teaching device, the child is shown how a letter or number is "printed" by flipping the appropriate switches. In a sense, he is printing the letter electronically one segment at a time. Almost everyone likes to flip switches to make lights go on. Here, the display is far more dramatic than simply writing a letter on a piece of paper. In a relatively short time the shapes of numbers and letters are recognized and remembered.

As a game for children or adults, see who can "print" the entire alphabet with the least amount of switching errors. Or see who can do it the fastest.

For the electronics hobbyist, few construction projects using readout tubes have appeared in magazines because of the relatively high cost of the tubes.



PIN NO.	ELEMENT
1 —	ANODE
2 —	K6
3 —	K13
4 —	K5
5 —	K12
6 —	K4
7 —	K11
8 —	K3
9 —	K10
10 —	K2
11 —	K9
12 —	K1
13 —	K7
14 —	K8

Fig. 1—Simple half-wave power supply turns on each cathode through 13 spst switches. About 160 volts dc is on the anode.

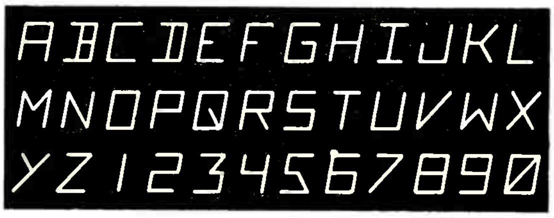


Fig. 2—Above are the cathode segments that are used to display both numbers and alphabet letters.

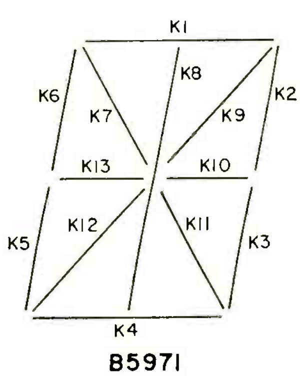


Fig. 3—Diagram of the Nixie cathodes that correspond to front-panel switch numbers used by author.

PARTS LIST

C1—16μF. 250 V electrolytic capacitor
D1—1N4819 diode rectifier
R1—6800 ohms, 2 watts, carbon resistor
S1–S141—spst switches
V1—B5971 Nixie tube
Misc: Socket for tube; case; line cord & plug; terminal strips

and the necessity of using costly driver circuits. This circuit is simple to build, requires a minimum of parts, is fun to use, and the display is unusual and fascinating. **R-E**

COMING NEXT MONTH

Getting the car ready for the warmer months ahead? The April issue is loaded with automobile projects and features you'll have to read.

- **Sequential Tail Light For Your Car.** Simple solid-state unit you can put together in a couple of spare evenings. Make your car distinctive.

- **Electronic Ignition System.** A you-build-it setup that will put extra zip in your car's performance. Easy to put together too.

- **What's New In Automotive Electronics.** Expert rundown of the latest electronic additions to the new cars. They make them run better, faster, safer.

KO COLOR FAULTS QUICK

Boosted voltages and added color functions put high-voltage circuits high on the trouble list

By MATTHEW MANDL

CONTRIBUTING EDITOR

AS WITH BLACK-AND-WHITE SETS, THE horizontal output and high-voltage section of color TV ranks high as a trouble source.

In color sets these circuits have additional tasks: focus voltage must be supplied, the system must be linked with convergence-correction circuitry, and because of critical voltage values, regulation must be included. Often, too, the boosted voltage gets an additional boost. Thus, for proper operation there are three critical elements: close-tolerance parts, close drive and voltage adjustments and adequate tubes or transistors.

In troubleshooting and adjusting the horizontal output and HV systems, there are as many don'ts as do's. Here are some of the more important "do not" rules:

- Don't attempt voltage or waveform measurements at the anode of tube-type horizontal output tubes. (This is all right in some transistor sets.)
- Don't operate the set with the plate cap disconnected from the horizontal output tube, or the yoke disconnected.
- Don't operate the set with the damper tube or shunt regulator tube out of its socket.
- Don't put in a new horizontal oscillator tube after the set has been on for a while. The cool tube provides no drive for the output tube, and high currents in the output tube cause an overload and shorten tube life.
- Don't adjust the HV control without a meter test to observe HV changes.
- Don't adjust the horizontal efficiency coil without checking the manufacturer's recommendations.

Typical HV system

The variety of components and controls found in modern color receiver HV systems is shown in Fig. 1. In general, this (Sylvania DO8-2 chassis) is typical of most large-screen, tube-type color sets. The horizontal pulse waveform in the output transformer is stepped up by autotransformer windings and applied to the plate of the HV rectifier. A regulator tube shunts the HV system and maintains fairly constant voltage amplitude once the high voltage has been adjusted to the level required. If voltage increases above normal, the tube conducts more current (current shunt) and the increased load decreases voltage. D1 is a regulator limiting diode and permits electron flow toward the cathode only.

The damper tube not only eliminates transient oscillations set up by the pulsing of inductive circuits into resonance but rectifies the boost voltage. An additional diode rectifier (D2) is used for a *boosted-boost* output of 1100 volts. A stacked-selenium focus rectifier is used, though some sets use tube-focus rectifiers. Note the extremely high-value bleeder resistor, 66 megohms. Note also the high rating of some of the capacitors. The series 130-pF capacitor to the focus control must have at least a 6-kV rating. For the 0.001-μF coupling capacitor from the boosted boost, use a 2kV unit.

The horizontal efficiency control ties in with the damper and regulator circuitry, as shown in Fig. 1. If the set has been operating satisfactorily and suddenly developed some HV troubles, check tubes and components before adjusting this control. A misadjustment here could overload the horizontal output tube and materially shorten its life.

If the horizontal output tube, damper or regulator tube needs replacement, some adjustments may be necessary to the efficiency coil for best horizontal output tube operation. This should be done only as detailed in the service notes for the receiver. Generally, proper adjustment requires reading cathode current in the horizontal output tube and setting the efficiency control for the 10 mA or 12 mA specified by the manufacturer. The HV is then measured and the HV control adjusted for the 25 kV (or other value) specified.

The boosted-boost voltage shown in Fig. 1 is applied to the red-, blue- and green-screen controls (Fig. 2). The controls permit adjustment—around a 600-volt range—of the potentials on the screen grids of the

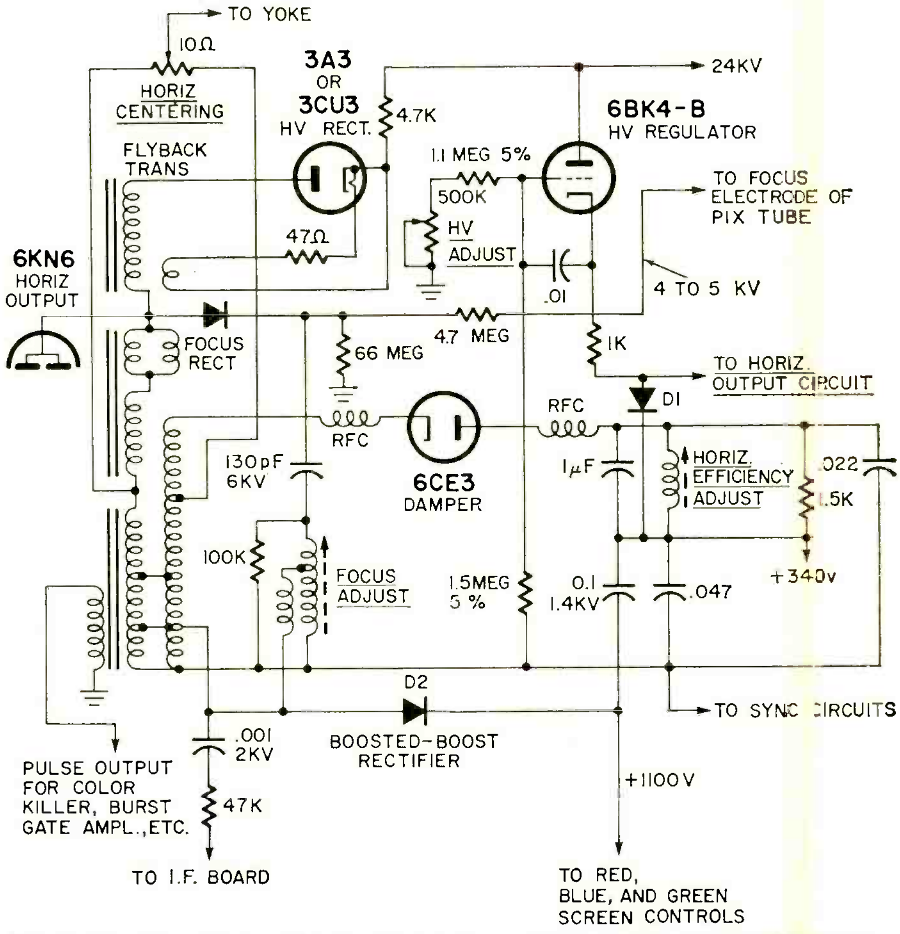


Fig. 1—Function of h-v and horizontal circuits are shown on Sylvania's DO8-2 chassis.

color picture tube. The high boosted voltages shown emphasize the necessity for starting voltage readings on the high scales of your vtvm or vom.

A quick check for control function is to read the voltage at a particular screen grid while rotating the associated control. If there is no voltage variation (or no voltage) the associated control may be defective.

Small-screen color

Because of the lower voltage requirements, the HV systems in smaller-screen color sets are not as complex. Typical is the circuitry shown in Fig. 3, used in the G-E chassis G-1. Note that no separate focus rectifier is used. Instead, five high-value resistors are used as a bleeder to drop the second-anode

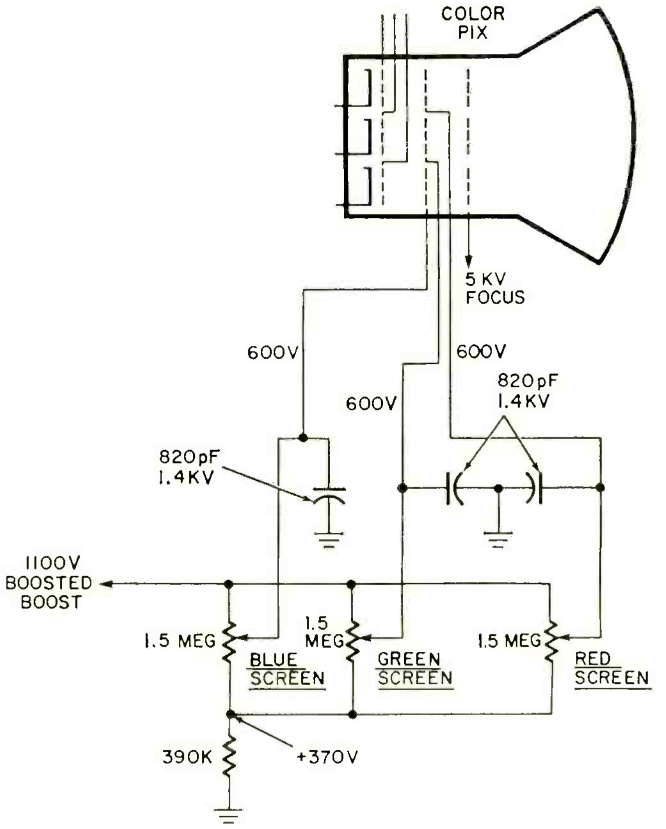


Fig. 2—Boosted-boost voltage is applied to red-, blue- and green CRT screens through screen controls that permit voltage adjustments in the 600-volt range.

