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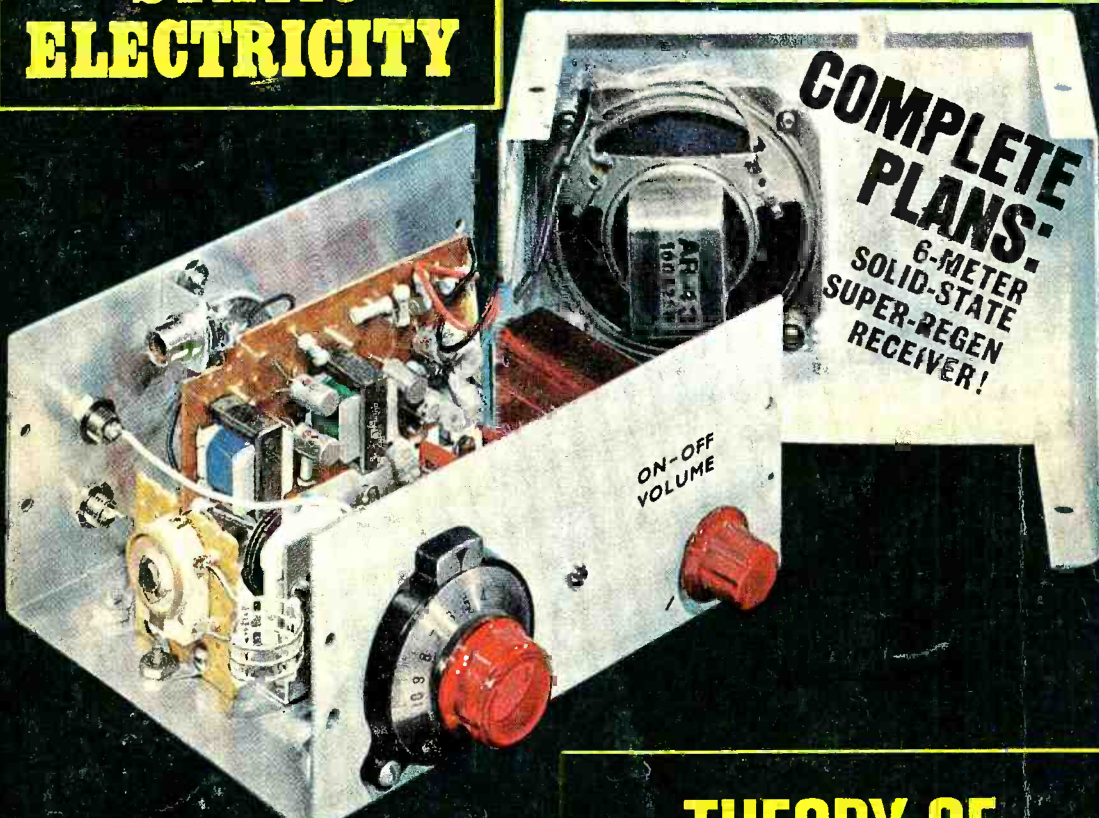

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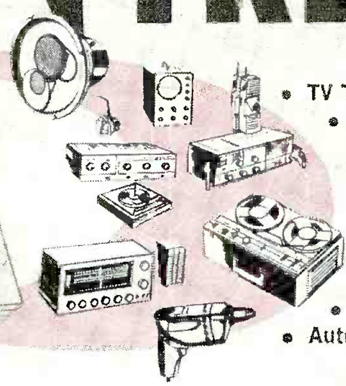

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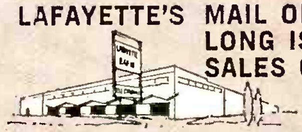

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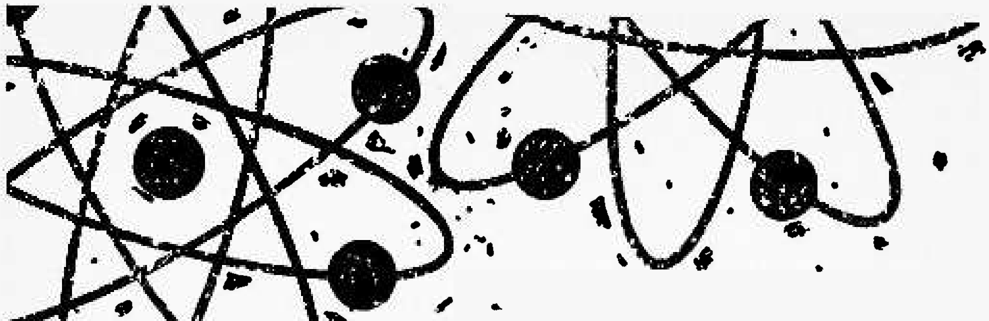

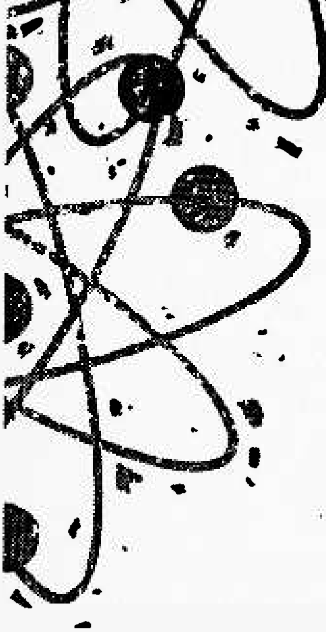

ELEMENTARY ELECTRONICS

MARCH/APRIL 1966

THEORY

CONSTRUCTION

FEATURES

DEPARTMENTS

☆ Cover Highlights

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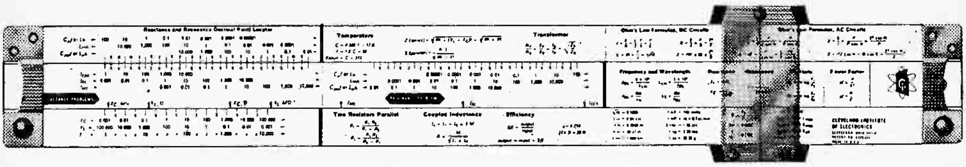

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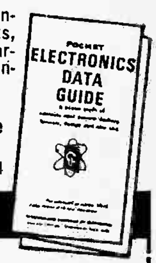

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ELEMENTARY ELECTRONICS

MARCH-APRIL 1966 Vol. 2 No. 1

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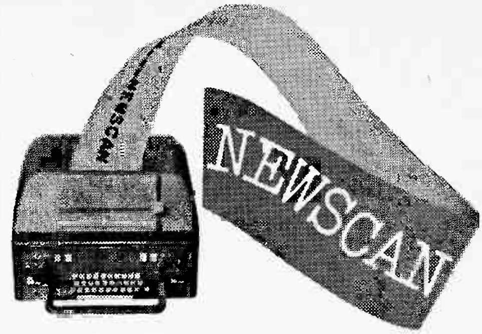
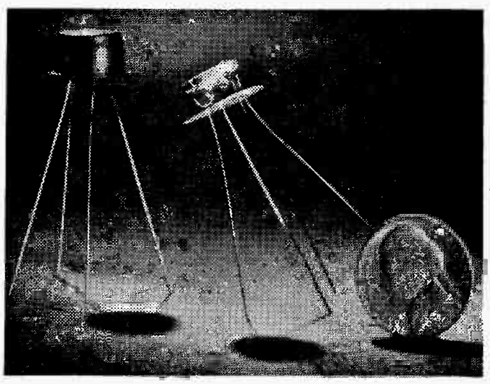


Pot with Light Control

Electrical isolation of remote controlled potentiometers looms as a significant circuit application now being developed at the General Electric Tube Department engineering laboratories. Photoconductive cells with their own light sources are sealed inside their metal cases with the light source next to the photosensitive surfaces, permitting the cells to be operated as variable resistors by changing the voltage on the tiny lamps enclosed. Varying the lamp voltage raises or lowers the lamp brilliance and thus controls the resistance of the photoconductive cells.

Photocell-lamp (PC-L) combinations can eliminate the need for motor-driven potentiometers or long, shielded "in-circuit" remote control cables. Another significant advantage is that they do not develop scratch noise common in mechanical potentiometers. Such scratch noise is caused by friction and wear between the moving contact arm and resistive surface of the mechanical potentiometer.

Though PC-L combinations are not unknown in the industry, the General Electric models



General Electric's new photocell has its own sealed-in light source. High reliability lamp permits cell to operate as a variable resistor, with changes of voltage on the lamp.

NEWSCAN

feature excellent seals for protection against moisture and the use of tiny aircraft-type lamps. These high-reliability lamps measure about one-eighth inch in diameter and one-fourth inch long. Both 5-volt and 28-volt lamps are being used in the developmental PC-L units.

Isolation of control circuits from functional circuits also is particularly helpful in audio feedback and compression circuitry. Engineers at the General Electric laboratory in Owensboro, Ky., say, too, that PC-L's are being considered for use in ballast controls and to simplify wiring in learning machines.

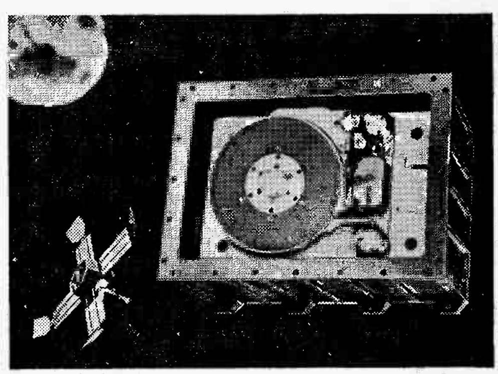
In the G-E types under development, resistances range from as low as approximately 25 ohms with the enclosed lamps at full brilliance to "dark resistances" of about 1 megohm.

The cadmium sulphide photoconductive elements of G-E's developmental PC-L's have maximum dissipation ratings of 30, 50, 100 and 350 milliwatts. Cadmium selenide elements also can be provided for applications where fast response is critical. PC voltage maximums are either 30 or 60 volts, again depending on type. Either neon or incandescent lamps can be enclosed to meet specific requirements of circuit and equipment designers.

One unusual PC-L unit has two 5-volt lamps enclosed, permitting the PC resistance to be varied by either or both of two isolated lamp circuits.

Two Bucks to Mars

A two-dollar strip of magnetic instrumentation tape was used to bring home to the world the "awe inspiring" photographs of the planet Mars. Mariner Four, the spacecraft that flew by the red planet July 14, was launched from Cape Kennedy November 28, 1964. During its



Unique recorder captured "near perfect" photos of Mars on 3M magnetic instrumentation tape. During manufacture, engineers passed the tape through 100 quality control tests.

NEWSCAN

228-day flight, Mariner Four's 138,000 components functioned admirably to place the spacecraft on a path that took it past Mars at a distance of 6,118 miles.

Photographic success of $120 million Mariner Four program depended on small, thin strip of Scotch instrumentation tape, on which pictures were recorded. This photo was recorded from 7,800 miles away. Area covers 170 miles east to west, 150 miles north to south.

More than 60 of Mariner's subcontractors provided 21 million dollars worth of hardware and instruments. More than 1,000 other firms provided another 19 million dollars worth of procurements. Officials of the National Aeronautics and Space Administration (NASA) estimate the entire cost of the Mariner Four flight at 120 million dollars.

But in the end, Mariner Four's photographic success depended on the ability of that one strip of magnetic tape—thinner than a razor blade, not quite as wide as a pencil and about as long as a 15-cent spool of thread—to record and faithfully reproduce photographs of Mars. The tape was 3M Company's Scotch instrumentation tape, which was also used in Ranger Eight and Ranger Nine to record and reproduce thousands of photographs of the moon.

As Mariner Four passed Mars, a single television camera took 21 black-and-white pictures described as "near perfect." The pictures were stored on the tape in digital form for later playback. This was necessary because, while picture data was recorded at 10,700 binary digits per second, the radio transmission rate from Mars was an extremely slow 8.33 bits per second. The slow transmission was needed to achieve reasonable picture quality over the 144 million miles of communications distance.

Tape length was held to 330 feet by the recorder's ability to operate at the extremely slow speed on one-one-hundredth of one inch per second.

Back on earth, the telemetry transmissions of the photographs and engineering information was received through 85-foot antennas of the deep space network and was recorded on much the same kind of 3M tape. A 3M Mincom recorder-reproducer was in use, among other ground equipment, to record transmission from the spacecraft.

Photographs were reproduced by running the ground-recorded tapes through a video kinescope system in much the same manner as Ranger Nine's moon pictures were processed.

Although the Mars photos were recorded from thousands of miles out in space, they were so clear they showed details of the Martian surface down to about two miles in diameter.

To China with Love Via Hopped-up Watts

Millions of watts—those tiny bits of electronic energy that can transmit the human voice around the world—will punch thousands of holes in the "Bamboo Curtain" in the near future

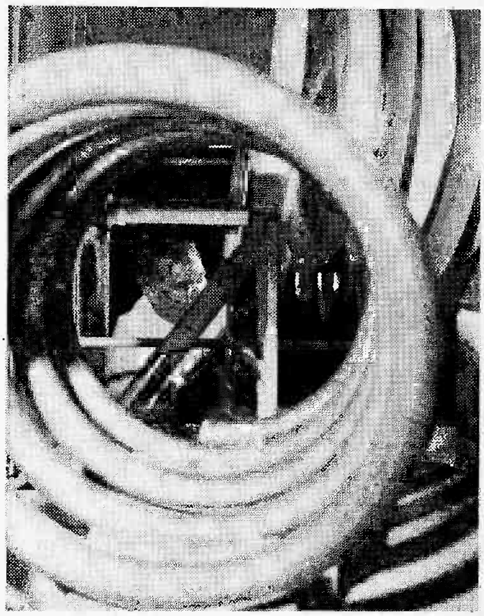
NEWSCAN

to tell the uninformed peoples of Asia that there is another way of life.

The Voice of America, the United States Information Agency's radio reporter to the world, has contracted for the construction of a transmitting "farm" in the Philippines that will beam 24-hour-a-day, seven-day-a-week broadcasts in dozens of languages and scores of dialects in a sweeping arc from Southeast Asia up through Asiatic Russia.

The "barnyard" center of this broadcasting complex will be a building containing ten 250,000-watt transmission units now under construction by Hughes Aircraft Company at its Fullerton, Cal. facility. Surrounding the "barn" will be a "farm" of 2,000 acres sprouting 50 or more antennas, each capable of sending its signal as far as 5,000 miles—which reaches beyond the "curtain."

Hughes engineers, who have developed and have been refining the high power systems for



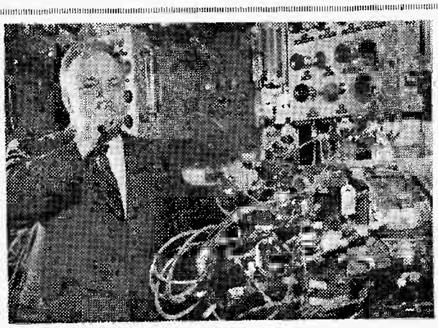
These coil and sheath assemblies are vital parts of a 250-thousand-watt transmitter, 10 of which are being built by Hughes Aircraft Company for the U. S. Information Agency's Voice of America for radio penetration of the "Bamboo Curtain" from Southeast Asia to Asiatic Russia. These unique assemblies will simplify automatic changes of transmitting frequency, necessary because of varying atmospheric conditions at night and day and during different times of the year, and can be used to avoid "jamming" by other stations.

many years, say that the total 2½-million-watt output of the ten transmitters is the bare minimum. If it were necessary, because of attempted signal jamming, it would be possible to tune all the 10 transmitters to the same frequency and direct the output at the Peking area, pouring one billion watts of effective radiated power.

The VOA's newest penetration of the Bamboo Curtain will rely on "sheer brute power" and concentrated directional beaming. Maximum power of American clear-channel AM stations is 50,000 watts. The signal, or broadcast program, is omnidirectional. It is distributed in a 360-degree radius and can be received at a distance of 100 to 200 miles. FM radio reception, also omnidirectional, is good for 50 to 60 miles. Short-wave broadcasts, also AM, can be tuned in at much greater distances because they are "bounced" off the ionosphere layer, 100 miles to 250 miles above the earth.

Although VOA operates several radio systems beamed to various countries around the globe, engineers report that the Hughes transmitters incorporated in the new complex in the Philippines offer these additional advantages:

- Operators can push a button and, within 20 seconds or less, the transmitting of a specific program can be switched from one frequency to another.
- Occupies less space than any similar system with comparable output.
- Higher over-all efficiency, requiring less power input from local sources, thereby greatly reducing operating costs.
- Remote control from as far as two miles away, also reducing operating costs.



I'll Drink to That!

A General Electric reliability manager drinks water produced as a by-product from the fuel cell batteries on test (shown at right). These batteries will produce electric power for the two-man Gemini spacecraft by combining hydrogen and oxygen, and deliver water for the astronauts to drink. Rigid checks will assure the quality of this water.

ask me another

By Leo G. Sands

Elementary Electronics brings the know-how of an electronics expert to its readers. Leo G. Sands, columnist for *Radio-TV Experimenter,* will be happy to answer your question. Just type or print your unsolved problem on the back of a 4¢ postal card and send it to "Ask Me Another," *Elementary Electronics,* 505 Park Avenue, New York, New York 10022. Leo will try to answer all your questions in the available space in upcoming issues of *Elementary Electronics.* Sorry, Leo will be unable to answer your questions by mail.