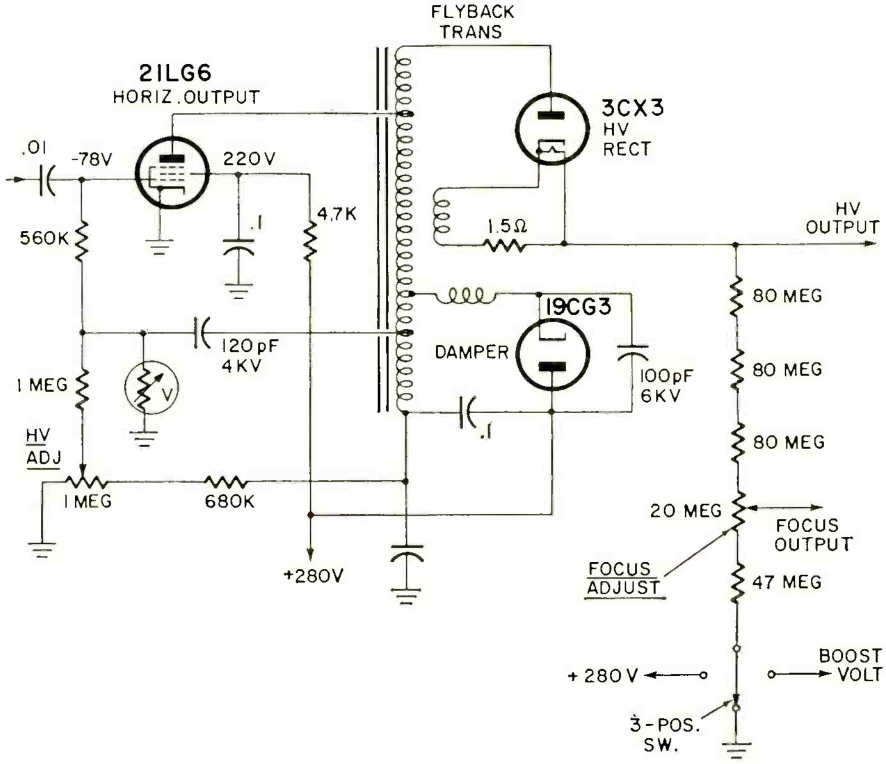


Fig. 3—Smaller-screen color sets like this G-E 15" G-1 chassis may not use a focus rectifier. Five high-value resistors and a 3-position tap are used instead.

picture-tube voltage to that required for the focus electrode. A 20-megohm potentiometer is used for the focus adjusting control. If good focus is beyond the range of this control, reset the three-position tap shown. One position picks up the boost voltage, the other approximately 280 volts.

Instead of a voltage regulator, a varistor is used in the grid circuit of the output tube to help stabilize voltages. The HV control affects bias on the horizontal output tube, and hence changes conduction. Again, an improper setting can overload the output tube and shorten its life. A HV probe should be in place on the HV line while this control is adjusted.

If high voltages are normal, but the horizontal output tube is short-lived, check grid and screen voltages. Improper screen-grid voltages call for a test of the bypass capacitor and the 4700-ohm resistor. Weak horizontal output and damper tubes could, of course, cut down the high voltage.

An item often overlooked is ac line voltage in the home. The service technician should be suspicious if the set acts up in the home but is ok in the shop. When tubes age and parts change value slightly, a drop in line voltage can cause decreased contrast, poor brightness and even some sync instability. Low line voltages are usually caused by excessive current consumption in the home—air-conditioners in summer or heating equipment in winter. If the condition is constant, the power company should be notified so it can correct it.

Excessive line voltage is more dangerous to the horizontal output and HV systems of color sets than to b-w because it increases drive to a dangerous level, raises filament voltage on the rectifier tube and causes HV arcing. If the line voltage is higher than normal, check to see if there is a tap on the power transformer. As shown in Fig. 4, such a tap is often provided to compensate for excessive line voltage. The tap, however, should be used only if you are sure the high line voltage is a permanent condition in the area.

Curing snivets

In early sets the horizontal output tube would go into Barkhausen-type self-oscillation and produce bar interference on the screen. Most modern horizontal output tubes are designed to minimize this effect, which is caused by the abrupt plate current cutoff and electron bounce around the highly positive screen grid. On occasion, however, you'll run across bar interference at the right of the screen, as shown in Fig. 5.

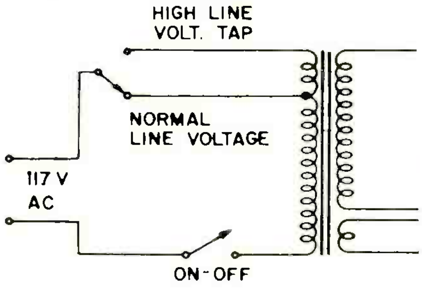


Fig. 4—High line voltage problems can often be corrected with transformer tap.

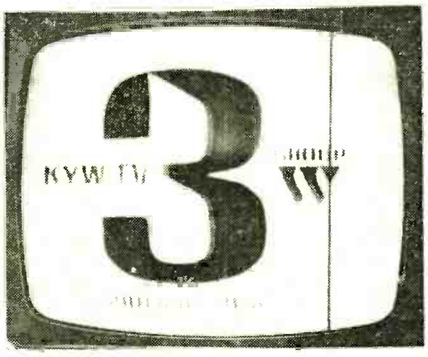


Fig. 5—A snivet (sharp vertical bar) caused by interference oscillations.

The vertical bar may be sharply defined or have fuzzy sides, and may be present for only some stations. On strong signals the bar may become white, while on weak stations it may appear as two or three broken black vertical lines. Such bars are called *snivets* and also appear on channels where no station is present. They are usually to the right of center.

For snivets at the right of the screen, try a slight adjustment of the horizontal efficiency coil. Measure the cathode current of the horizontal output tube and adjust the coil for a dip, then advance it slowly to about 10 mA. Recheck for snivets on all channels. Also try slight readjustments of the high voltage.

For persistent snivets, try a new horizontal output tube, even if it checks out all right on a tube checker. Sometimes a change in brightness and contrast control settings will affect snivet formation, since there is some affect on circuit loading. Also check the position of the short length of twin-lead from the antenna terminals to the tuner. Move this lead away from any HV leads or circuits. Similarly, change the position of the built-in antenna if one is used, and check performance with rabbit ears moved away from receiver.

If you've cured the snivets on the vhf channels, better check uhf reception too, since they are sometimes more frequent there. **R-E**

How to

Soup Up Low-Quality Speakers

by **CHARLES ANTHONY**

EXPERIMENTING WITH SPEAKER CHARacteristics is no longer limited to speaker manufacturers. You too can tailor speakers to fit enclosures and amplifier response.

Start at the bottom of the price range—where a little improvement can be heard easily. Don't expect fantastic improvement in audio quality from hi-fi speaker systems or higher-priced speakers. Manufacturers have worked on the better speakers and speaker systems for a long time. If there were any reasonable ways to improve their quality, you can be sure manufacturers would have made those changes for you.

Also don't expect much improvement in sound by altering those 2- and 3-inch flat-cone speakers in the pocket-sized portables.

But where you can really make a noticeable improvement—something that you can hear, not find with frequency response checks—is in the speakers that manufacturers use in low-priced table radios, television sets and automobile radios.

Many auto-radio speakers need replacement because they are mounted facing up through the top of the dashboard. Face up, the speakers collect a great deal of dust and grit, which filters down through the speaker's felt disk. There isn't much clearance between the voice coil and the pole piece of the permanent magnet (Fig. 1). So a little dirt can quickly go a long way toward making the audio output scratchy and raspy.

Keep the dust out

Although the felt disk keeps out the larger dust and grit particles, tiny particles sift through. It's easy to see what's needed is something less "open." Whatever is used will have to be lightweight. If it is too heavy the speaker cone will not be able to move freely and frequency response will be severely limited.

A combination of light weight and strength can be obtained from a disk cut from a ping-pong ball. Don't try to cut the ball with a knife—it's not easy! But you can do the job easily and neatly with the pencil tip of a hot soldering iron.

With the ping-pong ball cut in half along the seam, you can easily trim the thin plastic with scissors to make it fit the diameter of the voice coil (after you remove the felt disk). The section cut from the ping-pong ball should be slightly larger than the diameter of the coil.

Sealing the voice coil to prevent dust and grit from entering gives an unexpected bonus. The seal across the center of the cone completes a sealed chamber as shown in Fig. 2. This sealed chamber is much like the double-action shock absorber used to take the jouncing out of automobile rides. Sealed chambers are not new to hi-fi speaker systems, but few audiophiles would consider using an enclosure that wasn't sealed.

Making the sealed enclosure part of the speaker rather than the cabinet gives you some of the benefits of a sealed enclosure while maintaining ventilation in an open cabinet. Make sure that the section cut from the ping-pong ball is cemented fully to the voice coil. Any gaps will reduce the effectiveness of the sealed chamber.

Many speaker repair troubles occur with cementing. Never use a cement that becomes rigid when it dries. For cementing rips in a paper cone it is best to use paper cement—a translucent white rubber cement. It will not dry and stiffen and will not shrink or otherwise distort the paper cone. Remember, all the cement has to do is to stop the edges of the tear from rubbing together—you don't need a patch over a rip or puncture in the cone.

To cement the ping-pong ball to the voice coil you can use Pliobond or most contact cements.

If you have doubts about the cement, test it before you put it on a

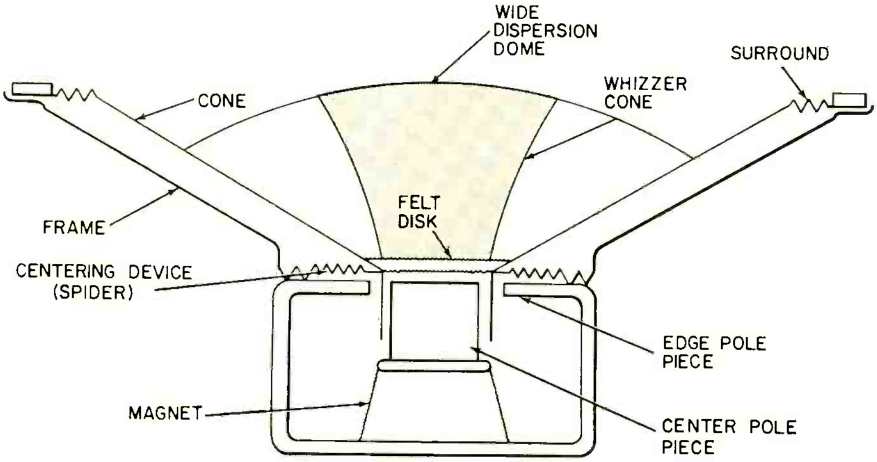


Fig. 1—Low-cost speakers like this can lose fidelity when grit particles sift through the felt disk, obstructing the pole piece. A paper whizzer cone improves treble response, and a wide-dispersion dome added will disperse high frequency sounds.

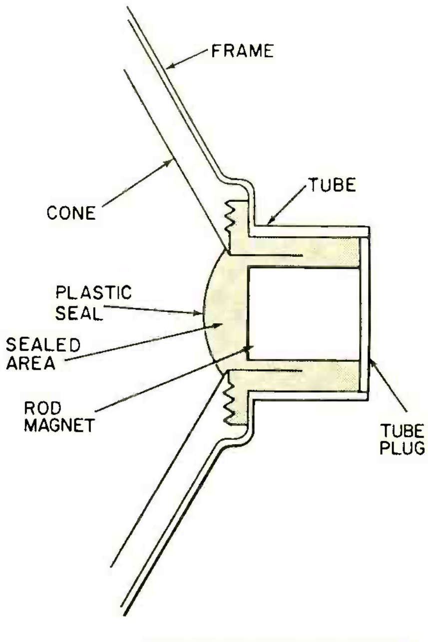


Fig. 2—A plastic ping-pong ball can be used to seal the voice coil and protect it from dirt. Sealed area is also an acoustic "shock absorber," aiding fidelity.

speaker cone. Spread some of the cement on a piece of construction paper. Squeeze out some cement in the form of a line and a circle. These three shapes will certainly show up any shrinkage or distortion caused by the cement.

Apply a little cement to the edges of the plastic dome and to the rim of the voice coil. Follow the instructions of the cement manufacturer.

As soon as the plastic dome is in place, invert the speaker and place it cone *down* in some safe place where the cement can dry. (Left face up the cement might run down between the voice coil and pole piece.)

Better bass

Bass response from these speakers can be improved by increasing their compliance. By making it easier for the cone to move, the fundamental resonance of the speaker is lowered and there is less chance of frequency doubling in the speaker and cabinet.

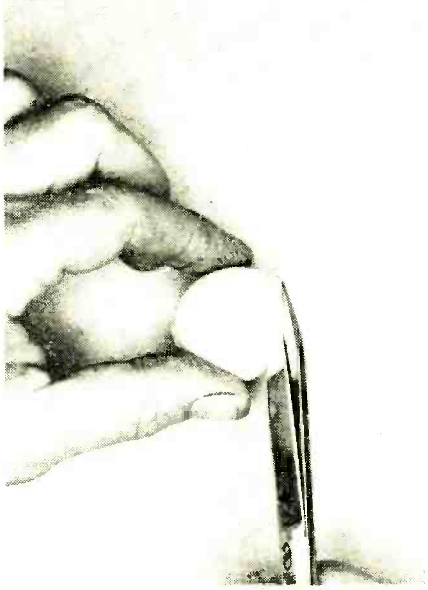
The easiest way to improve compliance is to reduce the stiffness of the surround holding the cone to the frame. If there is less corrugated paper in the surround, the cone will move with less resistance.

Using a very hot soldering iron, burn out as much of the surround as you want, but do the job symmetrically. This will keep the cone centered. Start burning where the paper has been overlapped and cemented to form the basic cone.

Some audio experimenters claim the spaces in the surround simulate the port in the bass reflex enclosure. Others feel the improved compliance is an explanation for more bass response. No matter which theory is correct, the bass response is improved.

Add a whizzer

You'll find whizzer cones on the medium-priced speakers—generally on 8-inch and larger sizes. But you can add your own whizzer made from a paper cone. Just roll a sheet of construction paper into a cone. Run a thin strip of cement from the peak of the cone to the base. Then snip off the point of the cone to fit the diameter of the voice coil, and trim the base of the cone to the proper height. Be sure to keep the overlap (down the side of the cone) to a minimum to keep its weight down.



Cut ping-pong ball in half with hot soldering iron, then trim to cover voice coil.

That's about all you can do with paper. Special shapes have to be light and strong, and about the only way to make them is with a vacuum-forming process.

It's not too expensive to make your own preforms. All you need for the smaller shapes is a toy appropriately called *Vac-U-form* (made by Mattel) that sells for under $15. You get a small supply of plastic material with the *Vac-U-form*, but you can buy additional plastic sheets.

You'll need shaped master forms —something that will let the plastic shrink around it to give the sealed dome. whizzer cone or wide dispersion dome most suitable for your speakers.

Generally a lathe is needed to turn these forms to your specifications. Sometimes you'll be able to find manufactured items that have shapes close to what you need. With a little luck you can pick up items from the toy counter or housefurnishings department that will give you nicely curved forms for exponential whizzers, rigid wide-dispersion domes, sealed domes and other shapes that are almost impossible to create with paper.

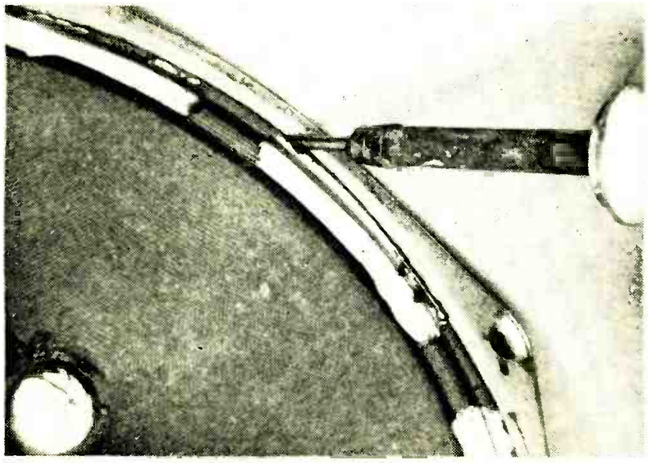
Usually tweeters are constructed with wide-dispersion domes since a normal-shaped cone concentrates the treble in the area directly in front of the speaker. Bass notes are less directive and the wide-dispersion dome spreads the sound better.

A wide-dispersion dome can be combined with a whizzer cone to give the benefits of both the increased high-frequency response and the spreading of treble tones. Simply cement a wide dispersion dome to the open end of the whizzer cone as shown in Fig. 1. Note that the dome is cemented only to the whizzer cone. Do not cement the dome to the speaker cone.

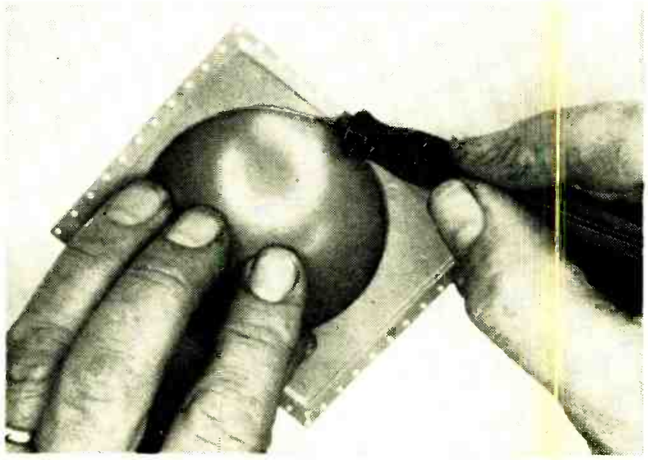
It doesn't take a lot of money for better sound if you're not content with the sound passed on to you in a manufacturer's latest mass-produced model. And you don't need a lot of expensive test equipment—let your ear be the judge. **R-E**

A set of basic preforms to fit the common ⅝-inch voice coil may be purchased for $2.00 from Carlson Electronics, P.O. Box 151, Cocoa, Fla. 32922. The set includes two wide-dispersion domes, two whizzer cones and two voice-coil dome sealers. Special shapes and sizes can be made to order.

Boost bass response by burning away part of surround paper holding cone to frame. This increases compliance of the speaker.



Wide-dispersion domes like this can be made in a toy vacuum-forming machine. Trim excess plastic and glue to the cone.



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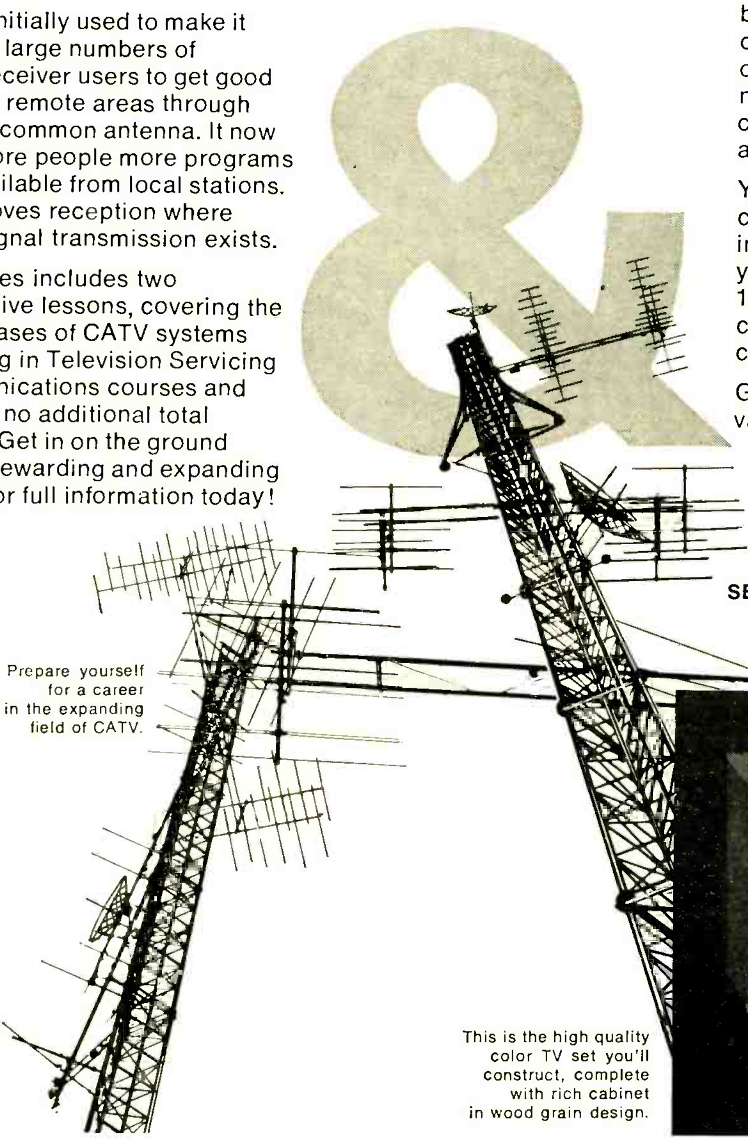

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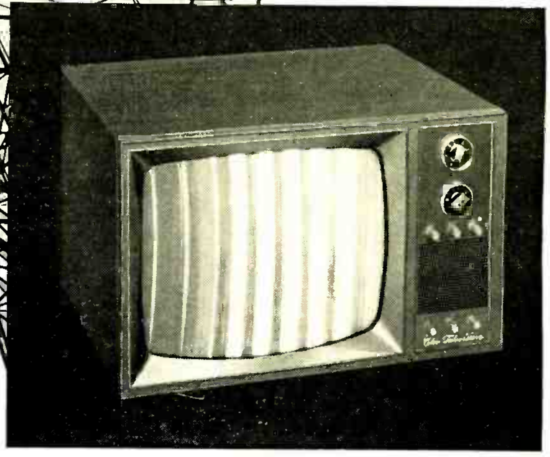


This is the high quality color TV set you'll construct, complete with rich cabinet in wood grain design.

EQUIPMENT REPORT

Scott LR88 Solid State AM-FM Stereo Receiver Kit

For manufacturer's literature, circle No. 27 on Reader Service Card.

HAVING BUILT A SCOTT LT110 FM tuner some years ago, I knew what to expect upon opening the LR88 carton. I was not disappointed. The carton contains three KIT-PAK® molded expanded polystyrene trays consisting of a base tray and two parts trays. Larger components such as the power transformer and the sheet metal parts are packaged in the base tray, while the parts trays are subdivided into a number of small compartments holding all the smaller components.

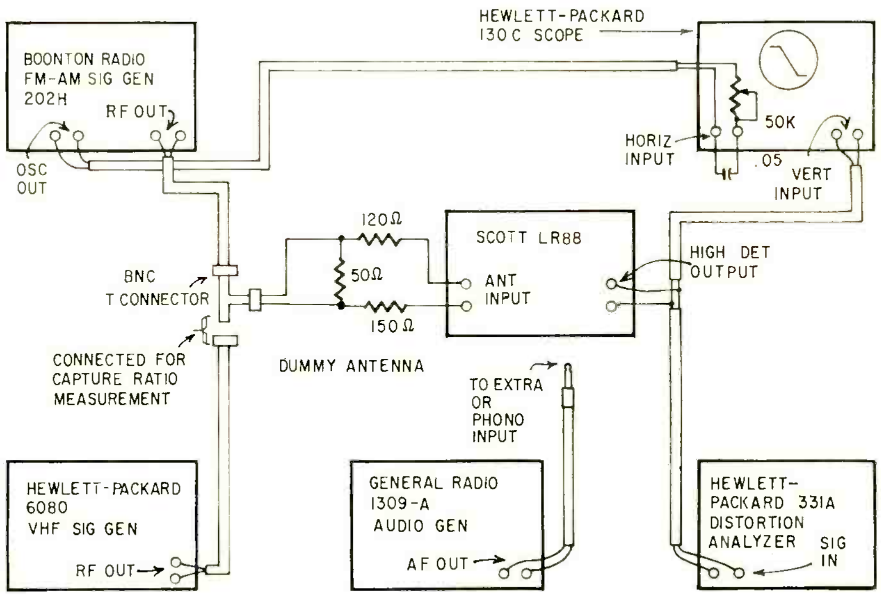
These compartments are opened sequentially, minimizing the possibility of using the wrong component in any one step, eliminating the need of sorting through a large number of components, and reducing the chance of losing small parts during storage times between construction installments. The trays along with a 152-page well-illustrated instruction book, makes this a Cadillac of electronic construction kits. When completed, the receiver has a professional, factory finished appearance and is mechanically solid.

As pointed out by a friend with considerable audio design experience; "There was a time when high fidelity was an art. Today with the advent of sophisticated semiconductor technology, the majority of equipment in the medium price bracket performs with an excellence of the best equipment of a few years ago." Performance-wise the LR88 rates high in its price bracket.

Kit construction begins with mechanical and electrical assembly of the rear chassis. The audio output transistors, input connectors, output terminal strips, ac line cord, preamp gain switch, and ac outlets have been premounted on the rear chassis—indicative of the amount of mechanical assembly done by the manufacturer throughout. While the wires are pre-cut and the ends stripped, I trimmed a number of wires up to an inch shorter. Shortening the wires probably did not result in any increase in performance, nor should be taken as a recommendation, but resulted in a somewhat neater wiring job.

Convenient double-check pictorials showing the number of soldered and unsoldered connections at each component terminal are included. These pictorials appear after each major construction group, and are referred back to upon kit completion. Thanks to very clear instructions I encountered no wiring errors.

The input switch is then wired followed by mechanical and electrical assembly of the tuner chassis. The latter includes mounting and wiring to the multiplex, power supply regulator, and i.f. amplifier printed circuit boards, which like all the remaining boards were completely preassembled. Preassembly of the PC boards should result in a high percentage of kits operating properly at initial turn-on. As indicated on an addendum sheet, some changes in the printed circuit board layouts may be found. As there are some discrepancies in the location of some wire connection points, carefully determine which hole in a cluster



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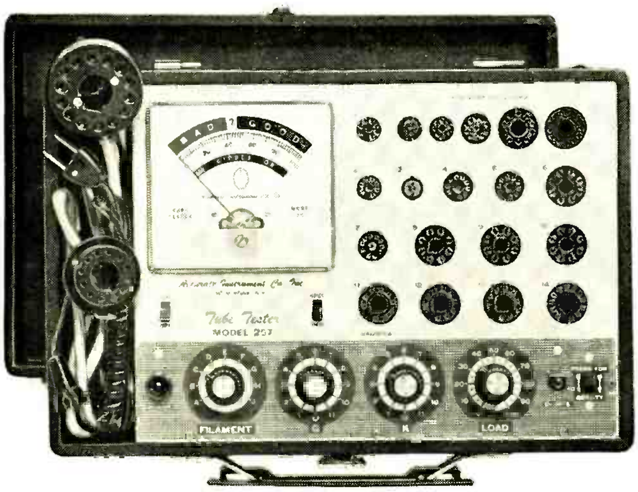

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is the one through which the wire should be inserted. Otherwise, a component lead may accidentally be pushed out by the inserted wire, as happened to me at one such point. The tone control driver board is then installed and partially wired. Solderless connectors are used almost exclusively on this board, greatly reducing the kit builder's strife. I also found they facilitated troubleshooting the audio output stages later on.