The Cat's Meow

For at least five years I have been asking what is the frequency of the energy being emitted by the brain which is detected, amplified and the resultant waveforms thereof exhibited visually by the use of the electroencephalograph? I have been trying to isolate a "brain wave" using an oscilloscope and I am beginning to believe these emissions lie beyond the frequency range of the instrument or perhaps the instrument is not sensitive enough. Cats react in a very peculiar fashion every time I get drunk. I would like to measure the voltage, amperage, wattage and frequency of the energy which travels from my brain to the cat's brain. I would certainly appreciate any information.

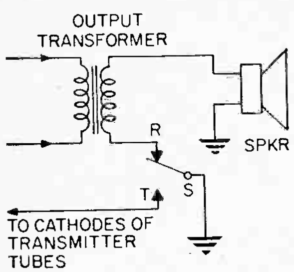
—*D. D. B., Mira Loma, Calif.*

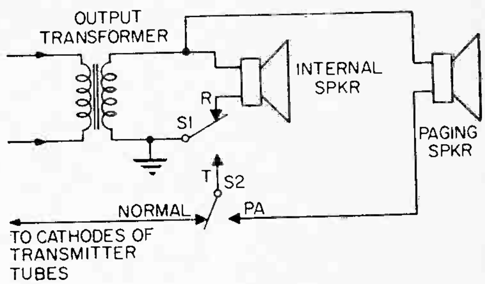
My Siamese cat acts in a peculiar fashion whenever I drink orange juice from his bowl. The amount of energy radiated by the brain is so minute that you need much more than a scope. Sorry, couldn't even make a wild guess. Perhaps another reader might know. But don't worry, Pussy Cat, I know a guy with a wooden leg and he has dog problems.

Calling CB

How can I modify a CB set so I can use it for paging?

—*J. C. P., Newark, N. J.*





The speaker circuit of a typical CB set is shown in the left drawing of the two schematics. When the transmit-receive relay (or switch) S is in the R (receive) position the speaker is connected. In the T position, the speaker is disconnected and the cathodes of the transmitter tubes are grounded.

To modify this circuit for paging an s.p.d.t. switch is added and the circuit is rewired as shown in the right schematics. Here S1 is the transmit-receive relay (or switch) and S2 is the added switch. When S2 is in the "normal" position, the set operates as before. When set to the PA position, the set's own speaker operates when receiving and the external paging speaker operates when the transmit switch is pressed. But, the transmitter won't go on the air except when S2 is in the "normal" position and the transmit button is pressed.

Hm mm mmm

I get a lot of hum on my AM-FM radio. Is there any way of getting rid of this hum? I do a lot of taping from the radio.

—A. S., Cleveland, Ohio

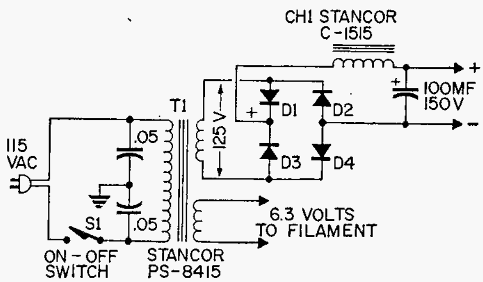
With the tape recorder disconnected, if the set still hums, chances are that it is due to dehydrated electrolytic filter capacitors or insufficient filter capacity. Try connecting a new filter capacitor across each section of the filter capacitor (one at a time) and note if there is any decrease in hum. On the other hand, if the hum is present only with the tape recorder connected, make sure that all of the cable shields are correctly grounded.

Preamp Power Supply

How can I build a power supply for a preamplifier requiring 125-135 volts DC at 7 ma. and 6.3 volts AC for the filament of a 6CB6 tube?

—G. W., Toledo, Ohio

A circuit diagram is given below. Pick diodes with a PIV (peak inverse voltage) rating of around 350-400 volts for maximum reliability. Mount the transformer in a metal chassis so the heat will be conducted away.



It Ain't Easy

I would like to change my 30-50 mc band FM receiver to cover the 152-174 mc band. Can this be done?

W. C., East McKeesport, Pa.

It probably can be done by changing the RF, mixer and oscillator coils. Try coils with about one-fourth as many turns. You will need a good RF signal generator to permit adjusting the coils (number of turns and spacing of turns) and re-aligning the trimmers. You can set the tuning range limits with the signal generator.

Be a UHF Copycat

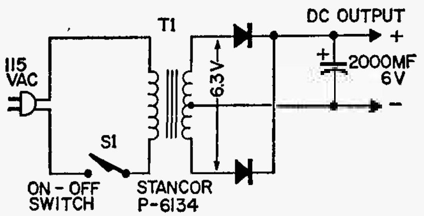
What type of antenna is best for reception of weak UHF translator TV stations?

F. B., Las Vegas, Nev.

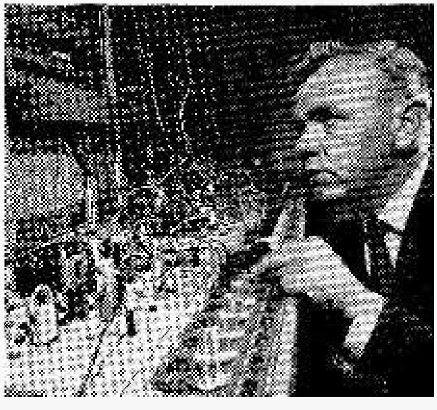
A parabolic, Yagi or corner reflector antenna will give you considerable gain but must be accurately aimed at the station. Since these antennas have relatively narrow frequency range, they cannot be used to cover the entire UHF TV band. These antennas are fairly inexpensive ($5 to $25).

Stick To Dry Cells

Can you draw a diagram and give me a parts list for a power supply for a portable tape recorder which uses two 1.5-volt cells?
J. G., Galveston, Texas

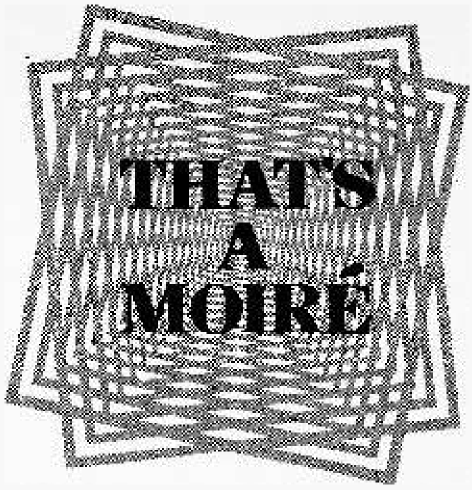


You can use a 6.3-volt filament transformer and a pair of diodes with low forward voltage drop as shown in the diagram. However, you might inject hum into the tape recorder. In view of the low cost and long life of flashlight cells, you might be better off staying with the batteries. ■



Time Shrinker

A 24-hour day shrinks to only 14 seconds on this analog computer developed in Honeywell's temperature-control laboratories. The computer electronically simulates temperature, humidity, wind, sunshine—even hills and trees—to help engineers like Honeywell researcher Lorne Nelson (above) design building control systems for the future. In 24 hours' actual time, the computer could give a building control system the equivalent of 17 years' use. Devices called "function generators" electronically duplicate changing weather conditions; solid-state resistors and transistors simulate building shapes, sizes, number of windows, type of construction, even geographic location.



■ The titles of each of our major articles in this issue are emphasized by a different geometrical design. These patterns are called moiré (pronounced mwa-reh—but if you can't quite wrap your tongue around your lips to get the correct pronounciation mor-ray is close enough).

There are moiré patterns all around us, although the term was first applied to the shimmering silk fabric produced in ancient China—moiré silk shimmers like water and came from the French word for watered.

These patterns have become "OP Art" as well as important scientific tools. Mathematicians compare these patterns to the more complex calculations of Fourier analysis.

Despite the usefulness and beauty of the patterns some people strive to avoid them. Television performers can't wear striped clothing—the scanning lines would transform other small stripes into constantly changing moiré patterns at the slightest movement. Pity the poor architect who finds that the moiré patterns, produced by the window screens and their reflections in the window glass, move madly about for the slightest breeze.

You can perform your own experiments in moiré patterns with the *Experimenter's Moiré Kit* (Catalog No. 70,718; $6—postpaid), from Edmund Scientific Co., 101 East Gloster Pike, Barrington, N. J. 08007. With the kit you will be able to make your own "OP Art" masterpieces, learn how to interpret moiré patterns in terms of projective geometry, their applications to physics and electron micrography and special measurements that can be made with the many screens that come along with the book *The Science of Moiré Patterns* by Dr. Gerald Oster of Brooklyn Polytechnic Institute. ■

You get shocks every day! Some are quite harmless. Others can be lethal.

High-Voltage Electrical Charges

By Leo G. Sands, W7PH

■ Walk across a carpet on a winter day and touch a door knob and you'll undoubtedly get a shock. As you walk on the carpet you develop an electrical charge. The carpet acts as an insulator which prevents the charge from leaking off too quickly. You get a shock because there is a potential difference (a voltage) between your body and the door knob. It was generated by friction as you walked on the carpet.

This kind of shock is irritating. It can be avoided by holding a key or other metallic object in your hand and touching the door knob with it. You may see a spark jump from the metal object to the door knob, but you probably won't feel the shock. The voltage that causes the spark is very high, perhaps several thousand volts. But the current is very small and the duration of the spark very short. Thus, the amount of power in terms of watt-hours is extremely small.

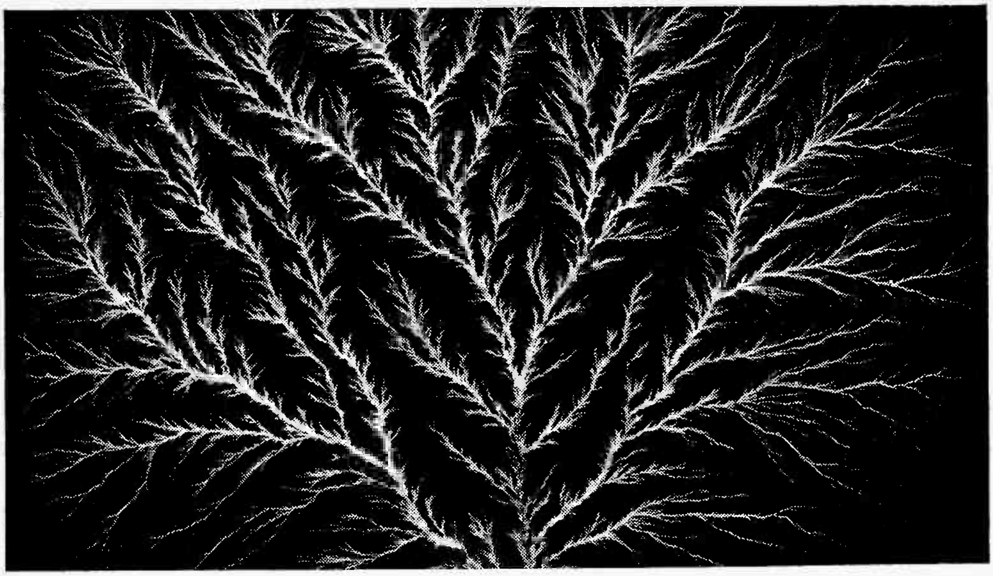
This phenomenon was used for training a cat to stay away from a caged parakeet. The cat was carried across a carpet to the bird cage. When the cat moved its nose toward the case, *zip* went a spark from the nose to the cage. The cat, thereafter, preferred to keep its nose out of the bird's business.

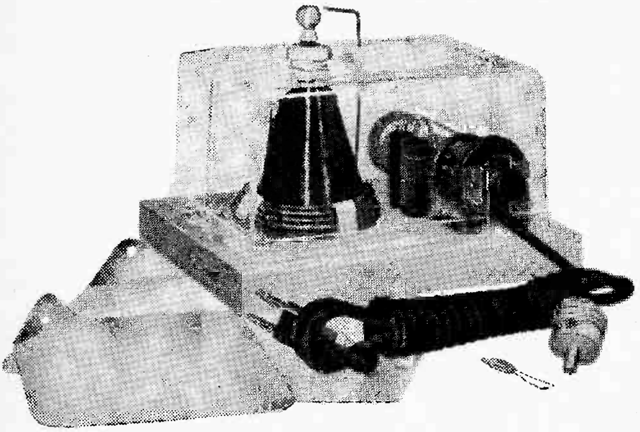
This is *static* electricity, so-called because it seldom serves a useful purpose. It is *static* when it is an electrical charge, but it becomes *dynamic* when it discharges. Electricity which flows through wires and other conductors is called *dynamic* electricity.

Hundreds of years ago, men discovered that pith balls and other light objects are attracted by a rod of amber or other material when rubbed. Run a comb through your hair on a dry, cold day and you will find that it attracts bits of paper like a magnet attracts nails.

A Difference in Potential. Two people,

Fig. 1. A hair-raising experience. The secret—make contact before voltage builds up on dome.





This fern-like pattern was produced when a 3,000,000-ev (electron volt) beam fractured a plastic block. The electrons, after puncturing surface of plastic block, flow like water from a broken dam. Effects of soil errosion and topographical map of river tributaries or watershed area produce similar branched pattern.

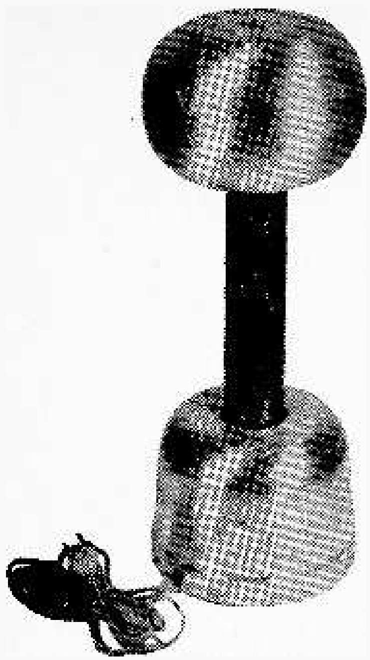
Tesla coil is another device for producing high-voltage arcs. Some units use vibrator-type spark coils but for higher frequencies and more power radio-transmitter circuits are used to drive the Tesla coil. Unit shown is Edmund Scientific Co., Catalog No. 70,301—cost: $42.

insulated from each other, will find that when one touches the other's skin lightly with a finger, the skin feels slightly raspy. But, if the two hold hands tightly or otherwise make firm contact with each other, the raspy effect disappears. When they touch only lightly, there remains an electrical potential between the two. But, when their hands make firm contact, they are both at the same electrical potential.

Touching the glass tube of a fluorescent bed lamp, while lying on a bed on a cold, dry night can sometimes cause the lamp to glow feebly around the point of contact when the lamp is turned off. The effect disappears when a metal bed post is touched with the free hand.

It is believed that all objects are charged to some electrical potential and polarity. If one object is charged to 15,000 volts positive and the other to 15,000 volts negative, or any other combination to produce a 30,000 volt difference in potential, a spark is apt to be produced when the objects are brought to within one inch of each other.

While it is difficult to measure electrostatic potential, the results can be quite realistic. For instance, while testing a transistor



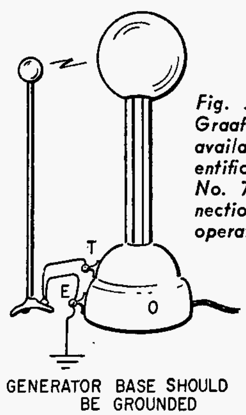


Fig. 3. A typical Van de Graaf generator (above) available from Edmund Scientific Co., for $39.50 (Cat. No. 70,264). Correct connections (left) are for the operator's personal safety.

in a power-line operated transistor checker, an experimenter temporarily took his hand off the transistor and scuffled about on the carpeted floor. When he again touched the transistor, the charge in his body discharged through the transistor to ground and punctured it.

Lightning is static electricity of amazing power. Discharges from one cloud to another are said to have spanned as much as 100 miles. The potential difference between a cloud and a grounded object is several million volts. The current flow through a conductor struck by lightning can be several

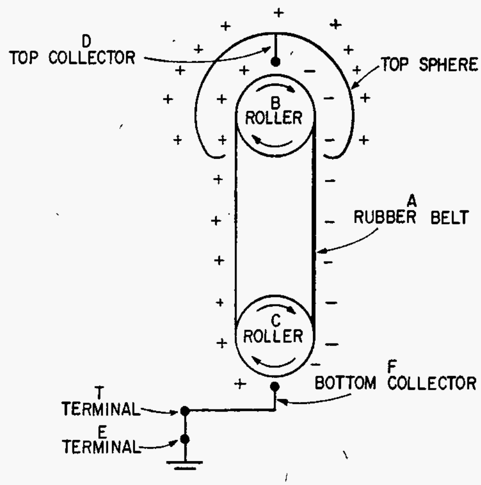


Fig. 2. Basic view of what goes on inside of the Van de Graaf generator. Mechanism is very simple.

thousand amperes at the peak of discharge.