The front and main chassis construction is completed followed by the final lamp socket, front panel, dial cord, and AM antenna installation.

Testing the receiver

Scott has gone to the trouble of installing a test switch which puts one of the ac outlets on the rear chassis in series with the power transformer primary winding. A 15-watt lamp is screwed into a lamp socket and plugged into this outlet. It provides a visual indication of excessive ac line current, and protects the receiver from damage. In addition, the series lamp enables measuring power supply voltages using the signal strength meter under reduced voltage conditions.

As an experienced kit builder, I was frankly tempted to skip the formalities, plug the receiver in with the test switch in the normal operating position and turn it on. I am very glad I resisted, since the bright lamp indicated there was a short causing excessive primary transformer current. I traced the trouble to a piece of wire under one of the output transistors, shorting the above-ground collector to the chassis. The short must have occurred when the transistor was installed by the manufacturer. This particular problem may or may not have been found by the inexperienced kit builder who follows the troubleshooting chart. Step 11 in the chart checks for wire scrap near the output transistors, and step 12 checks for proper transistor installation with particular note of the mica insulating washers. In any event the test procedure proved extremely valuable, and prevents the grief of burned-up transistors, blown fuses, and the like. While troubleshooting I discovered an error in the output transistor portion of the schematic which Scott has probably found and corrected by this time.

Adjustment and alignment

After the light bulb test, full ac line voltage is applied, the power amplifier bias adjusted, and the power supply voltages checked at their operating levels. The amplifiers, input switch, and function switch are

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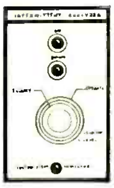

In fact, it's the only one that locates all vector inputs and controls on the front panel. Which is simply for your convenience. (Something for which oscilloscopes have not been noted.)

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checked by injecting hum at various input jacks. The signal strength meter is adjusted, followed by adjustment of the FM noise muting and stereo threshold circuits. Following Scott's adjustment procedure results in some weak stereo stations being received in the stereo mode resulting in an objectionably high noise level. I found it desirable to increase the stereo threshold slightly so that the weaker stereo stations are received in the mono mode with the corresponding 23 db increase in signal to noise ratio.

Next is the FM front end and i.f. alignment. One problem encountered during this procedure was that binding coil slugs combined with torsional give in the supplied alignment tool made some adjustments difficult to optimize.

Dial cord calibration was performed using an on-the-air signal. The optional FM tuner alignment was carried out with no discernible improvement in performance. The AM alignment was not done as the manual points out the improvement over the factory prealignment would be slight. Also using this receiver for AM reception seems a terrible waste.—*Steven H. Leckerts* R-E

DISTORTION

With an rf input of 1100 mV (strong signal condition) at 95 MHz, a frequency deviation of 75 KHz with a modulation frequency of 400 Hz, total harmonic distortion measured to be 1.1%. (THD was reduced to 0.7% by adjusting the discriminator transformer.) (A part of this distortion may have been produced by the alignment generator.—Editor)

RECOVERED AUDIO

With the rf input as above, the recovered audio at the high detector output is 150 mV rms.

SENSITIVITY

With the rf input as above, modulation is removed and the signal reduced until the detected output is reduced 30 dB. The rf input level at this point is 5 μV (300 ohm input, corresponds to 2.5 μV into 75 ohms).

CAPTURE RATIO

The capture ratio was measured at the tape output connector after the 75-μsec de emphasis network. With two rf generators on the same frequency, the desired signal is reduced to cause the detected signal to be reduced by 1 dB. The additional signal reduction necessary to reduce the tape output an additional 30 dB is measured. This change of 5 dB divided by two gives a capture ratio of 2.5 dB.

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generate

The RCA WR-50B RF Signal Generator with sweep features is versatile, portable, and exceptionally well suited for alignment and signal tracing of AM, FM, hi-fi and citizen's band receivers and trouble-shooting in nearly all sections of TV receivers. IT'S ONLY $65.00.* Also available in an easy to assemble kit, WR-50B(K).

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The RCA WP-700A and WP-702A Power Supplies are extremely reliable, solid-state, constant voltage DC power supplies that provide 0 to 20 volts dc at current levels up to 200mA. WP-702A is actually identical to WP-700A, except it is a dual unit with two complete power supply sections. WP-700A IS ONLY $40.00* in quantities over five, and WP-702A IS ONLY $73.00* in quantities over five. Prices on less than five units are $48.00* and $87.00* respectively.

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The RCA WR-99A Crystal-Calibrated Marker Generator combines in one compact, accurate, and stable instrument the functions of a multiple-marker generator, crystal calibrator and a heterodyne frequency meter. Ideal for servicing and aligning color and black and white TV receivers, communications and other equipment in the frequency range of 19 to 260 MHz ONLY $256.50.*

*Optional Distributor resale price.

For a complete catalog of descriptions and specifications for all RCA test equipment see your RCA Test Equipment distributor or write RCA Electronic Components, Commercial Engineering, Department No. C-39W, Harrison, N. J. 07029.

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RCA

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EQUIPMENT REPORT

Heathkit SB-310 Shortwave Receiver

For manufacturer's literature, circle No. 26 on Reader Service Card.

HEATHKIT SEEMS TO TURN OUT REGularly kits that match or outperform similar assembled units at several times their price. With the SB-310 shortwave receiver, they've obviously done it again.

The 310 is a nine-band, nine-tube, dual-conversion superhet receiver that, as purchased, uses 13 crystals and a $73 "linear master oscillator" to deliver outstanding stability and performance. Six of the nine international shortwave bands are covered —49, 41, 31, 25, 19 and 16 meters. (An optional kit, replacing the 11-meter CB band, covers 13 meters and the 15-meter amateur band.) Amateur band coverage is on 80, 40 and 20 meters.

With the AM crystal filter supplied, reception is possible on AM, CW and upper SSB. Three accessory crystal filters sharpen CW and SSB selectivity, and an additional bfo crystal included with the SSB filters extends coverage to lower SSB.

A PRESELECTOR control tunes both grid and plate circuits of rf amplifier V1 (in conjunction with switch-selected antenna coils) to the proper frequency. It is quickly adjusted by tuning for maximum noise or signal.

Next the signal is coupled to the grid of first mixer V2, and combined with the crystal-controlled output of oscillator V4. An oscillator crystal and coil combination is switched into the plate and grid circuits of V4 with the BAND selector.

Sum and difference frequency outputs of V4 are filtered by pass-band coupler T2, which passes only 8.395–8.895-MHz frequencies.

Tuning is handled at the second conversion stage, V3, where the signal output of T2 is beat with the output of a "linear master oscillator" (LMO).

The LMO is a sealed, prealigned unit. V5's output can be varied from 5–5.5 MHz with the tuning dial, which adjusts a linear permeability-tuned coil in the grid circuit. LMO frequency output is the difference between the signal from filter T2 and the receiver's 3.395-MHz second i.f.

Selectivity in the 310 is the result of three crystal filters, to which the i.f. output of V3 is sent. The basic kit is supplied with a filter for AM only. Other filters offering sharper selectivity can be purchased separately for CW and SSB reception. Bandwidth of the AM is 5 kHz at −6 dB and 15 kHz at −60 dB. An accessory CW filter has a 400-Hz width at −6 dB and 2-kHz width at −60 dB. A "standard" filter for SSB is 2.1 kHz at −6 dB and 7 kHz at −60 dB, and a "deluxe" filter is 2.1 kHz at −6 dB and 5 kHz at −60 dB.

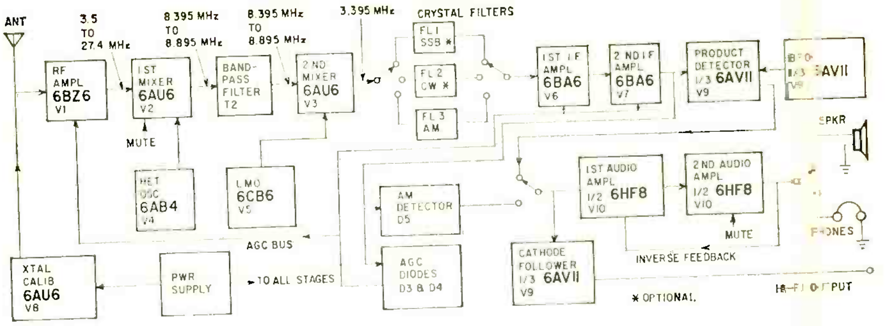
After filtering, the i.f. signal is amplified by V6 and V7. A front-panel meter, marked in S-units and decibels, is connected between these stages, and calibrated initially to zero with the antenna removed. A noise-limiter circuit (two diodes, two capacitors) is included in the plate circuit of V7, and is activated by pulling out the A.F. GAIN knob. The limiter is a self-biasing type, so its limiting point varies as the signal level rises and falls.

Automatic gain control voltage varies the gain of rf amplifier V1 and i.f. amplifiers V6 and V7. A front-panel AGC switch varies the control time of this voltage with "slow" and "fast" settings.

Triple triode V9 is used as a product detector in the single-sideband and CW modes, a beat-frequency oscillator (bfo), and a cathode follower for a low-impedance connection to a hi-fi amplifier. Oscillation frequency of the bfo is determined by the position of the MODE switch: in the LSB (lower sideband) position it is 3393.6 kHz and in USB (upper sideband) 3396.4 kHz.

In all but the AM mode of reception, the i.f. and bfo frequencies are mixed in the product detector portion of V9. The output of V9 is fed to a two-stage audio amplifier, V10. During AM reception, the bfo is off and the i.f. signal is detected by a diode prior to af amplification.

The 310 is calibrated through V8, a crystal-controlled 100-kHz oscillator. Alignment of the calibrator calls for adjusting the oscillator to time station WWV.



The 310 went together in about 22 hours. The two PC boards (i.f. and rf) included can be prepared very quickly. There are 21 coil–capacitor combinations to be prepared for connection to the main band-selector switch. (The coils are shielded from stray fields by a metal cover on top of the chassis.) Connecting crystals and coils to the selector switch requires care; I discovered two wiring errors during a final check before turning the receiver on.

Biggest challenge is attaching the circular dial to the LMO with its dial pointer arm, drive pulleys and dial window. When the combination is aligned, a nylon pointer attached to the dial-pointer drive arm tracks in a spiral groove behind the calibrated dial, and the dial pointer travels smoothly from 0 to 5, indicating the position of the LMO in 1-MHz steps.

Once the dial assembly was properly aligned, I found the 310 offered excellent accuracy, stability, sensitivity and selectivity. Reception was impressive even with the simplest of antennas: an indoor antenna consisting of a length of wire. On all bands that were tested, dial calibration indicated an accuracy of ±1 kHz. (When shifting from one band to another, the zero hair line in the dial window can be adjusted slightly with a small knob while zero beating with the 100-kHz calibrator.)

I first put the 310 through its paces during a period of high solar activity, and consequently the shortwave bands were crackling with action. The receiver's excellent selectivity and image rejection were demonstrated at several crowded points on some bands: a series of six to eight stations were often tuned at 5-kHz separation without interference between them.

In addition to providing excellent selectivity, the receiver's crystal filter shape factor of 3 provides good fidelity to AM signals.