Lightning Arrestors. For the sake of lightning protection, all radio and TV antenna systems should be equipped with a lightning arrester. This is merely a spark gap. Ordinarily it is an open circuit. But, when the static potential of the antenna exceeds a certain level, with respect to ground, a spark jumps the gap and discharges the static.

The static charge on an ungrounded antenna can become extremely high. When a VHF base-station antenna was being installed at a railroad-yard office in Atlanta, a spark several inches long, jumped from the connector at the end of the antenna's coaxial cable to the radio equipment cabinet when the smoke from a steam locomotive enveloped the antenna some 60 feet above the ground. When the antenna coax was connected to the radio equipment, which was grounded, the static problem was eliminated because the antenna was now at ground potential—for two reasons: (1) the shield of the coax was grounded and, (2) both antenna elements were connected to the shield through a shorted matching stub within the antenna assembly.

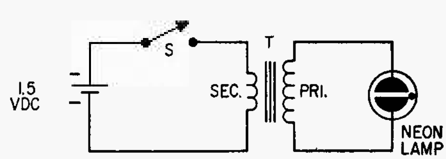
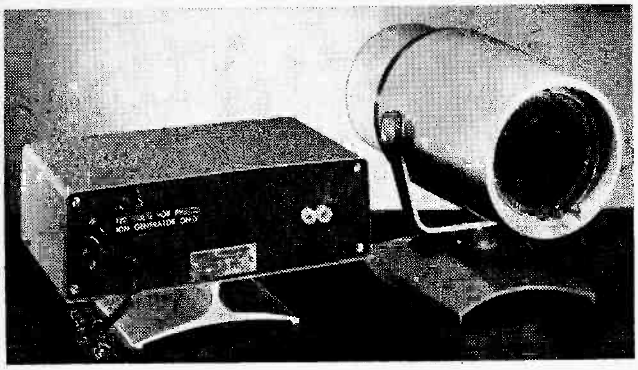
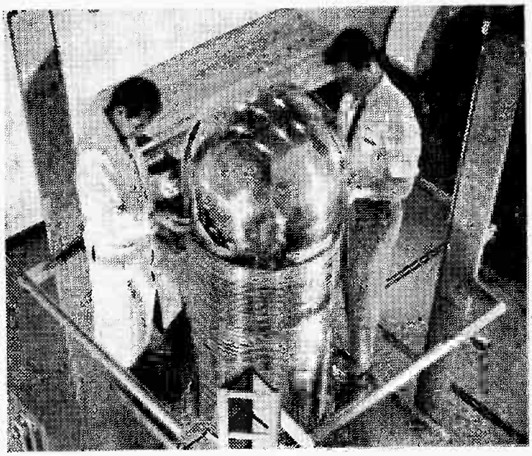


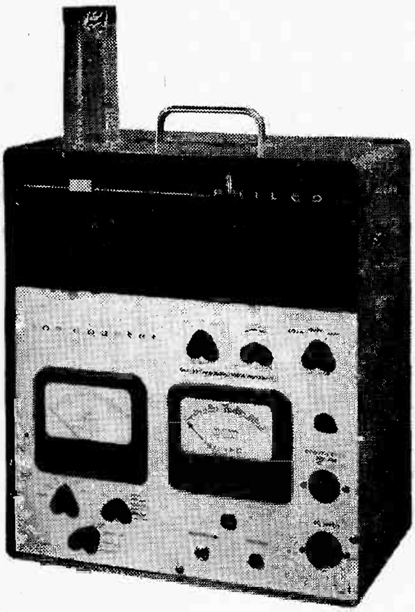
Fig. 4. Simple circuit produces higher voltage than turns-ratio would give with sine wave input.



Ion generator charges air negatively with corona discharge from a needle-like electrode in spotlight type housing. Built-in fan circulates air. Power supply, at left, connects to generator through high-voltage cable connected to white jacks on right of front panel.



Van de Graaf electron accelerator at Emeryville Research Center of Shell Development Co. is the most powerful radiation source available to industry. Electrons, stored inside stainless steel dome, are used to bombard experimental samples in target room below generator.



Photos courtesy of Philco

Ion Counter measures ionization and indicates charge of air, whether air is negatively or positively charged. The air in private homes, hospitals and industrial plants is checked and accurate readjustments easily made.

coated with varnish is located in the base of the generator. The lower roller is driven by the motor. One collector (D) is in close proximity to the top roller and is connected electrically to the inside surface of the top sphere. A second collector (F) is in close proximity to the bottom roller and is connected electrically to an insulated terminal (T), which in turn is grounded. The base of the generator is also grounded.

When the belt travels over the rollers the top roller becomes positively charged, and the descending belt becomes negatively charged. This negative charge is removed from the belt by the bottom collector. This positive charge, on the ascending belt, is carried into the top sphere where together with the positive charge on the top roller it attracts the negative charge from the top collector by induction. These negative charges are drawn from the sphere, leaving a surplus of positive charges on the surface of the sphere. As the belt continues to move, the process is repeated and the surplus of positive charges is increased. The maximum voltage obtainable is limited by the diameter of the sphere, the efficiency of the insulation used and by the humidity of the surrounding air.

The ball of the discharge sphere (Fig. 3) is placed about one inch from the top sphere of the generator. The power is switched on

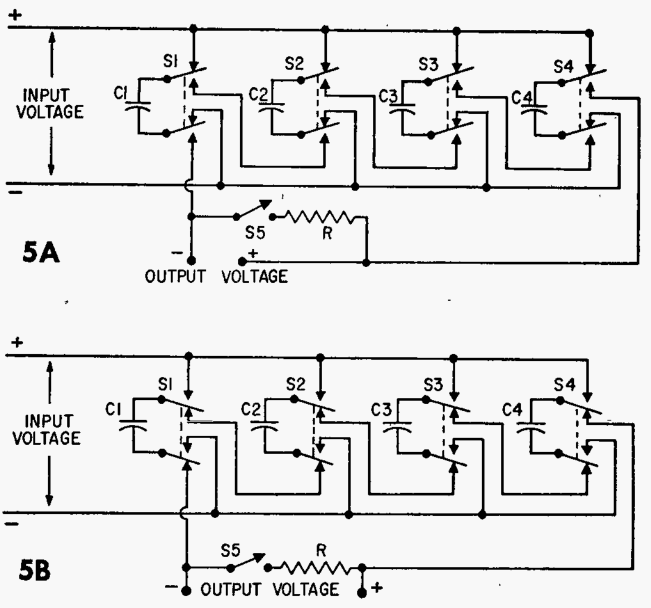


Fig. 5. Schematic at top is one of connections used to put high-voltage charge on each of the capacitors connected in parallel. More than the four capacitors shown can be charged at one time. The lower schematic shows the series connection when the switches are flipped prior to discharge through the resistance R when switch S5 is closed or discharged through a spark gap for some experimental simulated lightning tests.

and the speed of the belt adjusted. The generator will then charge up and sparks pass between the top sphere of the generator and the ball of the discharge sphere. The sparking distance may be increased until a spark of one half to one inch in length is obtained. The voltage of the generator may be determined, approximately, by the length of spark (1 cm. = 30,000 volts approx.).

While a person walking across a carpet can get a shock when touching a grounded object, a garbage collector in Sacramento got the shock of his life when he touched a garbage can. Its owner had placed the can on bricks to insulate it from ground and had connected it to the ungrounded side of the AC line through a lamp (to limit the current) and a piece of nearly invisible wire. The idea was to discourage dogs from dumping over the can. But, on a rainy day when the ground was wet, a garbage collector firmly grabbed the can. When the AC tingled through his body, he screamed and threw the can through the air like a missile leaving a launching pad. This was *Dynamic* electricity at a very low power level triggering tremendous human energy.

A Kick From Inductance. Back in the days when Model-T Ford spark coils were readily available, youths wired them to doors so that the coil could be energized from a battery when the door was opened.

In some parts of the country, particularly in dry climates, static is extremely severe in the summer, raising havoc with radio reception in the form of noise—also called static.

Electrostatic Generators. You can build or buy a Van De Graaf generator which produces almost 500,000 volts electrostatically. Touching the charged sphere, as shown in Fig. 1, can be a "hair raising" experience. Edmund Scientific Co. in Barrington, New Jersey, is now selling a belt-type electrostatic generator incorporating the Van de Graaff principle. This machine generates direct current of high voltage and low amperage. Some generators give a maximum potential of almost 500,000 volts, with a short-circuit current of 10-15 microamperes.

A generator consists of a hemispherical base supporting an insulating tube on which is mounted the top electrode—a highly-polished hollow-aluminum sphere. The motor, in the base of the instrument, drives the belt. A speed control can be varied to adjust the speed of the belt, and thus the charging rate.

In Fig. 2 an endless belt (A) of rubber or other material runs over two rollers. Roller (B), made of acrylic resin and covered with fabric, is in the top sphere and the other roller (C), also made of acrylic resin, but high-voltage output terminal was connected to the door knob. Anyone touching the door knob got a frightening but non-lethal shock. The voltage was very high because of the charge and discharge of an inductance.

When DC is applied to a coil, a magnetic field is developed. When the DC is disconnected, the field collapses, with a violent inductive kick. Try it yourself. Take a 6.3 volt filament transformer. Connect a neon lamp across the 115-volt primary winding (Fig. 4). Then touch the 6.3 volt secondary leads momentarily to a 1.5 volt flashlight cell. The lamp will flash when you disconnect the battery. The turns ratio of the transformer is less than 20:1. Yet, the battery voltage is stepped up to well beyond the 60 or 70 volts required to fire the lamp. (See Fig. 4).

The same basic technique is used in auto ignition systems to create a spark that will jump the gaps in spark plugs and in some radar sets to provide high voltage.

Adding Capacitive Charges. A capacitor, on the other hand, holds its charge. Take an 0.5-mf paper capacitor and temporarily connect it across the B-plus of a radio set or audio amplifier. If the B-plus voltage is say 300 volts, the capacitor will charge to that voltage and retain the charge until it leaks through the dielectric or until the capacitor leads are shorted. Touching the leads of a charged capacitor can cause a startling shock.

By connecting four capacitors and four DPDT knife switches as shown in Fig. 5A, and by applying 300 volts DC to the circuit, each capacitor can be charged to 300 volts. By throwing all of the switches as shown in Fig. 5B, their charges are then connected in series and the circuit will deliver 1200 volts. When this voltage is connected to a load, such as a resistor, the voltage will drop off exponentially at a rate determined by the value of the capacitors and the resistance of the lead.

Capacitor banks with as much as seven farads (7,000,000 microfarads) of total capacitance are used in some computer power supplies. When the power is turned on, the capacitor charging current would be prohibitive if it were not for a motor-driven variable-autotransformer assembly which gradually increases the output voltage from zero to full value.

When a capacitor is connected across the B-plus of a radio or amplifier, high current flows momentarily as the capacitor charges and then drops off to zero. When the capacitor is disconnected and its leads are shorted, a fat spark is produced as high current again flows momentarily.

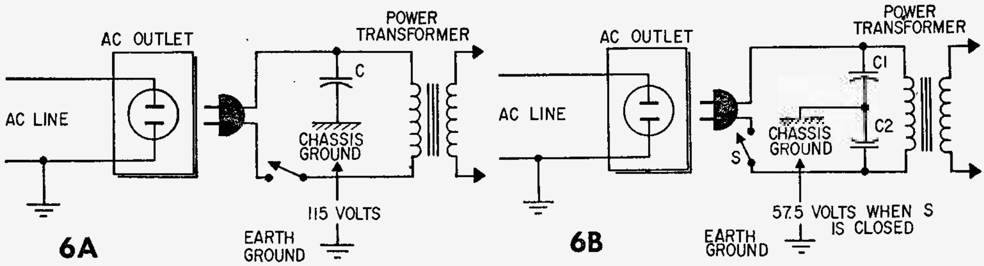


Fig. 6. Circuit at left has chassis "hot" to ground in only one position of line-cord plug. Chassis has half of line voltage to ground in either position of plug in circuit at right.

Hot to Ground. The ungrounded chassis of a radio or TV set or amplifier can be *hot* electrically to the touch. It is not charged in the same sense as a statically charged object. The chassis is at an AC potential above ground because of line-filter capacitors. If there is only one line-filter capacitor, as shown in Fig. 6A, the chassis can be at ground potential if the AC plug is inserted into an AC outlet so that the grounded side of the AC line is connected to the line filter. But, if the hot side of the line is connected to the line capacitor, the chassis will be at a potential above ground equal to the line voltage. You can get a jolt if you touch the chassis when also touching a grounded object (earth ground) or standing on a damp floor.

However, if you connect an incandescent lamp between the chassis and ground, it will not light because of the high *reactance* of the

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capacitor (54,000 ohms for an 0.05 mf capacitor at 60 cps). But when you touch the chassis, your body resistance is so high that the series reactance of the capacitor won't drop the voltage sufficiently to prevent shock.

On the other hand, if there are two line capacitors, as shown in Fig. 6B, you can get a shock when you touch the chassis regardless of the orientation of the AC plug. But the chassis will be at a potential of only half the line voltage. Shock can be avoided, whether the set has one or two line capacitors, by grounding the chassis. But, never ground the chassis unless the set has a power transformer to isolate the line from the rest of the circuits.

These capacitors are alternately charged, discharged, recharged in the opposite polarity and discharged again during each cycle of the AC line voltage.

Negative or Positive. Some 200 years ago, Benjamin Franklin assumed that electricity flows from positive to negative. Later it was found that electrons flow from negative to positive. While many still cling to Franklin's theory it now makes sense to assume that electrons and current both flow from negative to positive. Electrons, which are negative, are attracted by positively charged objects. Like charges repel each other and unlike charges attract each other.

Ions are generated. It is said that everything is charged to some electrical potential, even the air we breathe. Scientists have found that people feel better when the air is negatively ionized and may become nervous, grouchy or fatigued when the air is positively ionized.

Right after a thunderstorm, most people feel exhilarated. It is said that this is because the air has an abundance of negative ions. Air conditioners and electronic precipitators are said to cause the air to be positively ionized. It may be for this reason that some people don't like air conditioning.

Air conditioners with built-in negative-ion generators appeared on the market about six years ago. Separate negative-ion generators are also available which are used to heal burns faster, provide comfort to allergy sufferers and to pacify nervous people. One type has a sharp needle which is fed a negative DC voltage at several thousand volts. Air is forced past the needle by a fan to blow the negative ions out.

Static charges are also a problem in thread mills where lint is produced by static attraction and repulsion. Ion generators have been installed in some plants to offset these static charges.

An ion is an atom which has lost electrons. More elaborate means for generating positive ions are used in so-called atom smashers than for generating negative ions for conditioning the air. In a cyclotron, positive ions are fed to the center of a large circular chamber and travel around and around in a spiral, within a high intensity electrical RF field and a magnetic field produced by DC electro-magnets. With each orbit the speed of the ions is accelerated. As the ions near the periphery of the chamber, a deflector charged to a high-negative potential directs them to a target or portal at the rim of the chamber. The kinetic energy can reach several-million electron volts. Synchrotrons are similar but are used for acceleration of either electrons or positive ions. Linear accelerators employ very strong microwave pulses to accelerate charged particles through a waveguide and produce energy up to 50-million electron volts.

Irradiation. While these devices are used primarily for nuclear research, smaller radiation devices are used to process food and chemical products. For example, insulated wire may be irradiated to change its actual chemical composition. Meat may be subjected to radiation to make it unnecessary to keep it under refrigeration. When the news about irradiation of meats first came out, it was thought that the freezer business might suffer. However, it is reported that meat and other foods subjected to radiation, while edible, taste different and lose their appeal to many persons.

Radiation has been applied to popcorn processing. Cyril C. Miller of Yucca Valley, California, has been awarded a patent for an electronic popcorn machine which pops corn *in the bag*, to the size of logan berries, in a matter of seconds.

Dynamic electric current requires an electrical conducting path, such as wire. However, dynamic electricity can also flow through space, such as when an arc or spark is formed—a gas is formed through which the current passes. Sparks produce ozone, a gas which has many industrial uses but which is toxic and considered dangerous to

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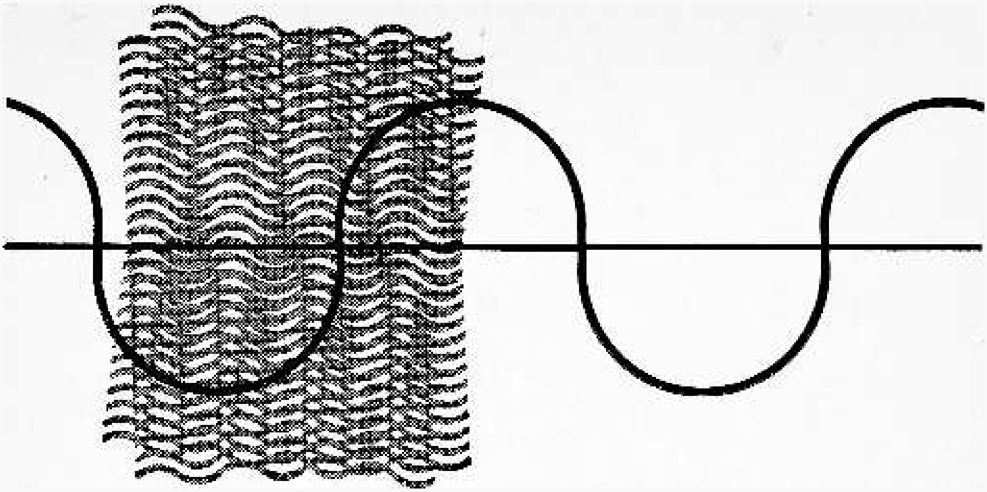


Frequency Measurement

By Jim Kyle, K5JKX

Accurate knowledge of frequency is a help to the experimenter and CB'er—a basic necessity for the Ham

■ As you tune through the 31-meter band you pick up a station you've never heard before; it will make your *100th country*. But up here your receiver calibration can't be trusted to closer than 100 kc., and for a QSL you have to give almost exact frequency of reception.

Or maybe you're chasing DX on the 20-meter ham band. You find a rare one right at the low end of the band and begin to slide your VFO down toward his frequency. Are you going to end up out of the band, with an FCC pink ticket instead of the rare-DX card for your efforts?

If you're a CB'er, you may want to know how close to the center of the channel your rig actually is operating. But you don't want to lay out the cash for a frequency check at the nearest service shop.

In all of these cases—and many more—what you need is an accurate way to measure RF frequency. While frequency measurement isn't at all difficult, the techniques and equipment aren't usually found in the average experimenter's kit of gear.

However, you can set up to measure frequency with surprising accuracy for less than $15. And if you're willing to lay out from $50 to $75, you can make measurements far more precise and accurate than any FCC requirement. It's almost ridiculously simple to make measurements accurate to one cycle per megacycle, or 0.0001 percent; this is 50 times more precise than the allowable tolerance for Class D CB frequency!

Basic Frequency Measurement Methods. Before we get into actual equipment or specific techniques, let's look at the three basic methods used to measure frequency.

Most direct of all is simply to count the number of cycles which occur in a given length of time. This gives the frequency directly.

An example of this, in utmost simplicity, is the way we tell time. It comes down to counting the number of times the sun rises. Every sunrise marks another day; seven sunrises make a week, and 365 of them make a year (except during Leap Years). We could then say that the "frequency" of days is 365 cycles per year—and the year is actually one of the international standards of frequency.

To apply this idea to RF, we must have an extremely rapid counting device, and it must be able to count to large numbers. For

FREQUENCY MEASUREMENT

instance, if it could count to one million, and we counted the number of cycles in one second, it would only give us an indication up to 1 megacycle.

By reducing the counting period to 1/10 second, though, the same counter would read to 10 megacycles. And by counting for only 1/100 second, we could read up to 100 megacycles. Counters can work in the audio ranges and provide very excellent results. Tuning an electronic organ with a counter is almost effortless.

Counting devices do exist, (Fig. 1) and are widely used in labs. However, they require exceptionally complicated circuitry to be able to count so rapidly, and as a result carry extreme price tags. About the least expensive around costs over $600, and this is a basic unit which requires several expensive adapters before it can be used in practice. The counter, then, is not for us.

Almost as direct, and equally accurate, is to *compare* the unknown frequency to a known standard. We tell time in this way, too. Our clocks are "known standards" in that we know they will indicate 24 hours between successive sunrises (after allowing for the daily change in time between sunrises). To find out the time of day, we simply look at the clock without having to see the sun.

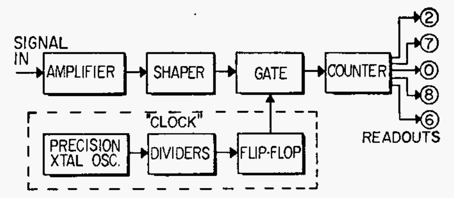
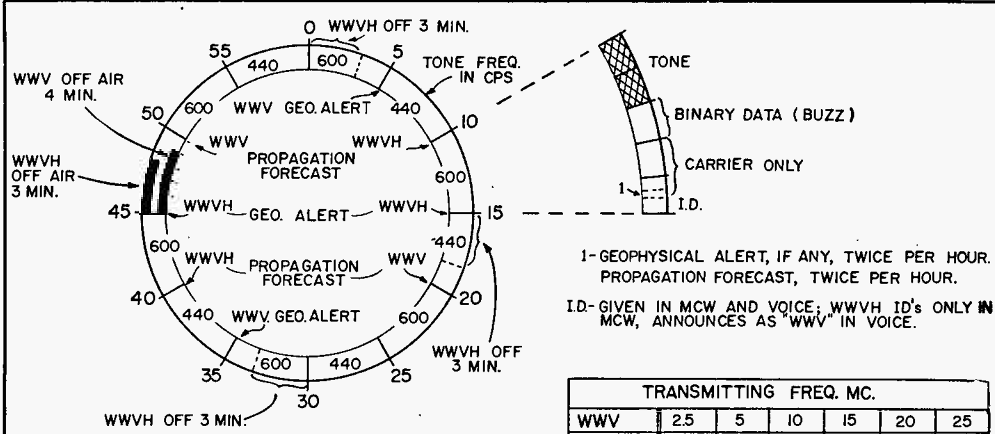


Fig. 1. This block diagram shows typical digital frequency counter operation. "Clock" divides down from precision crystal oscillator (usually operating at 1 mc.) to provide accurate time intervals from 1/100,000 second to 10 seconds. Amplifier and shaper convert the waveshape of the incoming signal to a standard form to eliminate error due to waveform. Clock opens gate circuit for precisely timed interval, allowing cycles of incoming signal to pass through to counter. Counter circuits actually count number of cycles passing through gate during this interval and display the total on readout tubes, as shown by "27086" in illustration. If interval is 1/1000 second, this means frequency is 27086 ±1 cycles in 1/1000 second, or 27,086,000 ±1000 cycles per second (27.086 mc. ±1 kc.). Counter's accuracy is always limited to ±1 count in lowest decimal place; the longer the interval the greater the accuracy. If counted for 1/100 second and readout gives 270854, frequency would be 27.0854 mc. ±100 cps, a ten-time improvement in measurement accuracy.

To apply this *comparison* method to measuring RF, all we need do is provide an accurate standard. The government gives us one in radio station WWV, which broadcasts continuously on a number of "standard" frequencies. We can then build a "secondary standard" and "set" it to WWV, and use this secondary standard as a comparison device



TRANSMITTING FREQ. MC.						
WWV	2.5	5	10	15	20	25
WWVH	–	5	10	15	–	–

Fig. 2. WWV/WWVH schedule; shown for one hour, is same for every hour. EST is announced in voice during each ID. Seconds are marked by time "tick" except during binary data and ID. Minutes are marked by double ticks while the last (59th second) of each minute is always omitted.

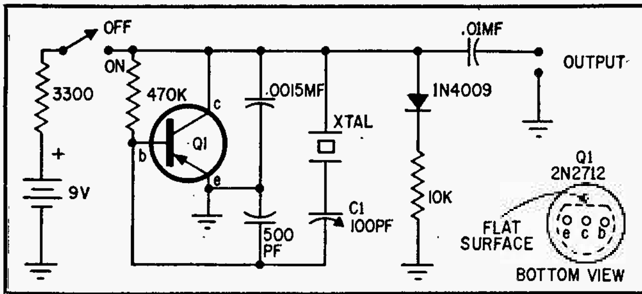


Fig. 3. Inexpensive 100-kc. secondary frequency standard suitable for home construction. See text for adjustment of C1; note that neither side of capacitor C1 is grounded.

for the unknown. WWV also provides audio standards which can be used to spot check the audio calibration.

The third method of measuring frequency is to *match* the unknown with an accurately calibrated known-frequency source. This is the technique a jeweler uses when he determines if your watch is running fast or slow, before adjusting it to keep proper time.

Applying this technique to RF measurement requires only the calibrated source. The instrument most often used as the source is the "heterodyne frequency meter"; this is simply a ruggedly constructed oscillator with calibration considerably more accurate than that of the usual signal generator or ham VFO.

A good frequency meter will cost (new, from the factories) about as much as a counter—but many thousands of them were made during World War II for the armed forces, and are still available on the surplus market at prices ranging from $20 to $100, depending on model and condition. This makes the frequency meter technique as attractive to the experimenter as the comparison method.

Measuring Frequency by Comparison. The most common, as well as the least costly, technique for measuring RF frequencies is the comparison method. You can build yourself a "secondary frequency standard" for less than $15, and with it you can measure frequencies to within 5 kc. easily throughout the HF spectrum.

As mentioned before, the comparison method consists of comparing the unknown frequency to a known standard. The national frequency standard is provided by National Bureau of Standards radio station WWV and WWVH, which broadcast on 2.5, 5, 10, and 15 mc. (as well as some other frequencies). At least one of the broadcasts can be received anywhere in the country, at any time of day.

These frequencies are easily identified by the one-second marker "ticks"; most of the time the "ticks" are accompanied by an audio tone of either 440 or 600 cps. See Fig. 2. When you find the signal, you can be sure that it is accurate to within one part in 10,000,000. That's .00001 percent. But the WWV signal alone isn't much good for comparison, because no other signals operate on

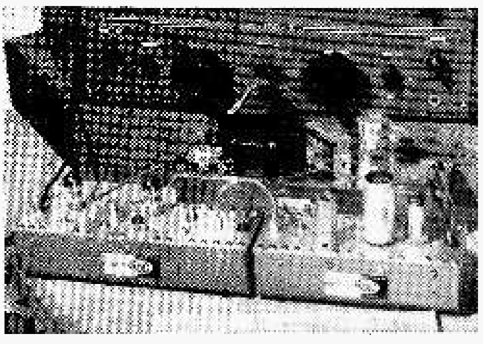


Fig. 4. High-precision secondary-standard frequency measuring equipment can be purchased commercially at reasonable prices. Typical units of this nature are these from International Crystal Mfg. Co., Oklahoma City, shown set up for operation in front of author's receiver console. AOM-100X, in right foreground (short chassis) is 100-kc. crystal oscillator. Crystal is contained in thermostat-controlled oven for maximum stability; oven is large cylindrical container near center of chassis, between tubes. On panel immediately to left of left tube of AOM-100X two adjusting shafts can be seen; these are dual frequency-zeroing capacitors, corresponding to C1 in Fig. 3. One sets rough adjustment, other provides "bandspread" slow effective for final zero-setting. Long chassis in left foreground is AOM-201 frequency divider unit; this takes output of AOM-100X oscillator and divides it down to 10-kc. signal to be fed to receiver. In background is AOP-100 power supply which furnishes power for both units. Alternatively, power can be "robbed" from most receivers. In near foreground, "tuning graph" of receiver calibration chart is seen.

the internationally-cleared "standard" frequencies.

So to make the comparison technique useful, you have to have a "secondary frequency standard" which will provide known frequencies at much closer spacings than those given by WWV. The most common such standards operate at 100 kc. and they are crystal-controlled.

Fig. 3 shows the schematic diagram of a simple 100-kc. crystal standard which you can build. Capacitor C1 is a control which lets you vary the operating frequency a few hundred cycles either way, so that you can "zero" or set the standard to exact synchronization with the WWV signal.

If you don't want to build your own standard, you can buy them ready-made from a number of firms. Fig. 4 shows the elaborate standard manufactured by International Crystal in their "AOC" line of equipment; also shown here are some other components we'll discuss later. In between the extremes of Fig. 3 and Fig. 4 you can get about anything you want.

To use the standard, tune in WWV and wait for a "quiet" period when only the time ticks are being transmitted. Then turn on the standard and adjust its zero-set capacitor (C1 in Fig. 3) for an exact zero-beat with the WWV signal.

You Can Beat Accuracy. The accuracy of your measurements will depend upon the accuracy with which you make this adjustment. Use the highest-frequency WWV signal you can receive, and don't be satisfied to get merely a beat note so low you cannot hear it. If the WWV signal and the signal from the standard are about the same strength, and the WWV signal is relatively free of fading effects, then as you approach *exact* zero beat you will find that your receiver's S-meter begins to fluctuate. Its gyrations will be rather rapid at first, and will slow down as you get closer to zero. You can count the number of times per second that the needle swings from a high peak through a low one and back to high, and that will be the number of cycles per second that you're out of sync.

It takes only a little patience to get the swing down to one complete fluctuation every two or three seconds, and when this happens your secondary standard is within ½ cycle of the exact WWV frequency. The percentage accuracy of your standard is then found by dividing the amount of error (½ cps) by the WWV frequency (15,000,000 cps if you use the 15-mc. signal). To make it percentage, multiply the result by 100—and you come up with 0.0000033 percent accuracy. That's far more than you will be able to use in most cases.

Band Spotting. Now that you have an accurate secondary standard (to be sure of its accuracy, recheck it by this technique before every use), what can you do with it?

For general use, such as spotting the edges of ham bands or determining the frequency of SW broadcast stations to within 5 kc., you need nothing else. All ham-band edges are even multiples of 100 kc., so you need only tune to the harmonic of your standard which comes in closest to where you think the band edge is located, and you have your limit point.

For logging SW stations, use the harmonics of the standard to provide accurate calibration for your receiver's bandspread dial. Set the receiver up with the bandspread dial at "0" and using the main bandset knob, tune in the first standard point below the band you're interested in. Now lock the bandset, and tune with only the bandspread. Note the readings for each of the standard harmonics you come across.

Your next step is to prepare a "tuning graph" similar to that shown in Fig. 5. This is calibrated from 0 to 100 on its vertical scale (to match the bandspread dial calibrations) and in frequency on the horizontal scale. The graph of Fig. 5 is for the 31-meter band and a hypothetical receiver; don't

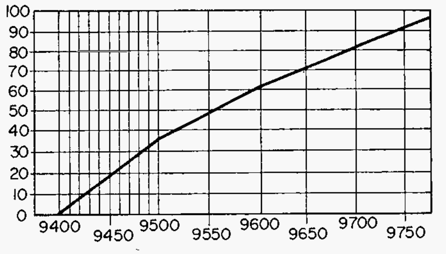


Fig. 5. Sample tuning graph for calibration of receiver's bandspread dial using 100-kc. standard plotted at the 100 kc. points. Vertical scale is bandspread dial reading, horizontal scale is frequency. Accuracy to 5 kc. or better can be expected even with straight-line calibration as shown in this sample calibration chart.

try to use it directly—it's a sample!

Start by putting in a dot where the "0" of the vertical scale meets the first (9400 kc.) standard-harmonic frequency on the horizontal scale. Move on to 9500 kc., the next standard harmonic, and up to the reading at which you tuned it in. Put in another dot. Keep this up until you've gone all the way across the graph.

With many receivers, you'll find that the dots lie on a perfectly straight line. If they don't, they will be on a smooth curve which you can match with a draftsman's "french curve" template—but you won't be far off if you simply connect adjacent dots with straight lines anyway.

Now, to spot the frequency of an unknown station, set the bandspread at "0" and tune in the 9400-kc. marker with the main dial. Then tune over to the unknown, with the bandspread dial. Look at its reading, and look up the corresponding frequency on the dial. You'll easily be within 5 kc.; usually, much closer.

This technique is fine for SWL use, but if you want more precision you'll have to add another piece of equipment to your 100-kc. standard. It's a "frequency divider," which subdivides the 100-kc. intervals into ten 10-kc. segments. This is the additional item shown in Fig. 4.

When the 10-kc. divider is added, your standard known frequencies are spaced at equal 10-kc. intervals throughout the RF spectrum. This means that *no* signal can be more than 5 kc. away from one of your markers. For instance, if the unknown signal happened to be at 9726.1 kc., it would be 6100 cps *above* the 9720-kc. marker, but only 3900 cps *below* the one at 9730 kc.

Its Good for CB. You can use this fact to measure the operating frequencies of CB transmitters to as close accuracy as your zero-setting of your standard will permit. Fig. 6 shows the set-up for doing it, and here's the technique:

First locate the approximate frequency of the unknown by counting 100-kc. markers (with the divider turned off) and then 10-kc. markers (with the divider on). This will give you the first digits of the unknown frequency; if you're checking a CB rig you already know what channel it's supposed to be on.

Next, run the output of the receiver you're using to listen to everything on into a mixer circuit such as that shown in Fig. 7, or into the vertical-input terminals of an oscilloscope if you have one. Feed the output of an accurately-calibrated audio oscillator which can be varied from around 100 cps up to 5000 cps into the other mixer input, or to the horizontal input of the scope.

With the marker, divider, rig under test, and audio oscillator all turned on, adjust the frequency of the audio oscillator while listening for a *low-pitched* beat tone. If you're using a scope, adjust for a line, ellipse, or circle as shown in Fig. 8. When you find the beat note, adjust for zero beat (same as Fig. 8 if using scope).

At zero beat, note the frequency of the audio oscillator. This is the number of cycles per second by which the unknown frequency differs from the *nearest* standard harmonic. However, you still don't know whether it is *above* or *below* this harmonic.

To find out which side of the harmonic the unknown is on, do some more marker-counting. Tune the receiver *up* to the un-

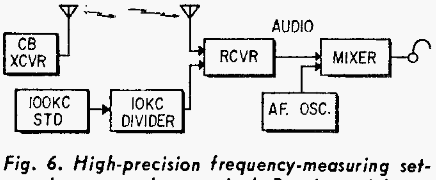


Fig. 6. High-precision frequency-measuring set-up using comparison method. Receiver picks up signal from transmitter, which beats against harmonic of 10 kc. from divider. Results is two audio tones, one below and the other above 5 kc. Lower tone, together with variable-frequency tone from AF oscillator, goes to mixer. AF oscillator is turned for zero-beat by ear. Frequency at which AF oscillator is set is number of cycles per second unknown frequency varies from 10-kc. harmonic. Accuracy of this technique is limited only by 100-kc. standard and AF oscillator.