A meter with high input impedance is the only equipment needed to set up the 310. It is used to peak the 21 heterodyne-oscillator, antenna and rf coils.—*John R. Free* **R-E**

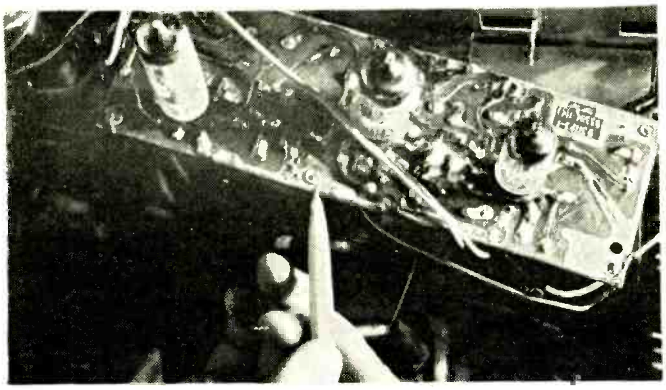
Manufacturer's Specifications

Frequency range (MHZ): 3.5–4, 5.7–6.2, 7.0–7.5, 9.5–10.0, 11.5–12.0, 14.0–14.5, 15.0–15.5, 17.5–18.0, 26.9–27.4. I.f.: 3.395 MHz. Frequency stability: Less than 100-Hz drift after 20 minutes warmup, and for ±10% line-voltage change. Sensitivity: less than 0.3 μV for 10 dB signal-plus-noise to noise ratio (SSB). Gain: Less than 1.75 μV for ½-watt audio output (SSB). Selectivity: AM: 5.0 kHz at 6 dB down, 15 kHz at 60 dB down. Image rejection: 60 dB or better. I.F. rejection: 40 dB or better. Spurious response: all below 1 μV equivalent signal input except at 10.0, 15.375 and 27.1 MHz. Dial accuracy: within 400 Hz (electrical), 200 Hz (visual). Dial backlash: less than 50 Hz. Antenna input impedance 50 ohms nominal unbalanced.

TECHNOTES

INTERMITTENT SOUND

We had an RCA KCS-97 chassis come in with intermittent sound. Slight pressure on the sound i.f. and audio printed circuit board caused the sound to come and go. A close inspection of the board did not reveal any possible cause for the trouble. Broken capacitors in the ratio detector can have been known to cause the same symptoms so we replaced the transformer. The intermittent remained.

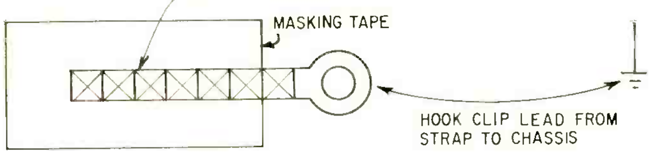


Checking the board more closely, we found one of the grounding eyelets was not making good contact with the printed circuit. A good hot soldering iron and a little rosin flux on the eyelet cured the intermittent.—*Homer L. Davidson*

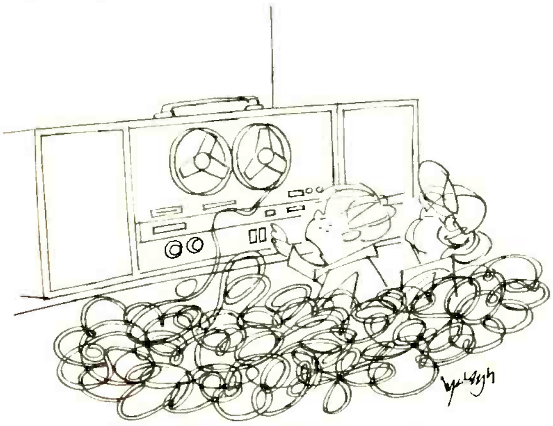
GROUND THAT PIX TUBE

It is very important that you ground the picture tube Aquadag coating when troubleshooting any chassis which has been removed from its cabinet.

In addition to the uncomfortable shock hazard, there is the possibility of erroneous voltage readings throughout the chassis. Also, the static voltage spikes which appear on the ungrounded Aquadag coating can harm some components—especially transistors. Picture size and appearance may also be affected.



A practical grounding device is shown in the drawing. Apply a wide piece of masking tape over a length of flat braided ground strap. After pressing it against the CRT Aquadag, connect a clip lead between the braid and chassis.
—*Sylvania Service Notebook* **R-E**



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SWEEP/MARKER GENERATOR, *SM-152,* combines a vhf/uhf sweep and a crystal controlled marker generator. Designed to reduce alignment generator costs and to simplify color TV alignment. Provides 10-920 MHz linear sweep for all

TV and FM work; sweep width from 0.3-15 MHz. Pushbutton selection for i.f. or rf markers. Chroma and i.f. alignment is within 47.25 MHz range. Delivers rf video carrier on channels 4, 5, 10 and 13. Features post marker injection on all markers. $349.50.—**Sencore Inc.**

Circle 46 on reader service card

STEREO HEADPHONE, *Model SP-55,* has two 2½" transducers, and soft foam rubber ear pads. Sensitivity, less than 2 mW; response, 30-15,000 Hz; impedance, 8 ohms. Has junction box for sets without

phone jack and 5" cord with standard phone plug. $11.95.—**Lafayette Radio Electronics Corp.**

Circle 47 on reader service card

STEREO RECEIVER, *TK-140x,* 200-watt, FM/AM, solid state, features a front-end section with 4-gang tuning capacitor, 3 FET's and 4 IC i.f. circuits. Sensitivity, 1.7 mV. Image rejection, cross modulation and i.f. rejection better than 100 dB. Alternate channel selectivity 45 dB. Harmonic distortion less than 0.5% at 400 Hz, 100% modulated signal. Includes 2 output terminals, 2-

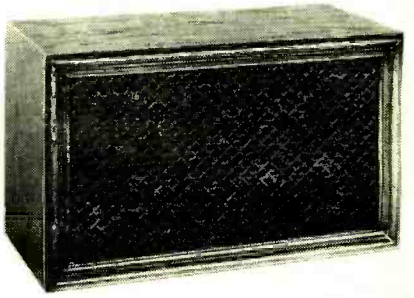
channel preamp outputs, main amplifier inputs, electronic protection circuit and silicon power transistors. $319.95.—**Kenwood Electronics Inc.**

Circle 48 on reader service card

CB TRANSCEIVER, *"Royal,"* 23 channel, solid-state, provides high selectivity with outside interference rejection. Features a full-time range-expand and speech compressor and modulation sampler to adjust input to a proper audio level. Also includes hybrid ceramic filter, hand-wired and hand-soldered circuitry. Supplied with built-in 12 V transistor power supply for mobile operation. $279. —**Courier Communications Inc.**

Circle 49 on reader service card

BOOKSHELF SPEAKER SYSTEM, AS-48, the damped reflex, tube ported 8-ohm system uses a 14" woofer with an 11½ lb. magnet assembly and a 4" copper ribbon voice coil in conjunction with a



2" radiator tweeter to handle up to 50 watts of program material. LC crossover network for 2000 Hz and wiring of hi-fi level control are completed before installation. $169.95, kit.—**Heath Co.**

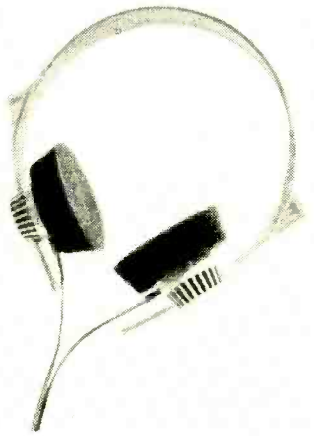
Circle 50 on reader service card

HI-FI MAINTENANCE KIT, *"The Parastat,"* is designed for use on new records to be played with cartridges requiring

tracking pressures of less than 2 grams. After applying the chemical fluid (supplied) the fine nylon bristle brush (1/10 gram) against the surface of the disc gets into and cleans the minute high-frequency waveform grooves. With a pressure of only 1/10 gram any dirt in the grooves is removed. $15.—Elpa Marketing Industries Inc.

Circle 51 on reader service card

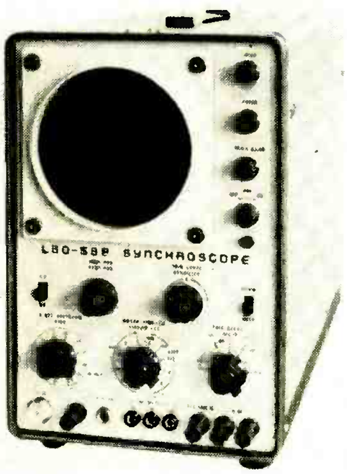
STEREO HEADPHONE, *Model HD-414, Open-Aire,* eliminates the need for closed cavities on either side of the earpiece diaphragms, and for air-tight seals against the user's ears. Without dis-



tortion, sound reproduced from 20 to 20,000 Hz. Low power requirements of voice coils permit direct connection to either low-impedance amplifiers or high-impedance outputs such as tape decks. $28.50.—Sennheiser Electronic Corp.

Circle 52 on reader service card

TRIGGERED SCOPE, *Model LBO-5SB,* powered by 115 V @ 60 Hz 150 VA, is designed for a wide range of applications in audio, radio and pulse circuit development, waveform observation and voltage measurements. Features a frequency



response from dc to 5MHz with a rise time of 80 nanoseconds. Vertical sensitivity: 10 mV/cm, horizontal sweep speed: 1 μsec/cm maximum with a 5X sweep magnifier. $299 includes 1 probe, 10:1 stepdown and 1 terminal adapter.—Leader Instruments Corp.

Circle 53 on reader service card

INSTRUMENT AMPLIFIERS. *Model Pro* features 3 inputs and a 12" Jensen speaker ($69.95). *Model Realistic* (pho-

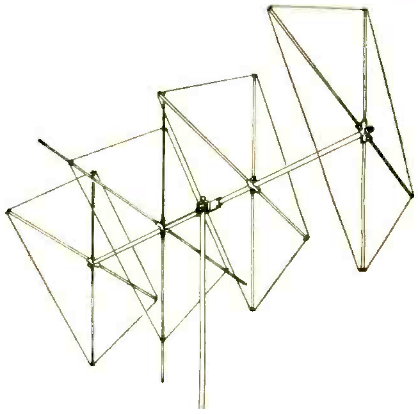
Circle 110 on reader service card

to), 20 watts, has a 15" speaker and two inputs, plus volume, bass and treble controls ($119.95). Dual-channel model, 65 watts, has 4 inputs and two 12"

Jensen speakers ($159.95). All housed in sturdy wood cabinets and covered with black vinyl. 117 Vac circuitry is fused with a power-on pilot light and on/off switch.—**Radio Shack**

Circle 54 on reader service card

CB CUBICAL ANTENNA has extended aperture elements and selectable polarity. A 3-position switch permits selecting horizontal, vertical or omnidirectional antenna. Boom diameter, 2"; boom



length, 20'; wind survival, 90 mph; front-to-back ratio, 38.7 dB; forward gain, 18 dB; SWR at resonance, 1.24:1; 52-ohm coax feedline. $149.50.—**Hy-gain Electronics Corp.**

Circle 55 on reader service card

CB TRANSCEIVER, *Courier 23,* for either base-station or mobile operation.

Features 23 crystal-controlled channels; dual conversion; built-in 12-V transistor power supply; single-knob tuning; illuminated S–rf meter and channel selector; PA system; adjustable noise limiter; covered plug-in relay and squelch. $189. —**Courier Communications Inc.**

Circle 56 on reader service card

ELECTRONIC MUSICAL INSTRUMENT, *Tunesmith*, has 32 standard organ size keys and provides melody with accompaniment from any keyboard instrument. Delivers six different voices, real pitch-change vibrato variable from

nothing to a warble. Draws only 3 watts of power for its solid-state circuitry and can be plugged into any guitar or hi-fi stereo amplifier for sound production. $189.50, assembled; $149.50, kit.—**The Schober Organ Corp.**

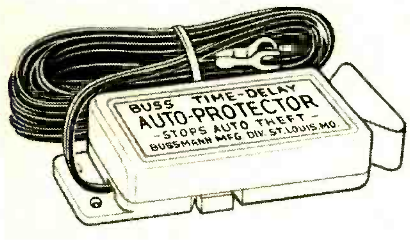
Circle 57 on reader service card

CB TRANSCEIVER, *Model GT-523*, solid-state, 23-channel unit is designed for mobile applications. Operates on a standard 12-14 volt dc source. Has a minimum transmitter output of 3 watts from 5 watt input. Sensitivity: less than

1 μV for 10 dB S + N/N at 1,000 cycles. Modulation: 30%. Transmitter frequency accuracy ±0.005 max. $189 with coil-cord mike, mobile mounting bracket and synthesized crystal circuitry for all 23 channels.—**Regency Electronics Inc.**

Circle 58 on reader service card

AUTO PROTECTOR makes vehicle with 6 or 12 volt systems thief-proof after



installation. Conceal unit in location with space for operation and pass cable

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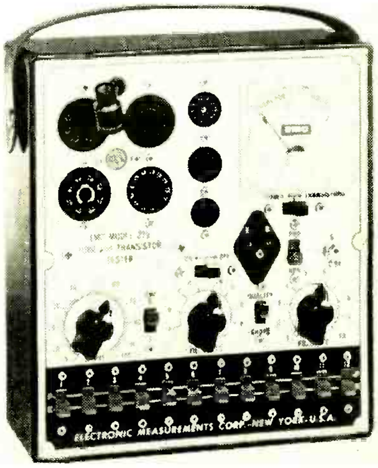
Circle 116 on reader service card

Circle 100 on reader service card

through convenient hole into engine compartment. Pull out control knob when you leave car. If car is started without resetting motor will stop in about 1 minute. Car will operate normally when owner returns and resets device. $4.98. Extra Fusetron fuses available.—**Bussmann Mfg. Div., McGraw-Edison Co.**

Circle 59 on reader service card

TUBE AND TRANSISTOR TESTER, *Model 215,* checks over 2000 current tubes—7 to 10-pin tubes, compactrons, magnavols, nuvistors, etc. Also pnp and npn high and low power transistors for



ac amplification. Read-out on 3-color meter scale. Housed in rugged, portable, high-impact bakelite case with carrying strap. $27.95, kit; $42.95 factory-wired and tested.—**Electronic Measurement Corp.**

Circle 60 on reader service card

TREASURE FINDER, *Model GB-1A,* pinpoints a 12" long, ½" dia. rod at 12". Device is on when the headset is connected. Probe is 42" long, with electronics and batteries at one end. Headset

emits a constant low frequency tone. When probe nears a magnetic object, tone changes to a high-pitched squeal. Useful for treasure hunters, surveyors or police departments. $595.—**Schonstedt Instrument Co.** R-E

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NEW LITERATURE

All booklets, catalogs, charts, data sheets and other literature listed here with a Reader Service number are free for the asking. Turn to the Reader Service Card facing page 78 and circle the numbers of the items you want. Then detach and mail the card. No postage required!