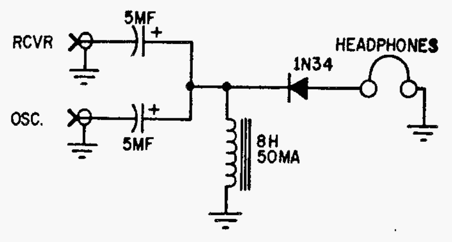


Fig. 7. Simple audio-frequency mixer circuit to allow detection of zero-beat point. Phones must complete DC path to ground; if louder signal is needed, transformer may be used in place of phones. Connect secondary of transformer to input of high-gain audio amplifier; amplifier must have excellent low-frequency response for listening to frequencies around 10 cycles.

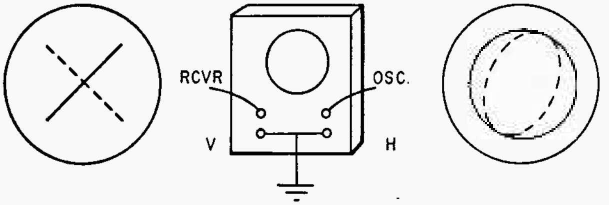


Fig. 8. Oscilloscope is more sensitive indicator of zero-beat than are phones. Diagram shows hookup to receiver and AF oscillator (Fig. 6). Any of four patterns shown above indicate zero-beat point. If receiver tone and oscillator tone are exactly in phase with each other, or exactly 180 degrees out of phase, straight line will appear (left). If phase difference is 90 degrees, circle will appear. Other phase relations produce ellipse (dotted, right). Frequency error of as little as 1/10 cycle per second is apparent as slow rotation of the 1:1 Lissajous pattern seen.

known signal, listening for the beat between the unknown and the 10-kc. markers. If, as you tune up, the first beat note you hear is higher in pitch than is the second one, the unknown is *below* its nearest marker. If the first beat is lower than the second, the unknown is *above*. In every case you will hear two beats. If both have about the same pitch, then the unknown is almost halfway between the two markers and you can measure both differences; the same rule will apply to determine direction.

Let's run through an example to show how it works. You hook things up to measure out a rig that's supposed to be on Channel 9 (27.065 mc.). We trust the crystal marking to be somewhere near 27.060 mc., and between there and the next 10-kc. marker at 27.070 mc. The audio oscillator indicates 4600 cps when we have a zero-beat tone.

This means that our rig is either 4600 cps above 27.060 mc., at 27.0646, or is 4600 cps below 27.070 mc., at 27.0654. Either way, it's only 400 cps away from the channel center, and since we have almost 1300 cps tolerance we can be sure its okay. But to find the exact frequency, we tune our receiver up slowly from around 26 mc. As we approach Channel 9, we hear a high-pitched beat note. We keep on tuning, and as we pass over the signal and move away on the other side still going up the note becomes slightly lower in pitch. This means that the rig is operating 4600 cps below 27.070 mc., and we know that its exact operating frequency is 27.065400 mc.; it's 400 cps high from channel center.

With sufficient care in setting the 100-kc. standard, and with an accurate audio oscillator and scope-detection of zero-beat, the comparison technique can give lab accuracy without lab expense. However, it *does* involve a certain amount of time and trouble; to get a high-precision reading in a hurry, we must use the frequency-meter approach.

Using the Frequency Meter. Unlike the comparison method, the frequency meter will give a virtually instant indication of the unknown frequency. However, for equal accuracy the frequency meter usually costs considerably more than the secondary standard, divider, and audio oscillator all put together.

The only fact making the frequency-meter technique practical for the average experimenter is that thousands of high-accuracy frequency meters built during World War II have been dumped on the surplus market, and many of them are still available. The most common models are the Army/Air Force version known as the BC-221, and the Navy equivalent, the LM. These two models are almost identical to each other; the major difference is that the LM includes internal modulation of its signal, so that it may be used as a signal generator, while most models of the BC-221 do not have this feature.

These meters may be purchased for anywhere from $20 to $100, depending on the exact model, condition, and presence or absence of the original "calibration book."

The "calibration book" is a tabulated listing of dial readings in terms of frequency; each one was prepared individually for its accompanying instrument, and is identified with the instrument's serial number. Without the book, the dial readings must be converted to accurate frequencies by use of the comparison technique—which means, of course, that instruments *with* their books command a higher price than those without.

However, no additional equipment is necessary to carry out the calibration—just time. If you're looking for a good instrument at lowest possible cost, and don't mind spending some time getting it, you can save money by getting a book-less meter. We'll go into the calibration procedure a little later.

To use the frequency meter, with the calibration book or your own equivalent of it, is simplicity itself. You turn the instrument on and let it warm up. While it does so, you set the dial to the general region of the unknown frequency you're going to measure, and look in the book for the nearest "check point."

These "check points" are dial settings at which the frequency-meter oscillator has a harmonic which should be at exactly 1 megacycle. The instrument has a built-in 1-mc. standard oscillator, so at the check points you should find the frequency meter and its standard zero-beat with each other.

If, instead, you hear an audio tone, adjust the "corrector" knob for exact zero-beat. This provides a fine adjustment of frequency-meter calibration.

Now, tune the frequency meter until you hear its signal beating with that of the unknown signal, in the receiver. Adjust the meter for exact zero beat, and read the meter's dial.

Look up the corresponding dial reading in the calibration book, and read off the frequency. That's all there is to it.

These frequency meters use a dual-range oscillator; on the "low" range it operates from 125 kc. to 250 kc., and on the "high" range it ranges from 2 to 4 mc. When measuring frequencies from 125 kc. to 2 mc., the "low" range is used; above that, the "high" range. Obviously, when measuring a frequency in the neighborhood of 10 mc., you're using a harmonic of the high-range oscillator.

Because of this use of harmonics, the rated accuracy of either the BC-221 or the LM is only 0.05 percent. For many uses this is good enough, but for many more it won't do. Fortunately, with a slight modification of the instrument, the accuracy can be improved to be comparable with either of the other techniques. Here's how to do it, and how to use it:

We've already mentioned that the frequency meter has built into it a 1-mc. standard oscillator, for providing check points. It also contains a mixer circuit which mixes the output of this oscillator with that of the calibrated oscillator, so that the check-point beat note can be heard.

Normally, when the controls are set to hear the check point, no external signal can be fed in, nor can the mixture of standard-oscillator signal and frequency-meter signal be routed to the outside of the case for use.

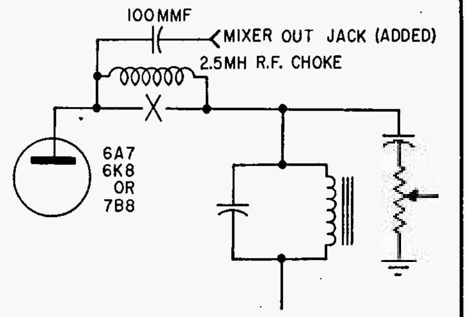


Fig. 9. Modification of most models of BC-221 for high-precision frequency measurement. Tube involved may be either 6A7, 6K8, or 7B8, depending upon model of BC-221. Lead to plate pin is removed and RF choke inserted in series, then 100-mmf capacitor run from plate pin to added output jack. For high-precision, use new jack. Set controls in the same manner as for crystal calibration during all measurements.

That's the purpose of the modification. Fig. 9 shows how it's done on most models of BC-221, while Fig. 10 shows the changes necessary on the LM. Fig. 11 shows the author's LM, after the modification.

With this change, we are no longer restricted to using the instrument as previously described. The signal appearing at the output connector may be a harmonic of the basic oscillator, as previously described, but it also may be either a harmonic of the standard oscillator, the sum or difference of any harmonic of the standard oscillator and the calibrated oscillator, or the sum or difference of the standard oscillator and any harmonic of the calibrated oscillator as well.

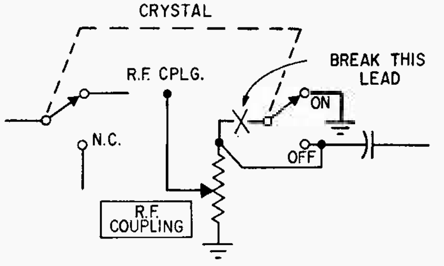


Fig. 10. Modification of LM frequency meter for high precision is much simpler. Diagram shows wiring on back of crystal on-off switch. Remove wire connected to center contact on side of switch away from side of case ("OFF" contact on other side has no connection) and connect this wire to "OFF" contact on same side. No other wiring changes are necessary in circuit.

e/e FREQUENCY MEASUREMENT

This may sound as if it would lead to unmitigated confusion in a hurry, but it doesn't. First, you determine the *approximate* frequency of the unknown signal in the ordinary way. Then you switch the frequency-meter controls over to crystal calibrate, turning on the internal standard, and set the basic oscillator to its "low" band.

Since the internal crystal oscillator operates at 1 mc. and has strong harmonics throughout the RF spectrum, you have known markers every megacycle. The unknown frequency cannot be more than 500 kc. away from one of these markers, in the same manner that the comparison technique locates the unknown within 5 kc. of its markers.

On the "low" range, the frequency-meter oscillator operates from 125 to 250 kc. The second harmonic of this range covers from 250 to 500 kc., and so we can reach *almost* any unknown signal with only the second harmonic of the frequency meter. However, if the unknown is less than 125 kc. away from the nearest marker we must move to the 4th harmonic to get the range 875 to 1000 kc., and measure from the *other* marker.

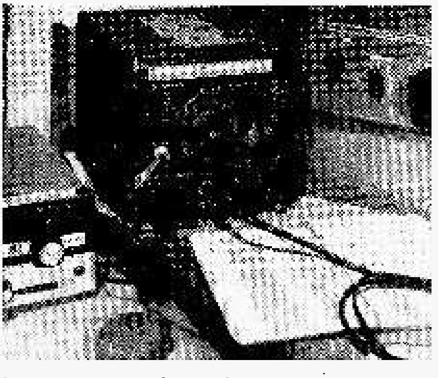


Fig. 11. Author's LM-10 frequency meter set up for use. Clip lead on "R.F. CPLG." post connects to receiver antenna terminals. Calibration book is visible under headphone cord. When used as described in text, LM and BC-221 series is easily accurate enough to measure operating frequencies of Citizens Band transceivers. Accuracy better than ±15 cps at 17 mc. is simple to attain. This unit has been modified as described; only external sign of change is hole visible on side, towards rear. If you'd like an LM-10 or similar unit, write John Meshna, Jr., at 21 Allerton St., Lynn, Mass. You'll get prices and availability information by return mail.

At the fundamental frequencies of the "low" range, the frequency meter is calibrated every 100 cps; even at the 4th harmonic, the calibration steps listed in the book are only 400 cps apart. This means that we can attain 400-cycle accuracy at radio frequencies as high as 30 mc.

When the frequency meter is used in this manner, a number of beat notes will be heard as the meter is tuned through its range. Most of these will tune rapidly, from high to low and back to high. They should be ignored during the measurement. The proper beat note will tune very slowly when it is reached, and may take a full revolution of the meter dial to go through the zero-beat point.

The basic limits to the accuracy of this method of measuring frequency are two: one is the accuracy with which the 1-mc. standard is set to match WWV, and the other is the mechanical accuracy of setting and calibrating the frequency meter.

The frequency meter may be assumed to have a maximum error of less than 500 cycles per second, on its low band (according to the original technical manual on this equipment), which is more than enough accuracy for virtually all experimenter purposes.

The internal standard may be set to WWV with an adjusting capacitor, built into the unit, in the same way that the comparison 100-kc. standard is zeroed. You will probably find it convenient to drill a hole in the case opposite the shaft of this capacitor, so that the adjustment may be checked often.

There is no question as to the frequency when this measurement technique is used. The first rough measurement gives you the frequency accurate to within 0.05 percent; the second, precise measurement simply refines the percentage to 0.001 or better. No calculations concerning "which side of the marker" are needed.

Calibration. Earlier, we said you could calibrate a frequency meter of this type without external equipment, even without the calibration book. It's time to see how this can be done.

The technique makes use of those many closely-spaced beat notes we said to ignore previously. Each one of these "tweets" marks a point at which *some* harmonic of the frequency-meter oscillator is beating with *some* harmonic of the 1-mc. standard. This

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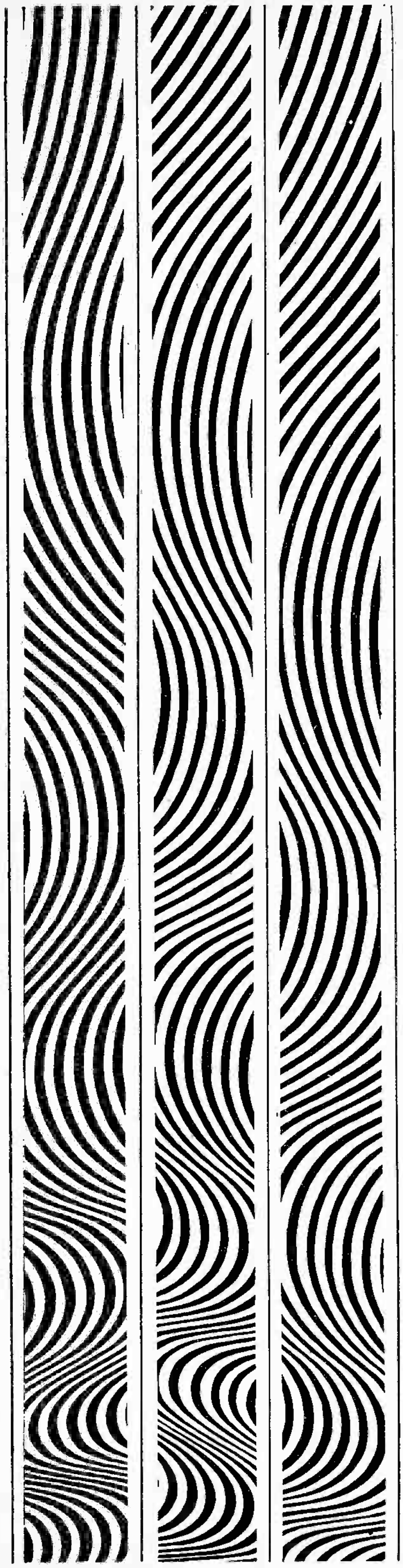


All About Tape Bias

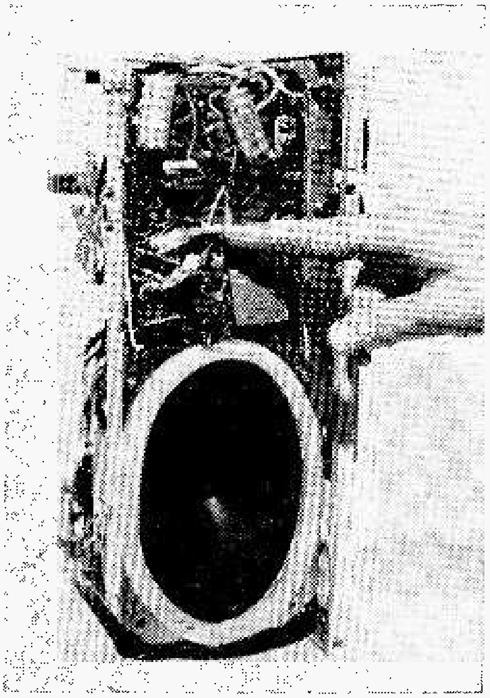
By Herbert Friedman

Don't hang your old recorder in the closet because it sounds so sad—change bias!

■ For many years one of the classic tape-recorder specifications has been *bias frequency*. Virtually every recorder manufacturer has a spec: one claims a bias frequency of 65 kc, another might claim 85 kc, and some get even more impressive by claiming their recorders use ultrasonic bias. Such specs might be meaningful if the bias *frequency* was the sole factor. Actually, within the present state-of-the-art, the bias *frequency* is a totally meaningless and valueless specification.

Bias Current. Foremost, it is the bias *current* which is important—and it is important whether the bias current, of a recorder, can be adjusted by the user. Few recorders, other than professional models, have *user determined* bias adjustments. The reason bias current is so important is because it's the key to the recorder's characteristics. It has great effect on distortion, output level, to some degree frequency response, and most important—which tape will record best.

The recording characteristic of magnetic tape isn't linear. It is severely distorted at dead center—the unmagnetized state. Fig. 1 shows a typical transfer curve. Note the severe distortion which turns the sine-wave input signal into a complex waveform. If the audio-signal level is low it can be centered on either of the two linear sections, as shown in Fig. 2, with a DC voltage and there would be no need for an AC bias. While this method is used in some inexpensive recorders, not using the full curve results in a much lower output and that, in



On some budget model recorders, bias current is changed by varying either a resistor or capacitor.

turn, gives a poor signal-to-noise ratio (among other ills).

To obtain a high-level output it is necessary to utilize the full curve. The bias current fills in the distorted section of the curve to obtain the full fidelity we now expect from the modern tape recorder and playback combination.

How Bias Works. Fig. 3 shows the effect of bias. Through the recording head (or in the recording magnetic field) an ultrasonic frequency is added to eliminate the distorted section (the dead zone of no magnetism) of the curve: the total input signal becomes the bias with the superimposed audio. As shown, the output-signal waveform does not resemble the input-signal waveform because of the distorted curve and the addition of the ultrasonic frequency bias. When the bias frequency is stripped away the resulting audio signal is undistorted.

Essentially, the bias *conditions* the tape. In the course of conditioning the tape it determines the output level, distortion, frequency response and a few minor characteristics.

Output Level and Distortion. Since output level and distortion go hand in hand let's start with them. Magnetic oxides aren't always identical. If they were, all tapes would reproduce exactly the same—and they don't. But tape is constantly being improved; for example, the Scotch-brand 111 tape that you buy today does not have the same characteristics as the Scotch 111 you bought ten years back (this applies to all brands of recording tape). Perhaps the greatest difference lies in the output level and distortion in relation to the bias current.

Fig. 4 shows the bias current vs. output level and distortion curves for three high-quality tapes manufactured over a ten-year period. (The curves also show the improvement made in recording tape, since curves A and B are of the same brand. Today all three tapes have almost identical curves.

As the bias current is increased the audio-output level, for a fixed audio-input level, rises sharply—and the distortion decreases sharply. When the bias current is increased a little more the audio-output peaks level off—then decrease gradually, as the bias current is increased still more.

Keep in mind that other tape characteristics, such as frequency response, follow the bias curve in that they are optimum at the tape peak-output level. Note also, that the distortion represented by tape C (a modern tape) just about levels off at the output peak and remains more or less constant.

Based on Fig. 4, it would be logical to state that bias current should be set to provide maximum tape output. But precisely what is maximum? Even if you standardized on one brand of tape, manufacturing changes occur in the oxide coatings (and improvements are also made) and what is optimum when using last year's tape might result in poor performance with this year's tape. Now, what happens if you use different brands, or different quality tapes?

Recording Quality. For example, assume you are now using a tape with characteristic C—but your recorder bias was set, years ago, to provide optimum bias (right on the peak) for a tape with characteristic A (Fig. 4). Without thinking, you splice in a section of tape from an old roll, one with A's characteristic, into a roll of C-type tape.

Then you forget about it. A week or so later, you use the roll to make a new recording. Now what happens? To begin with, since the bias is set for A-type tape the C-type tape is biased to the left of the peak (Fig. 4)—the high-distortion side—so your new recording is not quite as *clean* as the old ones (you might think it's time for a new recorder but there's nothing wrong with the recorder that a bias readjustment won't cure). Now back to the roll of tape with the A-C splicing. First note that there is a 4-db difference between the output from A-type tape and the C-type tape; at the splice there will be a sudden 4-db change in output. Should a sustained note be recorded across the splice the effect would be disastrous.

What To Do? The easy answer is to *standardize*. All you have to do is buy a life-time supply of tape when you buy your recorder. But most of us buy tape when we need it—a few reels every few months. The average tape library contains a conglomeration of brands, bought over a period of many years. The best bet is to make your own tests; every year or so; whenever you buy a new batch of tape; or, if you are real fussy—just before making those extra-special recordings. (See Tape Testing Made Easy, June-July, 1965 issue of RADIO-TV EXPERIMENTER for details on tests to determine proper bias.

Average Bias. You can start now! Take all your tapes (or a sampling from each purchase, each manufacturer, each year) and make the bias tests. You'll wind up with a set of curves similar to those in Fig. 4. There will be some bias setting where most tape curves intersect. (If they don't intersect they should be quite close.) The intersections will always be on the right—the low-distortion side—of peak tape output. Set the bias current—no matter what the frequency—to the bias indicated (straight down from the intersect point) by the group of curves you made while testing your tapes. By setting the bias current to the average value most of the tapes will be within 1 db of each other. (Remember, it is possible for bargain tapes to vary more than that from one end of the tape to the other.) Changes in frequency response are generally not as noticeable as severe changes in tape output level.

High-Output (HO) Tapes. This is a

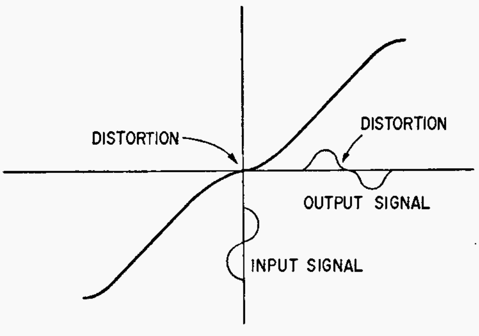


Fig. 1. Typical tape transfer curve shows distortion in the center that distorts sine wave input.

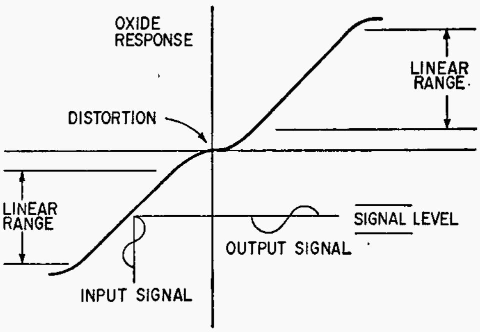


Fig. 2. Distortion can be overcome by using low audio signal but then output will be similarly low.

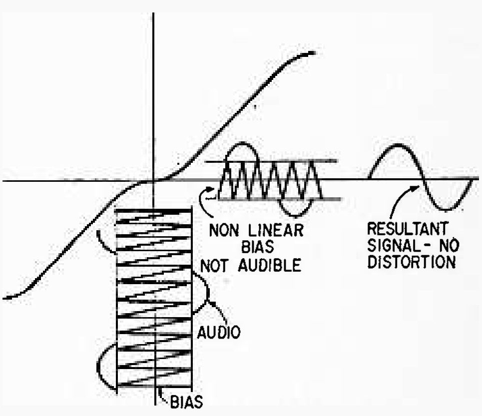
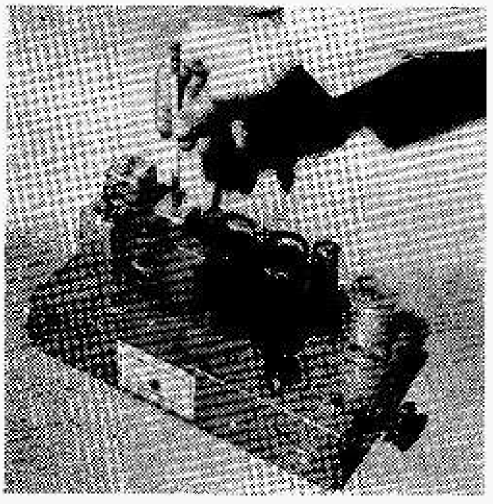


Fig. 3. When ultrasonic sine wave bias is used, it allows audio signal to "ride" linear part of curve.



The bias of this RCA recording amplifier, and other good machines, can be adjusted using coil or pot.

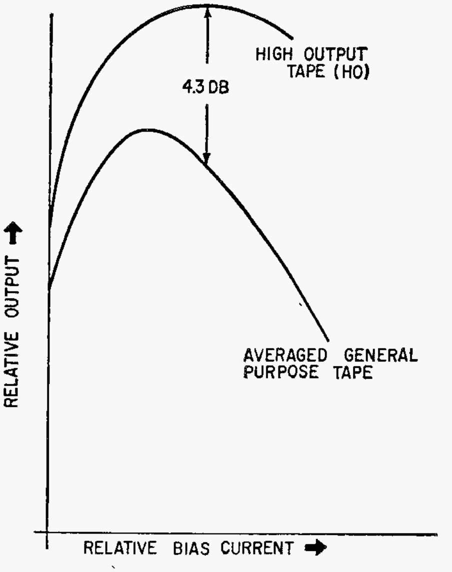
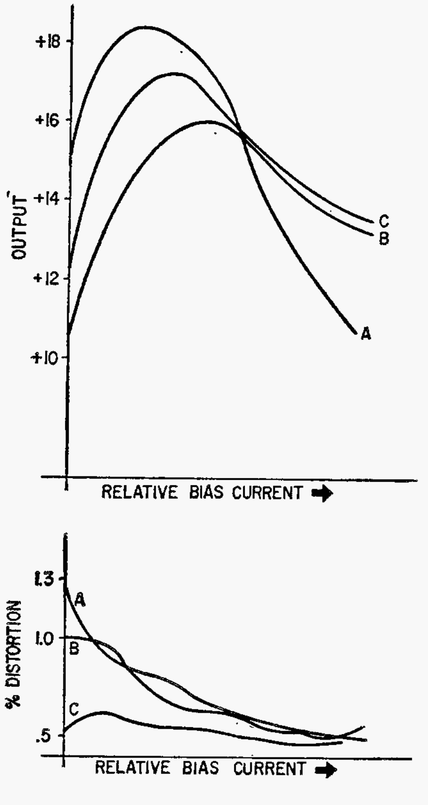


Fig. 5. HO tape has a relatively broad peak. It can deliver greater output than general purpose tape.

Fig. 4. The curves below show the output and distortion characteristics for three different tapes.



class by itself, you cannot use an averaged bias adjustment. As shown in Fig. 5, HO tape produces 4 to 5 db more output, for the same input level used for standard tape. Since HO tape can also handle a 2 or 3 db higher signal input (for a given percentage of distortion) a typical recorder can realize 6 to 7 db increase in signal-to-noise ratio as well as dynamic range. Both characteristics are important. HO tape can improve the noise factor of a just-marginal recorder and it also allows a greater dynamic range in music recording. But the recorder bias must be specifically adjusted for HO tape to realize all its potential—*it cannot be averaged.*

Frequency Response. The bias current also has great effect on frequency response. While many recorder characteristics determine the frequency response improper bias adjustment can place high-frequency losses beyond the compensation range of the high-frequency equalization circuits. Let us take, for example, a well-known recorder, which did not have sufficient equalization to compensate for the bias-caused loss of high-frequency response. The manufacturer of this recorder specified a bias adjustment that was actually to the left of the peak output

(Continued on page 115)

CB Selective Call

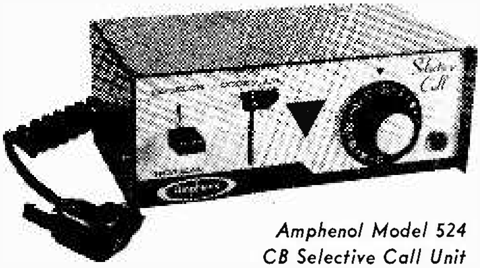
Encoders and decoders have taken the CB band out of the category of a maddening party line and put an end to the fatigue of listening for your call

By Len Buckwalter, KBA4480

■ Adding selective call to a CB rig is like putting on a pair of electronic ear muffs. The chit-chat, hullabaloo and assorted traffic on your channel suddenly grow quiet. There's blissful silence until—clank!—the set opens up and accepts a call. Is it from some crony trying to gas about a new antenna? . . . or a neighbor wanting to borrow a tool? It's neither. Only a signal bearing the "secret" code triggers open your receiver. That's the neat trick pulled off by selective call. First it decides if an incoming signal is from a unit in your system, then it lets you know about it. And just in case you want to restore normal operation, flick a switch and the set will take all comers.

Selective call is proving a boon to serious CB operators. Take a business office where CB is used to dispatch delivery trucks. During long hours of monitoring the formal atmosphere might be shattered by "Hey, Looie, that's a big fat 10-4 and gimme a rundown on your rig." With selective call the set stays locked tight. It also works the other way. If a dispatcher wants to alert only certain mobile units in the field, selective call can do that too.

The Tone That Counts. All CB selective call systems today are based on tone signalling. The idea is simply this: When one unit wishes to contact another station within his system, the operator presses a call button on his transceiver. This automatically transmits an audio tone over the air. At the receiving end the tone is picked up like any other signal on the channel. The receiver circuits, however, are wired with a sharp filter tuned only to the correct tone; all other incoming signals—voice, static, other tones—are rejected. After the tone is selected, it can be used to turn on the speaker, sound a horn, or light an indicator lamp. The point is that no other incoming signal can trigger or open, the receiver without a tone "key."



Amphenol Model 524 CB Selective Call Unit

CB SELECTIVE CALL

Not So Easy. Theory is one thing, practice is another. For any selective call system to work effectively, it must overcome a raft of technical obstacles. The hairiest one is what engineers call "falsing." It means the receiver trips open for signals other than the correct tone. Let's say the tone is on 2000 cps, a respectable frequency that lies somewhere in the upper ranges of the human voice. If someone gets on your channel and says "She sells sea shells . . ." chances he'll fire off your rig with those "s" sounds. They contain strong harmonics that hover around 2000 cps. What's more, atmospheric noise, static crashes or heterodynes on a crowded channel can upset a simple system. Trouble is there are plenty of ways for a simple system to be confused.

A look at actual circuits reveals that designers have come up with neat tricks to overcome the falsing problem. They also take care of problems like duplicate codes—where separate systems in one area might interfere with each other—and tone accuracy which keeps transmitter and receiver on the nose despite frequency drifting.

An Electronic Harmonica. The heart of most CB selective call systems is the *resonant reed relay* (Fig. 1). In a way it resembles an old-fashioned harmonica; there are thin fingers of metal, called reeds, which vibrate at audio frequencies. And like the harmonica, frequency depends on the physical size of the reed. Here the similarity ends. Your breath (air pressure) is used to set a harmonica reed

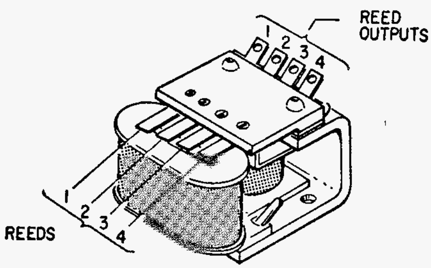


Fig. 1. Drawing shows construction of a typical resonant reed relay. The coil below the reeds is energized by the incoming audio signal. If the audio signal produces the same tone as the natural frequency of the reed, the reed vibrates strongly and strikes the electrical contact just above it. The system is extremely accurate due to low drift and precise frequency to which metal reeds respond.

vibrating, but the resonant reed relay requires an electromagnetic pull to set it in motion. The magnetic pull is provided by an incoming signal.

To illustrate the basic action, a 1-reed relay is shown in Fig. 2. Note there is a relay coil with a metal reed just above it. On top is positioned an upper contact. Let's assume the reed is physically sized so it naturally

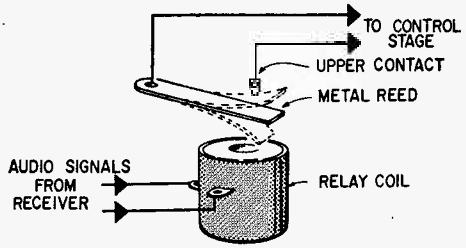


Fig. 2. The basic operation of the resonant reed relay—heart of most selective call systems—is illustrated here. The metal reed is brought to vibration by an audio signal that corresponds in frequency to the resonant frequency of the reed.

vibrates at 200 cps when plucked like a tuning fork. The plucking action is accomplished magnetically by the relay coil which receives audio signals normally intended for the speaker. But as these signal currents enter the coil they do not convert to sound, as in the speaker, but into corresponding magnetic fields. This energy represents anything that happens to be received on the channel—voice, static, tone. These fields commence to tug at the reed. But not until the right tone frequency comes along, does the reed really start to swing. A magnetic field at 200 cps (originating from the calling station) kicks the reed into its natural resonant frequency and resulting motion is so great that it bumps repeatedly against the upper contact. This raw switching action, as shown in a moment, is used to switch on the speaker. The distant station has now "awakened" the receiver.

A simplified schematic of the system, which is termed a *decoder,* is in Fig. 3. All incoming signals are fed through an audio amplifier stage and the relay coil energized. Note that there are now four resonant reeds instead of only one as shown in Fig. 2. With additional reeds on different frequencies, the user may change the tone code if it happens to coincide with another call system in his area. (Changing the code is generally done by sliding plastic tubes over unused reeds to keep them inactive.)