ILLUMINATED SWITCHES, snap-in mounting, push-button and matching indicator lights complete with data, drawings and ordering information for 513 Series momentary- and alternate-action switches are outlined with diagrams in 12-page *Catalog L-209*. Push-button caps described available in 5/8" round and square, and 3/4" x 1" rectangular. Indicator lights may be used as companion or independent switches.—**Dialight Corp.**

Circle 76 on reader service card

LOUDSPEAKERS in the Concert and Viking Series as well as Concert-Vibranto line of electronic musical instruments are illustrated in 16-page *Catalog 1090-C*. New items include waterproofed automotive stereo speaker, *Model C5T8*, and flame-retardant aircraft speaker, *Model C8TS* (C8800). Specs and prices listed.—**The Muter Co., Jensen Mfg. Div.**

Circle 77 on reader service card

PHOTOCELL-LAMP MODULES. Loose individual data sheets on each of these are included in catalog entitled *Photomods*. Specs and technical data are given together with diagrams and charts. The four types of modules offered are for 6-volt, 12-volt, low current and neon lamps. —**Clairex Electronics Inc.**

Circle 78 on reader service card

SOLDERLESS TERMINALS AND CONNECTORS plus noninsulated and insulated single grip, insulated bell-mouth single and double grips, various styles of quick connectors and adapters ranging from 6-22 AWG are shown in actual size in colorful "wall catalog" which permits easy selection of correct style to other applications. Hand-operated attaching tools and miscellaneous connectors and tubing are also displayed.—**Vaco Products Co.**

Circle 79 on reader service card

ELECTRIC POWER TOOLS and soldering guns, industrially rated for professional as well as home craftsmen are illustrated and described in 16-page *Catalog No. 158*. Also included are tool performance characteristics, power tool applications, accessories, multi-speed sabre saws and many others.—**Wen Products Inc.**

Circle 80 on reader service card

GUIDE TO RELAY BUYING. 12 pages, covers information on trade-offs in relay selection, showing many cost saving practices. Also included is a relay ordering checklist designed to answer most of the basic questions asked in fitting a relay to a particular application.—**Cornell-Dubilier Electronics**

Circle 81 on reader service card

POWER SUPPLIES Instruments and systems for laboratory, test equipment and OEM applications are fully described in 56-page catalog. Complete specs and prices for over 300 models of power supplies, including the company's new COMPAK Mark II™ line of IC power supplies and systems, plus the industry's first power supply assembly system using standard components and accessories supplied preassembled ready to plug into a customer's system.—**Lambda Electronics Corp.**

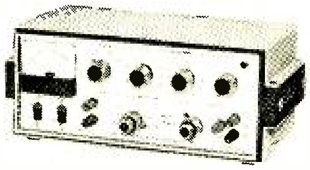
Circle 82 on reader service card

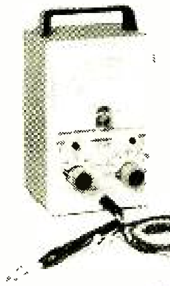
ELECTROLYTIC REPLACEMENT GUIDE, 68 pages, provides service technicians a handy reference for locating all kinds of electrolytic capacitor replacements. Cross reference sections including Color-Lytic, OEM numbers of 42 color set manufacturers to CDE Catalog numbers; other manufacturers to CDE numbers; and OEM numbers of major black/white set manufacturers to CDE numbers. Also a complete listing by voltage of CDE's tubular capacitors.—**Cornell-Dubilier Electronics** **R-E**

Circle 83 on reader service card

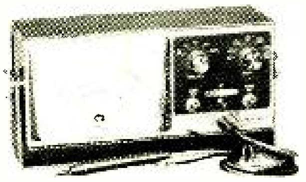
"Performance-Plus" Kits For Shop And

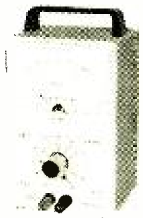
NEW
kit IG-18
$67.50
wired IGW-18
$99.50





kit IM-18
$28.50
wired IMW-18
$47.95

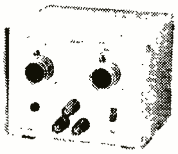




kit IM-13
$36.50
wired IMW-28
$56.95

kit IM-38
$39.50
wired IMW-38
$54.95

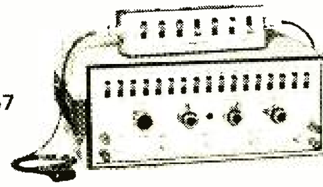
kit IP-18
$19.95

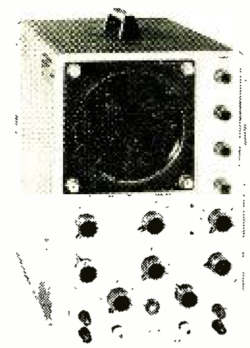


kit IT-18
$24.95

kit IM-17
$21.95

kit IG-57
$135.00
wired IGW-57
$199.00





kit IO-18
$84.95
wired IOW-18
$139.95

HEATHKIT IG-18 Solid-State Sine-Square Wave Generator

A precision source of sine or square waves at a low kit price . . . that's the new solid-state IG-18 from Heath. Delivers 5% accuracy thru the wide range of 1 Hz to 100 kHz. The sine wave section features less than 0.1% distortion thru the audio range, 8 output voltage ranges from 0.003 to 10V, switch-selected internal 600 ohm load or external load and metered output of both voltage & dB. The square wave section has a 50 nS rise time and three output voltage ranges from 0.1 to 10 V P-P. Both sine & square waves are available simultaneously and the frequency is switch-selected for constant repeatability and fast operation. Circuit board construction makes the new IG-18 easy to build . . . new Heathkit styling and engineering excellence make it easy to use. Put the new IG-18 on your bench now. 10 lbs.

HEATHKIT IM-18 VTVM

The new Heathkit IM-18 continues the features that made the IM-11 famous . . . 7 AC and 7 DC voltage ranges that measure from 0-1500 volts full scale . . . 7 ohms ranges for measurements from 0.1 ohm to 1000 megohms . . . the convenience of a single probe . . . 11 megohm input impedance . . . ± 1 dB 25 Hz to 1 MHz response . . . precision 1% resistors . . . DC polarity reversing position on the function switch . . . RMS & P-P AC voltage and dB measurement capability . . . precision 4½", 200 uA meter for extra sensitivity. In addition, the new IM-18 has 120 V. or 240 V. AC wiring options, new Heathkit styling and a 3-wire line cord for safety. 5 lbs.

HEATHKIT IM-13 "Service Bench" VTVM

The Heathkit IM-13 has the same performance specifications as the new IM-18 above, but it also incorporates other features that put it in a class by itself, such as a large, easy-to-read 6" meter . . . extra 1.5 and 5 volt AC ranges for additional accuracy . . . convenient gimbal mounting that allows attachment to your most convenient surface . . . "Set and Forget" calibration — all controls are adjustable from the front panel with a screwdriver . . . smooth ten-turn vernier control of Zero and Ohms adjust for greater accuracy and easier setting . . . clean, open parts layout and a readily accessible "ohms" battery. Assembly is easy, thanks to the famous Heathkit manual, and operating convenience and versatility are tops. For maximum value in a general service VTVM, you just can't beat the Heathkit IM-13. 7 lbs.

HEATHKIT IM-38 Laboratory AC VTVM

For all around general service work, audio design or laboratory analysis, there isn't a better value than the new Heathkit IM-38 AC VTVM. Here's why — 10 voltage ranges measure from 0.01 to 300 volts RMS full scale . . . extended frequency response of 10 Hz to 500 kHz at ± 1 dB . . . 10 megohm input on all ranges for higher accuracy . . . . wide —52 to +52 dB range . . . VU-type ballistic meter damping . . . very low AC noise . . . 120 or 240 VAC wiring options and new Heathkit styling in sharp beige & brown with an easy-to-grasp, easy-to-read knob. 5 lbs.

HEATHKIT IP-18 1-15 VDC Power Supply

If you work with transistors, this is the power supply for you. All solid-state circuitry provides 1-15 VDC at up to 500 mA continuous. Features adjustable current limiting, voltage regulation, floating output for either + or — ground, AC or DC programming, circuit board construction, and small, compact size. 110 or 220 VAC. 5 lbs.

HEATHKIT IT-18 In-Circuit Transistor Tester

In-Circuit transistor testers don't have to be expensive, and the IT-18 is proof of that . . . . tests DC Beta 2-1000, in or out-of-circuit . . . leakage Icbo and Iceo current 0-5000 uA out-of-circuit . . . identifies NPN or PNP devices . . . tests diodes in or out-of-circuit for opens & shorts . . . identifies unknown diode leads . . . matches PNP & NPN transistors. The IT-18 is completely portable — runs on just one "D" cell. Easy to use too . . . rugged polypropylene case, attached 3' test leads, big 4½" 200 uA meter, all front panel controls, 10-turn calibrate control. 4 lbs.

HEATHKIT IM-17 Solid-State Volt-Ohm Meter

Another very popular volt-ohmmeter from Heathkit engineering and it's easy to see why — all solid-state circuitry . . . high impedance FET input, 11 megohms on DC, 1 megohm on AC . . . 4 AC voltage ranges . . . 4 DC voltage ranges . . . 4 ohm ranges . . . 4½" 200 uA meter . . . 3 built-in test leads . . . DC polarity reversing switch . . . zero-adjust & ohms-adjust controls . . . continuous 12-position function switch. And that's not all — the IM -17 is battery powered for complete portability and comes in a rugged polypropylene case with built-in handle. Simple circuit board assembly. 4 lbs.

HEATHKIT IG-57 Solid-State Post Marker/Sweep Generator

The new IG-57 plus a 'scope is all you need . . . no external sweep generator required. Switch selection of any of 15 crystal-controlled marker frequencies (you can view up to six different frequencies on one 'scope trace). Select the sweep range and you are ready to instantly see the results of any changes you make. Four markers for setting color bandpass, one for TV sound, eight at IF frequencies between 39.75 & 47.25 MHz plus picture and sound carrier markers for channels 4 & 10. Three sweep oscillators produce the 5 most-used ranges . . . color bandpass, FM IF, color & B&W IF and VHF channels 4 & 10. Save hundreds of dollars and put full alignment facilities in your shop too — order your IG-57 now. 14 lbs. **Kit IG-14**, same as IG-57 w/o the sweep, 11 lbs. **$99.95.**

HEATHKIT IO-18 Wide-Band 5" 'Scope

The New Heathkit IO-18 is destined to be the world's most popular 'scope, just as its predecessor, the IO-12 was. Features 5 MHz bandwidth, the famous Heath patented sweep circuit — 10 Hz to 500 kHz in 5 ranges, two extra sweep positions which can be preset to often-used rates, frequency compensated vertical attenuation, built-in P-P calibration reference, Z-axis input, retrace blanking, wiring options for 120 or 240 VAC operation and new Heathkit styling in beige and brown. 24 lbs.

Home . . . From The Leader

HEATHKIT

Now There are 4 Heathkit Color TV's . . . All With 2-Year Picture Tube Warranty

NEW Deluxe "681" Color TV With Automatic Fine Tuning

The new Heathkit GR-681 is the most advanced color TV on the market. A strong claim, but easy to prove. Compare the "681" against every other TV — there isn't one available for any price that has all these features. Automatic Fine Tuning on all 83 channels . . . just push a button and the factory assembled solid-state circuit takes over to automatically tune the best color picture in the industry. Push another front-panel button and the VHF channel selector rotates until you reach the desired station, automatically. Built-in cable-type remote control that allows you to turn the "681" on and off and change VHF channels without moving from your chair. Or add the optional GRA-681-6 Wireless Remote Control described below. A bridge-type low voltage power supply for superior regulation; high & low AC taps are provided to insure that the picture transmitted exactly fits the "681" screen. Automatic degaussing, 2-speed transistor UHF tuner, hi-fi sound output, two VHF antenna inputs . . . plus the built-in self-servicing aids that are standard on all Heathkit color TV's but can't be bought on any other set for any price . . . plus all the features of the famous "295" below. Compare the "681" against the others . . . and be convinced.

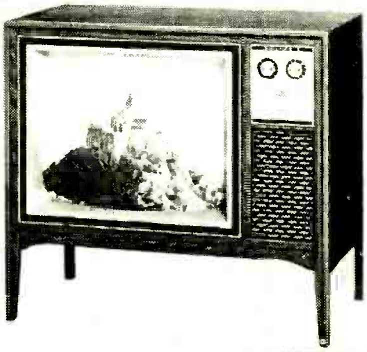
GRA-295-4, Mediterranean cabinet shown **$119.50**
Other cabinets from $62.95

kit GR-681
$499.95
(less cabinet)

Deluxe "295" Color TV . . . Model GR-295

Big, Bold, Beautiful . . . and packed with features. Top quality American brand color tube with 295 sq. in. viewing area . . . new improved phosphors and low voltage supply with boosted B + for brighter, livelier color . . . automatic degaussing . . . exclusive Heath Magna-Shield . . . Automatic Color Control & Automatic Gain Control for color purity, and flutter-free pictures under all conditions . . . preassembled IF strip with 3 stages instead of the usual two . . . deluxe VHF tuner with "memory" fine tuning . . . three-way installation — wall, custom or any of the beautiful Heath factory assembled cabinets. Add to that the unique Heathkit self-servicing features like the built-in dot generator and full color photos in the comprehensive manual that let you set-up, converge and maintain the best color picture at all times, and can save you up to $200 over the life of your set in service calls. For the best color picture around, order your "295" now.

GRA-295-1, Walnut cabinet shown **$62.95**
Other cabinets from $99.95



kit GR-295
now only
$449.95
(less cabinet)

Deluxe "227" Color TV . . . Model GR-227

Has same high performance features and built-in servicing facilities as the GR-295, except for 227 sq. inch viewing area. The vertical swing-out chassis makes for fast, easy servicing and installation. The dynamic convergence control board can be placed so that it is easily accessible anytime you wish to "touch-up" the picture.

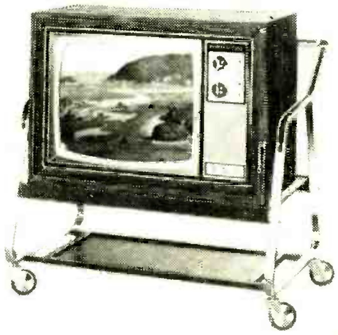
GRA-227-1, Walnut cabinet shown **$59.95**
Mediterranean style also available at $99.50

kit GR-227
now only
$399.95
(less cabinet)

Deluxe "180" Color TV . . . Model GR-180

Same high performance features and exclusive self-servicing facilities as the GR-295 except for 180 sq. inch viewing area. Feature for feature the Heathkit "180" is your best buy in deluxe color TV viewing . . . tubes alone list for over $245. For extra savings, extra beauty and convenience, add the table model cabinet and mobile cart.

GRS-180-5, table model cabinet and cart **$39.95**
Other cabinets from $24.95



kit GR-180
now only
$349.95
(less cabinet)

Now, Wireless Remote Control For Heathkit Color TV's

Control your Heathkit Color TV from your easy chair, turn it on and off, change VHF channels, volume, color and tint, all by sonic remote control. No cables cluttering the room . . . the handheld transmitter is all electronic, powered by a small 9 v. battery, housed in a small, smartly styled beige plastic case. The receiver contains an integrated circuit and a meter for adjustment ease. Installation is easy even in older Heathkit color TV's thanks to circuit board wiring harness construction. For greater TV enjoyment, order yours now.

kit GRA-681-6, 7 lbs., for Heathkit GR-681 Color TV's **$59.95**
kit GRA-295-6, 9 lbs., for Heathkit GR-295 & GR-25 TV's **$69.95**
kit GRA-227-6, 9 lbs., for Heathkit GR-227 & GR-180 TV's **$69.95**

New Wireless TV Remote Control
For GR-295, GR-227 & GR-180
$69.95

New Wireless TV Remote Control
For GR-681
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Prices & specifications subject to change without notice. CL-353

Circle 119 on reader service card

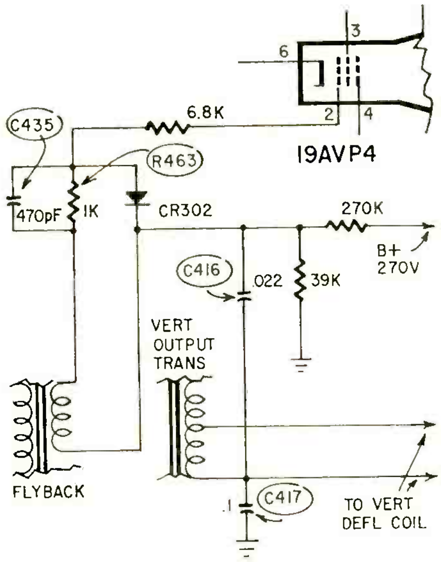
Service Clinic

By JACK DARR
SERVICE EDITOR

Horizontal shading in raster

I've a TV defect I've never seen before. In an Admiral 19A3 portable, the picture is "faded" from left to right! One side of the screen is almost entirely dark, there's an area in the center that shades from light to dark, and the vertical retrace lines show, but cut off very sharply in the center of the screen!—J. C., Berlin, N. Y.

If this shading was vertical—that is, if you had horizontal hum bars on



the screen, where would you look? Right—into something that was letting 60-Hz signals get into the video or sweep. You've got the equivalent of this, but your shading is horizontal; if broken into bars, they'd be vertical.

Something is letting *horizontal-frequency* ripple get into the picture. I'd check out all filter and bypass capacitors around the horizontal sweep circuits. Trouble in this chassis could also be due to an open-circuited C416 (0.022 μF), the retrace blanking capacitor that's connected from the vertical output transformer up to the control grid of the CRT through a resistor—diode network (see the diagram).

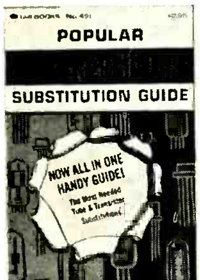
Since there is also a 0.1-μF bypass (C417) connected just below C416 at the feed point, this could upset the bypassing. This would allow some of the horizontal blanking pulses to be too great, by changing the time constant of the pulse-shaping network (R463–C435–CR302) which is fed from the flyback. R-E

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

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

At Last—An All-in-One Tube/Transistor Substitution Guide!

NOW—The most needed data for Tubes and Transistors all in one handy volume!



491—POPULAR TUBE & TRANSISTOR SUBSTITUTION GUIDE. Brand-New! No longer do you have to refer to one substitution manual for tubes and another for transistors—everything is here in one quick-reference guide. Designed to fit into a tiny slot in your tube caddy or on your workbench, this guide lists 99% of the tubes and transistors you'll ever need to replace. Moreover, only readily-available and comparably-priced substitutes are listed—no longer do you have to search through lists of tubes and transistors you'll rarely see in use, or search through pages of irrelevant material to find a substitute. Why buy a $10 switching transistor when a 98¢ popular type will do the job better? Contains 8 big sections—four devoted to tubes and four to transistors. You'll find this guide to be one of the most practical everyday aids you've ever used. It will enable you to repair many sets for which replacement tubes and transistors are not available. It will provide you with on-the-job substitutes so you can complete more repairs without waiting for exact replacements to arrive, or making extra trips to the distributor. Truly an all-in-one guidebook. **$2.95**

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493 — SEMICONDUCTORS From A to Z By Phillip Dahlen. Here it is — everything you need to know about semiconductors—from basic diodes and transistors to FETs, MOS FETs, tunnel diodes, integrated circuits, varicaps, photo-FETs, optic-electronic circuits, unijunction transistors, field-effect diodes, SCR and zener diodes, etc. Written in language anyone can understand, it explains how these various devices work and how they are used, with complete descriptions of all the common and unique circuits used in modern semiconductor technology. Considerable attention is given to integrated circuit applications—variable-current and constant-current sources, unbalanced differential amplifiers, IC applications in FM and TV receivers, TV sound circuits, discriminator circuits, and cascade amplifier networks. Several chapters are devoted to the new field of optic-electronic circuits, including uses for photovoltaic and photoconductive cells and a "needle-less" phono pickup. 256 pps., over 300 illus. **$4.95**

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How to Improve Your Efficiency in Using Modern Scopes

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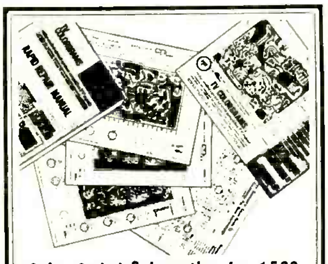

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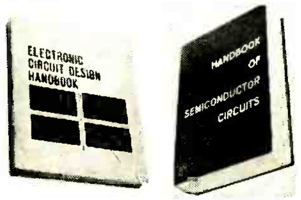

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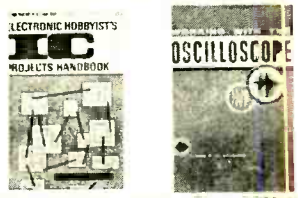

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The 2N5190–2N5195 form a series of npn/pnp complementary 4-amp plastic silicon power transistors with power handling capabilities to 35 watts. Pertinent ratings of the three complementary pairs (npn units are listed first) are

Type	V_{CEO}	h_{FE}*	f_T (min)
2N5190/ 2N5193	40 V	25/100	4 MHz
2N5191/ 2N5194	60 V	25/100	4 MHz
2N5192/ 2N5195	80 V	20/80	4 MHz

*$@I_C = 1.5A$

Additional data on these transistors are available from Motorola Semiconductor Products, PO Box 955, Phoenix, Ariz. 85001.

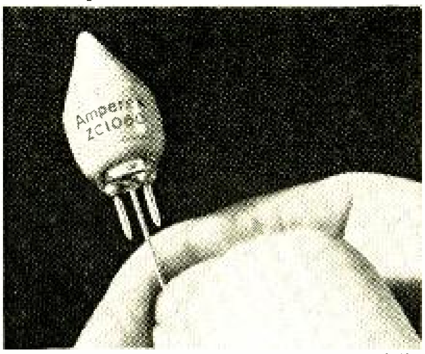
SUBMINIATURE TRIGGER TUBE

The new type ZC1060 subminiature trigger tube is a high-speed switching device that handles peak currents as high as 5000 amperes at 60 joules per discharge. It is developed for high-voltage switching ap-

SEMICONDUCTORS

plications such as flash-tube and laser-pump capacitor discharge circuits and in electrostatic and corona discharges where short ignition delay is important.

The required trigger waveform for this Amperex tube is a 30-μsec, 3.5-kV pulse at 400 to 500 kHz. Trig-



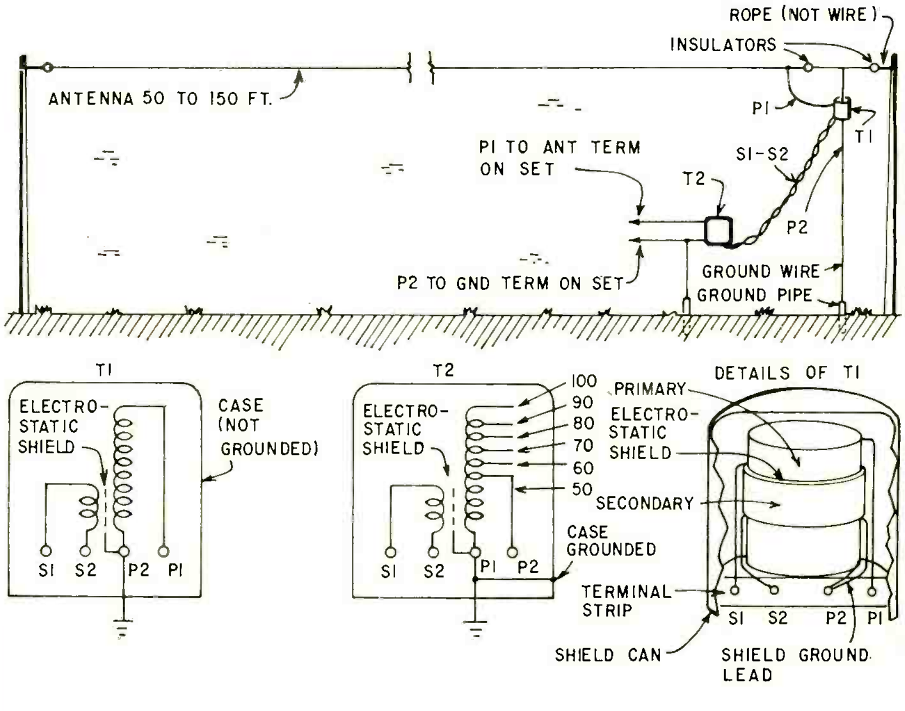
ger energy can be as low as 1 millijoule. At normal anode voltages—350 to 800 volts—maximum ignition delay is 2 μsec. Open-circuit impedance is 300 megohms. When conducting, impedance drops to 30 milliohms.