Returning to Circuit Action: Upon receiving the desired 200 cps tone, the reed vi-

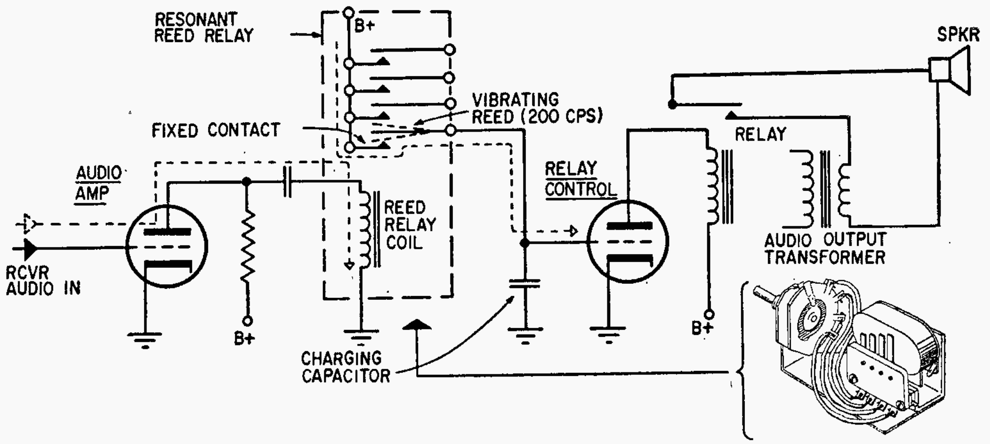


Fig. 3. Simplified schematic diagram shows operation of a decoder that employs a resonant reed relay.

brates and proceeds to strike its fixed, or upper, contact. Also note that every time a strike is made, the reed momentarily connects to a source of positive voltage—the B-plus. This voltage is now transferred to a charging capacitor located in the next stage. The capacitor's job: to smooth out the voltage interruptions from the vibrating reed. The capacitor stores these positive pulses and provides a steady bias voltage to trigger the relay control tube. This tube, in turn, closes a relay that completes the speaker circuit. Additional contacts on the same relay may operate an indicator light or starts a time-delay action which holds the speaker *on* for a number of seconds. If no one answers the incoming call, the circuit automatically returns to standby (speaker disconnected), waiting for the next call.

Encoding Signals. A remarkably simple circuit (Fig. 4), using the same reed relay, can transmit the calling tone. The encoder has neither tubes nor transistors. When an operator wants to alert his outlying station, he presses the call button. This is just a switch which connects a source of B-plus voltage (about 200 VDC) to a charging capacitor. As the capacitor charges, it sends a surge of current into the reed-relay coil. The signal is not a specific frequency, just a strong transient that twangs the reeds by magnetic pull. (The three other reeds are inactive.) But since the capacitor is operating from a source of DC, it rapidly charges to its full capacity and passes no further current to the coil. As the magnetic pull ceases, the reed springs back toward its rest position, overshoots it, and continues to vibrate, mechanically (at 200 cps), for another moment. This motion induces a voltage in the relay coil, actually an audio signal of 200 cps. The signal is passed to an audio stage in the transmitter and the call tone goes out over the air. The events occur so fast—approximately .2 second—that the signal may be termed a tone burst.

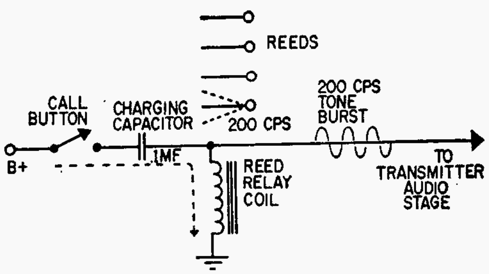


Fig. 4. Schematic diagram of encoder shows how circuit generates audio tone burst of 200 cycles/sec.

Hallicrafter HA-12 encoder uses 2-tone system with reed relay; encoder-decoder combo is available too.

Room For Improvement. The system just described has significant advantages. For one, a reed relay (like a tuning fork) provides extremely accurate and stable audio tones; there is little chance for frequency error between the two stations even with changing conditions of temperature and voltage (especially in mobile rigs). Also, the same reed relay is used for both encode and decode operations.

The falsing problem, however, plagues any 1-tone system. As mentioned earlier, a number of other signals, including the human voice, can trick the decoder into tripping open the receiver. The solution has been widespread use of 2- and 3-tone selective call systems. By transmitting more than one tone, the possibility of the circuits being tripped open by random interference is greatly reduced. The two approaches now in use are *simultaneous* and *sequential.* In the first, tones are sent at the same time; while the latter system strings them out in sequence. Another benefit of a multiple-tone system is that the number of coding possibilities is greatly increased.

Two-Tone Burst System. Let's consider an actual circuit that typifies the kind of selective call system now popular among CB manufacturers. It is the Lafayette "Priva-Com," which can be attached to most transceivers. It combines both encoder and decoder within one case and much of the circuitry is shared between the two functions. The complete schematic is shown in Fig. 5. In operation it transmits two audio tones simultaneously. Let's consider certain highlights of the circuit's operation.

At the top left of the schematic in Fig. 4 is the 4-reed resonant relay. When the instrument is first set up, two tones are selected; the other reeds are made inactive by plastic tubing. As the call button (S1) is depressed a surge of B-plus voltage is applied to the coil of the resonant reed relay at the top left of the schematic. In the same manner described for Fig. 4, the active reeds (1 and 4) are plucked into vibration. They induce audio voltages in the coil winding and this energy is used to modulate the transmitter with the desired 2-tone code.

During receive, the two incoming audio tones are fed to the coil winding where they

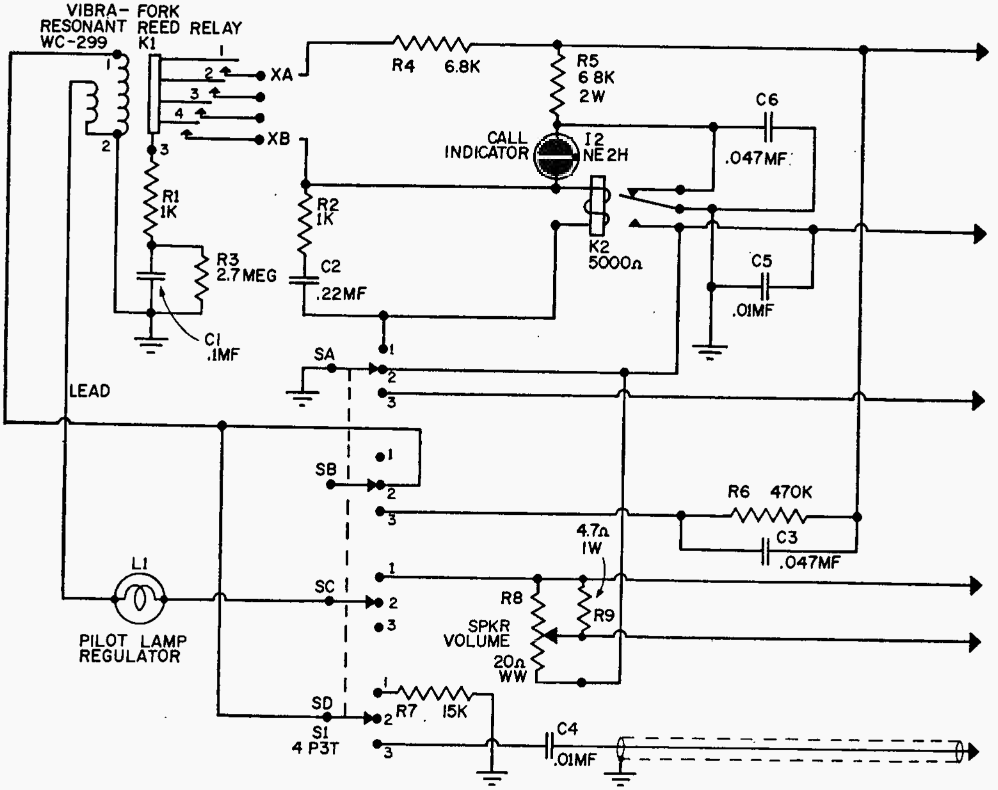


Fig. 5. Schematic diagram of Lafayette's Priva-Com encoder-decoder; leads at right terminate in plug.

proceed to vibrate reeds 1 and 4. This action applies B-plus voltage to a storage-type circuit consisting of resistors R1, R3 and capacitor C1. The same action occurs in a second storage circuit formed by R2 and C2. The circuit is wired so that voltages from both storage circuits *add*. The total voltage is then applied to the coil of relay K1 and it pulls in. (Note that this only occurs when the correct two reeds vibrate simultaneously. Otherwise, the required total voltage is not attained. It is highly unlikely that random noise or heterodynes could produce two precisely correct tones at the same time.) Contacts on the relay close the speaker circuit and illuminate a neon call lamp on the unit's front panel.

A protective feature of the circuit is the use of a pilot lamp (L1) as a regulator, seen at the lower left of the schematic. Any sudden or excessive audio peaks or noise tend to be limited by heating action in the bulb.

Various tone combinations with this system are shown Table 1. With four reeds the user may select various pairs for six different code possibilities. Six other combinations are possible with another reed relay using four other tone frequencies. Thus the system is flexible enough to provide a large number of codes and prevent possible duplication within a given region.

3-Tone Sequential. Another selective call system that has appeared in CB utilizes the more sophisticated 3-tone system. The tones are strung out in a row. It would be highly unlikely for interference to present three precisely correct tones—let alone generate them in proper sequence. The simplified operating principle of one system is shown in Fig. 6.

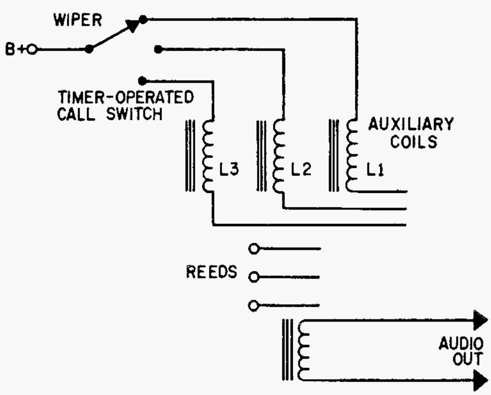
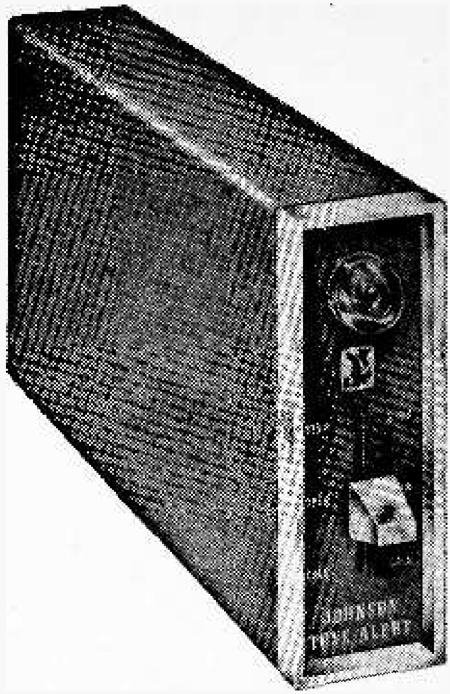


Fig. 6. Simplified schematic diagram shows operating principle of a three-tone sequential system.



Johnson Tone-Alert a one-tone system with plug-in choice of 37 tones, mounts on side of transceiver.

The ability to string out three tones, one following the other, is done by a mechanical arrangement of the call switch. When the operator depresses the lever, it does not snap back instantly. Rather, it slowly rides back to the rest position under control of a wind-up spring system—something like a kitchen timer. It takes about three seconds to return. During this period, the wiper on the call switch moves over the three switch contacts in succession.

There is another difference between this system and those described earlier. Note auxiliary coils L1, L2 and L3. Their sole purpose is to "pluck" the reeds, magnetically, as the call switch feeds a pulse of B-plus voltage to each one in turn. (You may recall

Reed Frequencies, CPS

Codes	Reed 1 266.0	Reed 2 296.5	Reed 3 330.5	Reed 4 368.5
1	X	x	—	—
2	X	—	x	—
3	x	—	—	x
4	—	x	x	—
5	—	x	—	x
6	—	—	x	x

that the pulse in the simultaneous system is applied directly to the reed relay coil. This is not practical where the tones must be spread out in time.) As each reed vibrates at its natural frequency, it induces a corresponding voltage in the reed relay coil, as before. The tones are applied to the transmitter and the encode, or call, function is completed.

How the same system decodes, or receives, the signal is shown in Fig. 7. During this

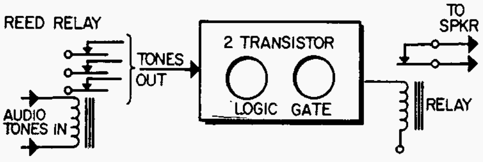


Fig. 7. The three-tone decoder uses logic-type AND gate to sum up correct tones and operate the relay.

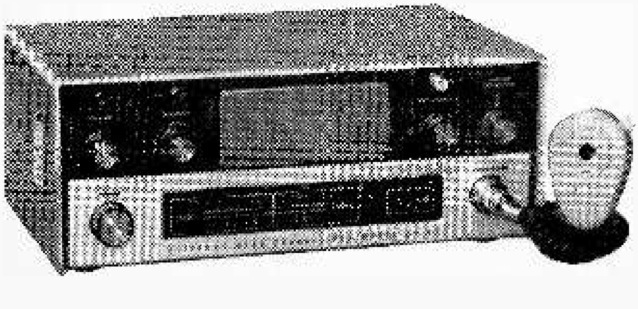
phase of operation, the auxiliary coils are not used. Incoming tones are applied directly to the reed relay coil which magnetically vibrates the reeds when the incoming code is correct. The designers of this system use some computer circuitry technology to decide whether incoming tones are correct. It is a logic circuit known as the *and gate*. It is nothing more than a two-transistor circuit which can tell whether it has received tone 1 *and* tone 2 *and* tone 3. The actual circuit is a rather complex arrangement of resistors and capacitors which charge and discharge according to the incoming tone voltages. Only when the audio contains correct frequencies, in the correct sequence will the various voltages add. The result forward biases the transistors to produce an output current flow. This operates the relay which controls the speaker or other desired function.

Installing a System. Many CB manufacturers, aware of the value of selective calling, now offer these units as accessories to their transceivers. They anticipate its installation by making provision for it. Usually there is a plug on the rear of the chassis which is simply removed. An identical plug from the selective call device plugs directly into the chassis socket and the system is ready to operate. No actual wiring required.

In other instances the device must be connected to the transceiver with a modification kit. This occurs when the rig is not already equipped with a pre-wired socket. Here the manufacturer provides wiring instructions and necessary hardware for converting the rig for selective call. Frequently the manufacturer provides detailed instructions for adding his system to transceivers of other makes.

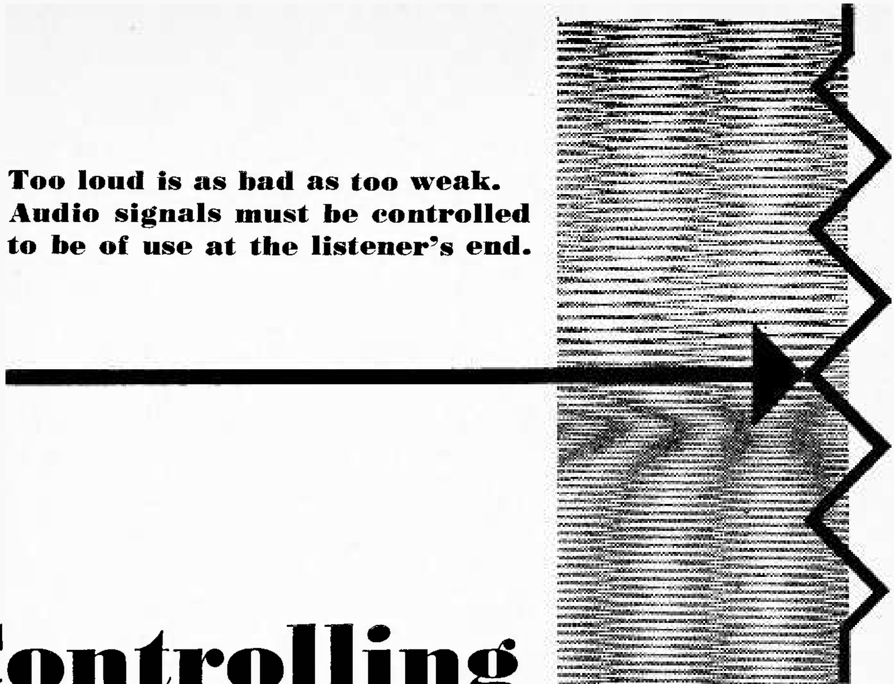
Operating Selective Call. All systems now on the market are operated in similar fashion. There is generally a switch marked Standby, Normal and Call. When the switch is on Normal, the transceiver functions as if the selective call system had not been installed. But set the switch to Standby and transceiver responds only to properly coded signals. The speaker is automatically triggered open and the calling station has an opportunity to speak. Alternatively, a call indicator may light to show that a call is being received.

If you wish to transmit a selective call to other stations in your system, it is necessary to observe FCC regulations. Just before pressing the call button, it is necessary to monitor the channel (switch on Normal). (You must be sure that the channel is clear and you're not interfering with other stations occupying the channel.) If nothing is heard, the call button is depressed. Of course, installing any selective call system doesn't prevent other stations from eavesdropping on your transmissions. That is unless they, too, are equipped with selective call to silence your signals on the channels. ■



The Heathkit GW-42 is an example of a Citizens Band transceiver with a selective call built in as original equipment. The operator can select one of four tones with the front panel control knob. One switch position permits simultaneous monitoring of all four tone frequencies in the receive mode.

Too loud is as bad as too weak. Audio signals must be controlled to be of use at the listener's end.