Further information on this device can be obtained by writing to Amperex Electronic Corp., Professional Tube Div., Hicksville, L.I., N.Y. 11802. **R-E**

NOTEWORTHY CIRCUIT

LOW-NOISE BROADCAST ANTENNA

A good outdoor antenna is essential to satisfactory AM broadcasting-band DX'ing. For most purposes, it may be a single-wire flat-top, as long and as high as practical. Man-made electrical interference is one of the major obstacles faced by the serious DX'er. Most of this comes from high-tension power lines, automobiles and industrial, commercial and domestic appliances. It is strongest close to the source and tapers off rapidly until it may not be objectionable a few hundred feet away.



For noise-free reception, the first step is to get the antenna as far as possible from noise sources. The second is to replace the most-often-used single-wire lead-in with a low-impedance balanced transmission line matched to the antenna and receiver by transformers. A low-noise broadcast antenna like this is shown in the diagrams, taken from *Electronics Australia*.

The lead-in is plastic-covered twisted-pair coupled to the antenna by T1 and to the receiver by T2. Both transformers are wound with No. 26 enameled wire on 2" diameter forms. For T1, wind the primary with 100 turns and mark the starting end P1 and the terminating end P2. Wrap with a single layer of insulating tape. Add an electrostatic shield made from thin brass 1" wide and just long enough to leave a ⅛" gap when wrapped around the center of the coil. Connect the shield to P2 and add another layer of tape. The secondary is 25 turns wrapped around the center of the shield. The starting end is S1, the other is S2.

Wind T2 with the 25-turn *primary* next to the form. Add the tape, electrostatic shield and then wind the 100-turn secondary. Tap the secondary at every tenth turn from the fiftieth on.

Transformer T1 should be waterproofed or saturated with coil dope and then mounted in a shield can at least twice the coil diameter. Mount it on the mast close to the antenna. Connect the end of the antenna to P1 and run a wire to ground from P2. Do not ground the shield can.

Mount T2 close to the receiver and connect P2 and P1 to the ANTENNA and GROUND terminals, respectively. Connect S1 and S2 to the lead-in. Tune in a weak station and try all the P1 taps to find the one giving the greatest deflection on a tuning indicator or a vtvm connected to the avc line. **R-E**

COMING NEXT MONTH

Learn how to design your own hi-fi stereo preamp around a differential amplifier IC in the April RADIO-ELECTRONICS. Engineer John Teeling puts the math into easily understood formulas, showing you how to design for playback equalization, bass and treble rolloff, and build a power supply.

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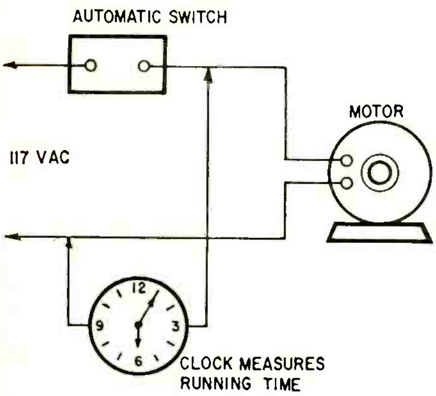
When Phillips screwdrivers wear to near-uselessness, extend their life by grinding away the flutes on two opposite sides, making a pointed single blade that still can be used efficiently for Phillips-head screws and bolts.—*Harry J. Miller*

CLOCK MEASURES RUNNING TIME

Anytime you have a need to measure the short-term running time of any device, such as an electric motor, which operates from the power line and goes on and off automatically, connect an ordinary self-starting electric clock across it. With this connection, when the motor starts, the clock will start and run; when the motor stops, the clock stops. If the clock is set at 12:00 initially, the po-



sition of the hands will thereafter indicate the running time directly in hours and minutes, up to 12 hours total (and then repeat). The clock in the illustration, for example, shows the total running time of the water pump to be 6 hours and 5 minutes. Make sure the voltage requirements of the clock and the motor are the same.—*Frank H. Tooker*

TEST SILICON DIODES FOR PIV

If you own or can borrow an Eico model 950 resistance–capacitance comparator bridge you can use it to determine the reverse breakdown voltage (up to 500 volts) of most silicon diodes.

Set the RANGE switch to PAPER–MICA TEST and the VOLTAGE control to zero. The remaining controls are not used.

Connect the diode's anode to the negative terminal, cathode to the positive terminal of the bridge. Starting from zero, increase the voltage until the eye of the electron-ray indicator tube closes. This is the approximate reverse breakdown voltage of the diode.

There is no danger of damaging diodes because the maximum current that can flow with the output short-circuited and the VOLTAGE control set to 500 is 600 μA. The eye closes completely when the diode circuit current is only 15 μA. Adding a 1-megohm resistor in series with the diode will limit short-circuit current to 160 μA.
—*Charles D. Rakes* R-E

SCHOOL DIRECTORY

NEW BOOKS

TRANSISTOR TV TRAINING COURSE, by Robert G. Middleton. *Howard W. Sams & Co., Inc., 4300 W. 62 St., Indianapolis, Ind. 46206. 8½ x 11 in., 128 pages, soft cover, $3.95.*

Fully illustrated with schematics, figures, graphs and scope waveforms, this addition to the author's growing list of publications in the service field offers a concise, 12-chapter discussion of TV circuits.

An introductory chapter analyzes transistors in TV circuit configurations and subsequent chapters cover each stage of TV receivers. One chapter briefly describes color circuits.

TRANSISTOR AUDIO AMPLIFIERS by D. V. Jones & R. F. Shea. *John Wiley & Sons Inc., 605 Third Ave., New York, N.Y. 10016. 9¼" x 6", 267 pages, hard cover, $9.95.*

This book covers the vast increase in the types of transistors and their applications. It can be used as a major tool in understanding the operation of transistors. Techniques include circuits for using FET's, obtaining transformerless operation and obtaining high impedance by feedback and bootstrap techniques.

FET PRINCIPLES, EXPERIMENTS, AND PROJECTS, by Edward M. Noll. *Howard W. Sams & Co., Inc., 4300 W. 62 St., Indianapolis, Ind. 46206. 5⅜ x 8½ in., soft cover, $4.95.*

Final three chapters of this nine-chapter book describe audio and timer projects. detector and tuner projects and radio-amateur projects. Earlier chapters cover FET (field-effect transistor) operating principles, and circuit design for good FET operation. A separate chapter is devoted to mathematics frequently used in FET design.

BENCH SERVICING MADE EASY, by Robert G. Middleton. *Howard W. Sams & Co., Inc., 4300 W. 62 St., Indianapolis, Ind. 46206. 5⅜ x 8½ in., 176 pages, $3.95.*

A bench servicing approach stressing careful preliminary analysis of symptoms and application of the correct troubleshooting approach. First chapter describes how to analyze symptoms accurately, the following nine chapters cover servicing techniques for each TV section and the last chapter tells how to tackle intermittent troubles.

FUNDAMENTALS OF INTEGRATED CIRCUITS by Lothar Stern. *Hayden Book Company Inc., 116 W. 14 St., New York, N.Y. 10011. 7" x 10", 176 pages, hard cover, $8.95.*

A basic guide to the complex technology of integrated circuits. Mathematics is kept to a minimum and charts, graphs and tables are used to illustrate key points. Separate sections cover semiconductor principles, semiconductor IC's and related components, compatible circuits, and packaging. **R-E**

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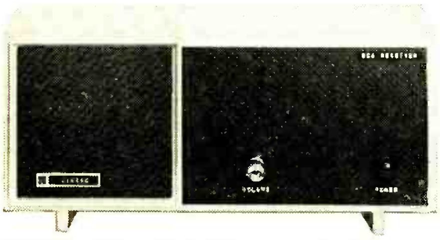

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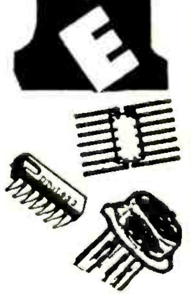

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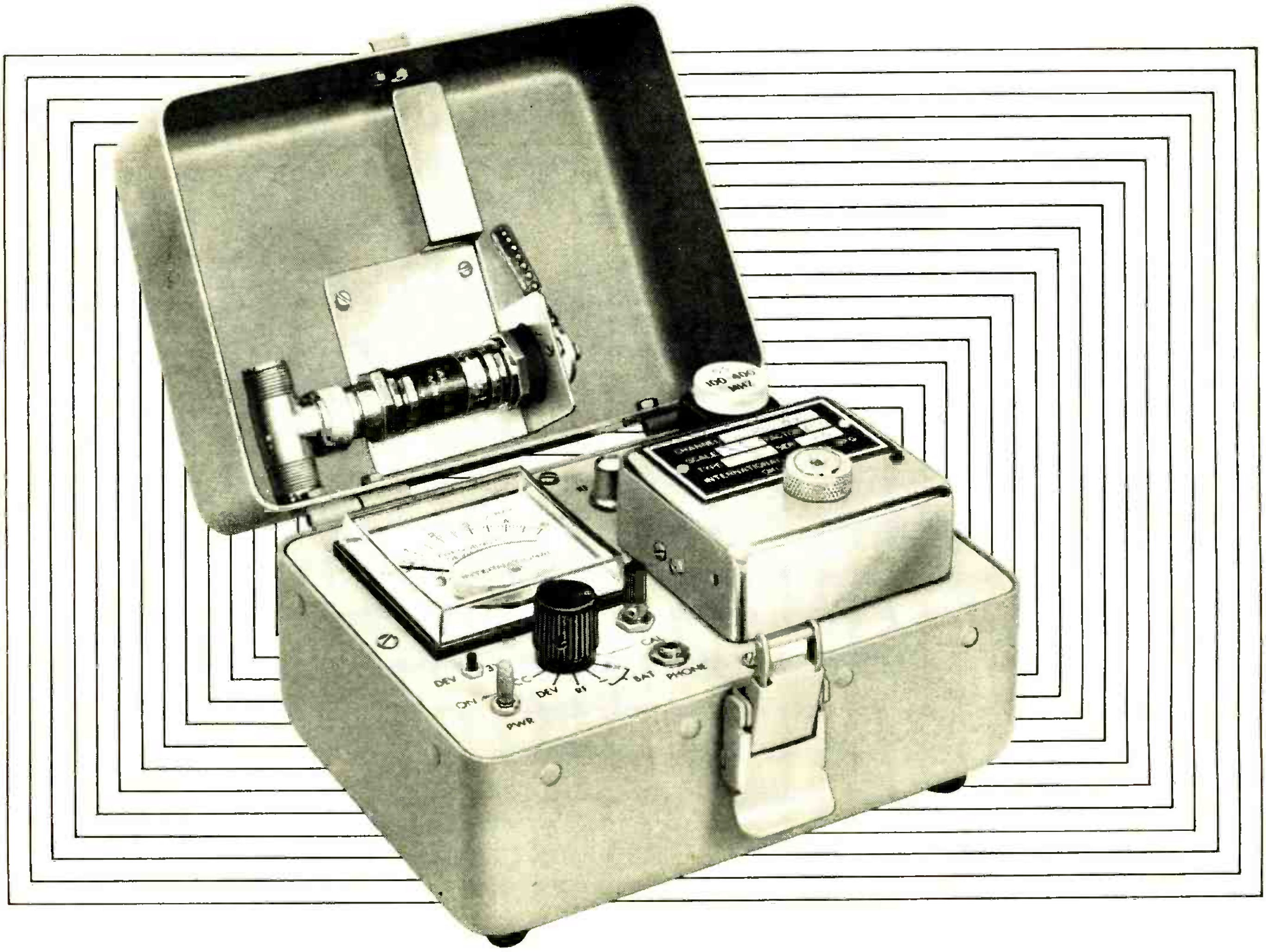

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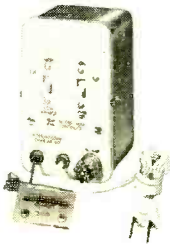

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