Controlling Audio Volume

By Leo G. Sands

■ The volume control, next to the TV channel selector, is the most widely used voting device. It enables the ladies to lower the sound level to a whisper and lets you bring Leonard Bernstein right into the living room. The tone controls, too, let us vote. You can make the bass rattle the house and the cymbals and bells crack the glassware. The tone controls enable you to make music sound almost live, or what you think it should sound like. In fact, tone controls have conditioned us to new sounds, as evidenced by the comments of a patron at the Warfield Theater (in San Francisco) a few years ago, who was overheard saying, "Sounds tinny, doesn't it?", as she listened to the superb music of Walt Roesner's live orchestra in the pit. Because of tone controls, many have forgotten what live music sounds like.

Early phonographs had no volume controls or tone controls. You merely turned it on and the music went 'round and 'round and came out the horn. The first phonograph volume control was a venetian-blind type shutter in front of the horn which reduced the volume by muffling the sound. When electronic phonographs became available, a pot (potentiometer) took the place of the shutter. Since then, the volume control has become more sophisticated. We have loudness controls, level controls and gain controls. We also have treble controls, bass controls and balance controls.

Volume Control. The most simple volume control of an amplifier, radio or TV set is just a potentiometer connected as shown in Fig. 1. It functions as a voltage divider ahead of the audio amplifier. Potentiometers used as audio volume controls have a resistance element which is not linear since voltage and loudness are not directly proportional. There is a small increase in resistance at the beginning of the clockwise shaft rotation and a faster increase in resistance toward the other end. This taper is known as *audio taper* or *left-hand logarithmic*. If a linear pot is used as a volume control, the change in volume, as far as the ear is concerned, would not be gradual. A linear pot would provide a linear increase or decrease in signal voltage. An audio-taper pot provides a linear increase or decrease in loudness which is logarithmic and is expressed in decibels (db). (See Fig. 2)

A volume control is often called a *gain* control. It is actually an input level control when it is at the input of an amplifier (as in Fig. 1). It is also a *gain* control since it is used to change the gain (amount of amplification) between the input and the output of the amplifier.

Level Control. A device between the audio signal source and the amplifier input terminals, with which the level of the signal applied to the amplifier can be controlled, is a true *level* control and is often called a volume control. But, it is not a gain control since it does not affect the gain between the input and output terminals of the amplifier.

The standard volume control circuit (Fig. 1) is usually at the input of the first stage of the amplifier. However, in some amplifiers it is connected between a preamplifier stage and a voltage amplifier stage, as in Fig. 3. It controls the gain through the stages behind it, but the gain of the preamplifier stage is not affected.

Bias Control. The actual gain of an audio stage can be controlled by varying the negative bias on the grid of a remote-cutoff tube as shown in Fig. 4. (In this and other circuits a battery is shown for simplicity but the voltage source can be a rectifier or a voltage divider.) In Fig. 4 the gain of the tube is reduced by increasing the negative bias on its grid, and vice versa. This will work only when the tube has remote cut-off characteristics. A sharp cut-off tube would just cause distortion since it would start functioning as a plate detector when the bias is increased close to, or beyond, cut-off.

Indirect Gain Control. The gain of an amplifier stage can also be varied by controlling the electron stream as shown in Fig. 5. Here, a pentagrid tube is used. The audio signal is fed into its injection grid (#3) and gain is controlled by varying the bias on its control grid (#1). Making the voltage applied to this grid more negative reduces the flow of electrons from the cathode to the plate and thus reduces the gain of the tube.

When a sharp cut-off pentode or tetrode tube is used, its gain can be controlled by varying its screen voltage as shown in Fig. 6. When a gated beam tube (6BN6, etc.) is

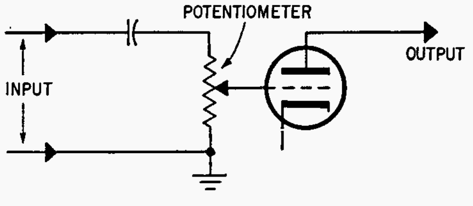


Fig. 1. Simple circuit controls volume or gain.

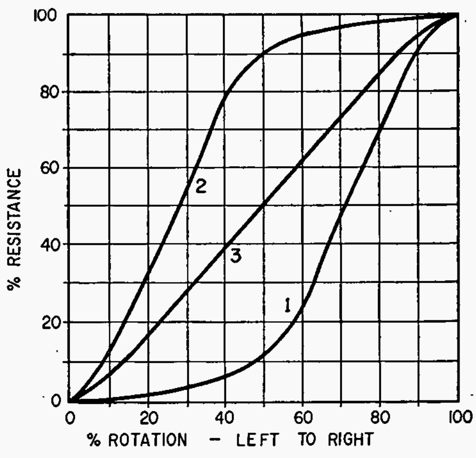


Fig. 2. Audio taper-1; reverse-2; linear-3. Some six tapers are available for special purposes.

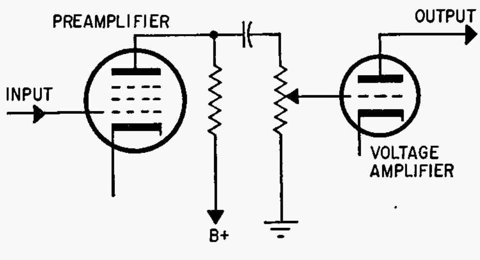


Fig. 3. Control between stages of amplifier.

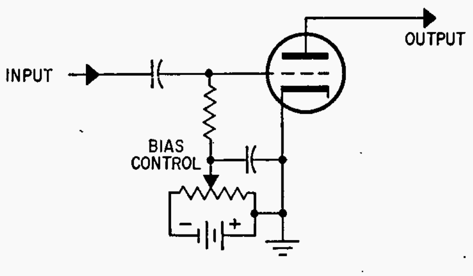


Fig. 4. Varying bias changes gain of vacuum tube.

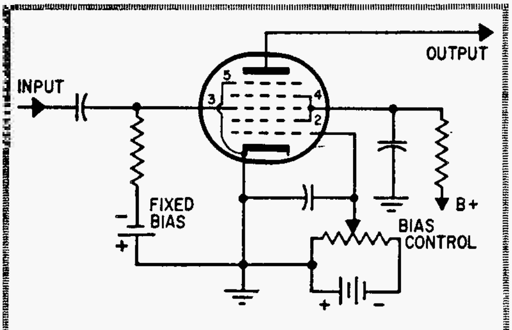


Fig. 5. Bias control with multielement tube.

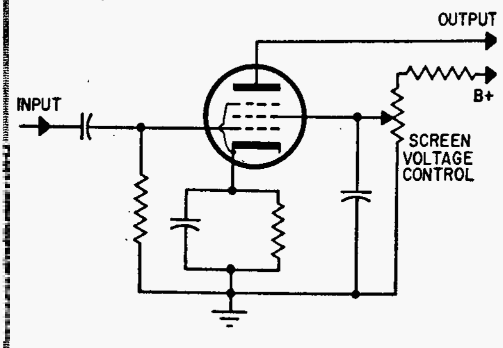


Fig. 6. Screen voltage changes pentode gain.

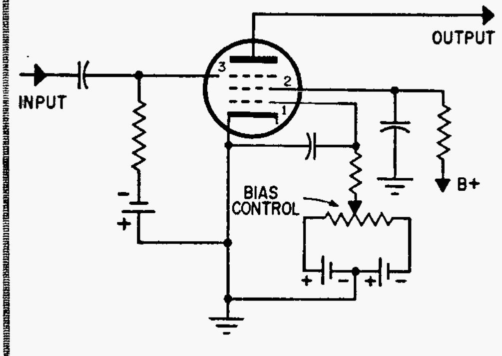


Fig. 7. Suppressor is control grid with low B-plus.

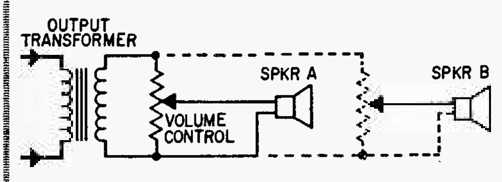


Fig. 8. Speaker volume A independent of speaker B.

used (Fig. 7), the signal can be fed into the quadrature grid (#3) and the gain controlled by varying the DC voltage applied to the control grid (# 1). Here, maximum gain is obtained by making grid #1 slightly positive. Making the grid more negative reduces the gain. The tube will cut off completely if grid #1 is made more than two volts or so negative.

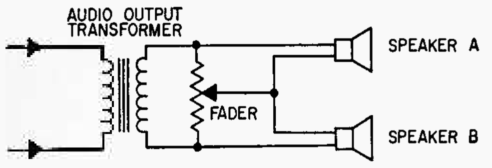
In all of the above examples, a potentiometer is used as a voltage divider, either in the audio signal path or in a DC supply circuit. A potentiometer can be used at the output of an amplifier, instead of the input, as shown in Fig. 8, to control the level of the signal being fed to a speaker. In dual-speaker automobile radio installations which have a speaker under the dash and another at the rear window, a potentiometer is often used to apply audio to both speakers simultaneously or to only one, using a circuit like the one in Fig. 9.

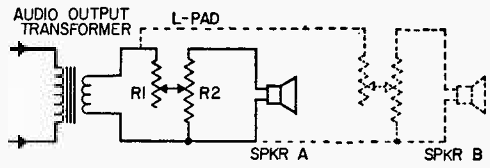
A fader is a potentiometer at the input of an amplifier which enables controlling the signal level from either of two audio signal sources, but not both at the same time. Faders are commonly used in theatre sound systems for switching over from one sound projector to the other smoothly, without a click.

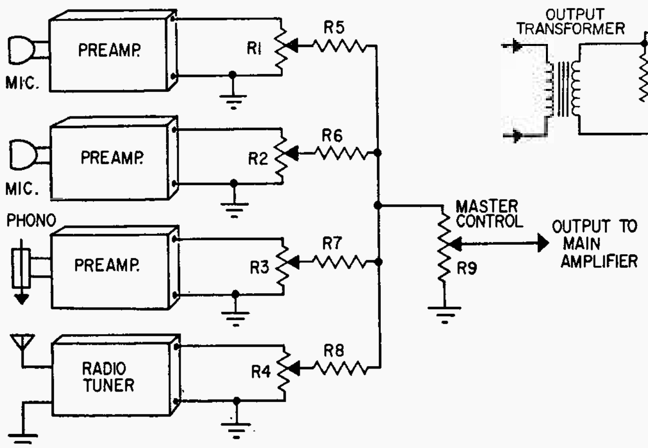
Potentiometers are also used in multi-input audio amplifiers, one for master control, as shown in Fig. 10. The level of each input channel can be controlled individually, making it possible to mix the signals. The level of the combined input signals can be controlled by the *master* control.

Attenuator Pads. So far, we have discussed only potentiometers as a voltage divider for controlling signal level or amplifier gain. In broadcasting stations and in high grade public address systems, variable attenuators are commonly used for controlling the level of audio signals. The most well-known types of attenuators are the L-pad, T-pad and the H-pad. The specially-constructed tap switches employing precision fixed resistors (used in broadcasting) are expensive, but inexpensive L-pads and T-pads are available. These are inexpensive ganged potentiometers.

An L-pad is two potentiometers with their rotors ganged and driven by the same shaft.







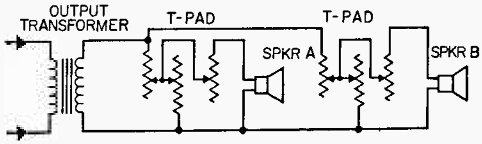


Fig. 9. (top, left) One circuit used for front-and-rear speaker systems in many automobiles.

Fig. 10. (left) Pots with isolating resistors is economical circuit for combining inputs.

Fig. 11. (top, right) L-pads are used for much less interaction.

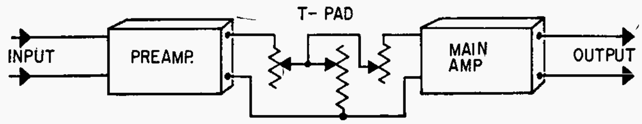
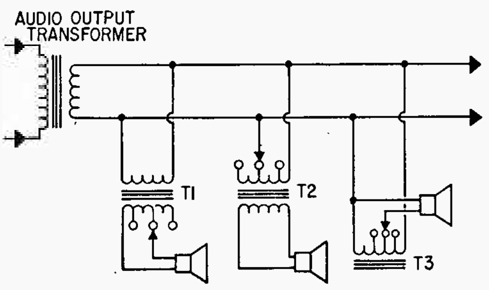


Fig. 12. (above) T-pads give most isolation to line from load change.

Fig. 13. (above) T-pad is needed when the distance between units become greater and line impedance has more effect on frequency response due to capacitive losses in line.



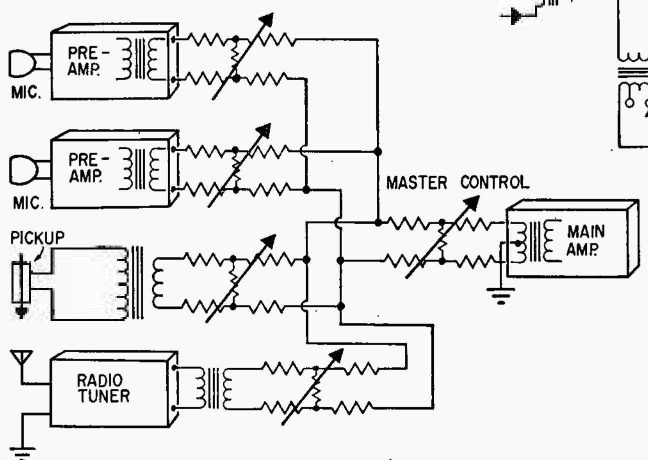


Fig. 14. (left) H-pads are needed for balanced lines to keep ground capacitance effects equalized and cross-talk kept to a minimum.

Fig. 15. (above) Three methods of connecting speakers to a line. Generally single method is used.

While it performs the voltage divider function of a single, conventional pot, it maintains, at all settings, a constant resistance looking back into the load or into the signal source, depending upon which way it is connected. Fig. 11 shows how an L-pad is connected for controlling the sound level of a speaker. It maintains constant load on the amplifier output regardless of its setting.

A T-pad consists of three potentiometers, also ganged and driven by a common shaft. At any setting, it loads the incoming and outgoing circuits with the same amount of resistance. An L-pad is used where it is important not to vary the loading on the signal source. A T-pad is used where it is important to keep the loading constant on both the signal source and the load.

T-pads are often used to control, individually, the audio signal level from an audio amplifier being fed to several speakers. This permits adjustment of the level fed to one speaker without affecting the level fed to the other speakers. If a potentiometer is used, as in Fig. 8, the loading on the amplifier will change as the pot is adjusted. When set to zero (fully counterclockwise), only the pot resistance will be across the signal source. At the other extreme setting, the load will consist of the speaker and the pot in parallel.

When an L-pad is used, as in Fig. 11, the amplifier load will not change, regardless of the setting of the pad, since R1 adds resistance to the circuit as the effective shunt resistance of R2 is reduced, and vice versa. The resistance across the speaker, however, varies with the setting of the pad.

By using a T-pad none of the impedance relationships are disturbed. When increasing the volume with the T-pad (Fig. 12), the resistances of the two series elements decreases while, at the same time, the resistance of the shunt element increases.

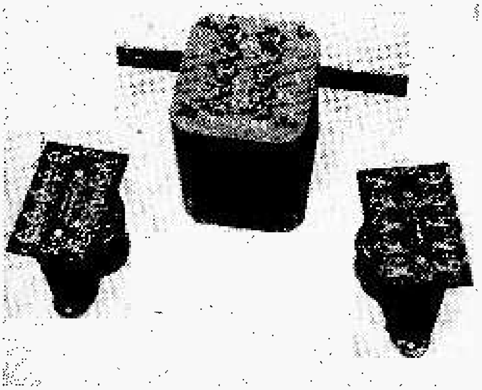
Attenuator pads are frequently used to control the level of signals fed to the input of an amplifier, particularly where long input cables are required. Generally, a T-pad or an H-pad is used since it is important to maintain a constant impedance in both directions. The H-pad differs from a T-pad in that it is designed for use in balanced circuits (neither side grounded). In Fig. 13 a T-pad is shown as the level control between the low-impedance output of a preamplifier and the low-impedance input of the main amplifier. A more complex circuit is shown in Fig. 14 where H-pads are used to mix signal levels from various sources, as well as for over-all level control.

Transformer Level Control. In audio work, transformers are thought of, primarily, as impedance matching devices. For example, to use a 50-ohm (low-Z) microphone, a stepup transformer is generally used to raise the impedance to match the input of the typical amplifier. At the same time, the transformer, of course, steps up the voltage. In many modern sound systems, transformers are used for the purpose of voltage control without worrying about so-called impedance matching. It is often assumed that it is necessary to connect an 8-ohm speaker to the 8-ohm amplifier output terminals. But, this is not so if the amplifier has good output-voltage regulation. The 8-ohm speaker can be connected to the 4-ohm output terminals, but with a small loss in volume.

In many public address and sound distribution systems, the amplifier gain is fixed and the input signal level is adjusted so that the amplifier delivers audio at a nominal level of 25, 70 or 140 volts. The audio-output line is used like an AC power line. The signal level across the line obviously varies with speech or music undulations, but its average level is maintained at a constant value. The amplifier output must have a very low impedance for this system. The output voltage varies less than 1.5 db whether there are several speakers, or none, across its output.

The speakers are connected to the output line (through three different kinds of transformers) as shown in Fig. 15. Here we are concerned with voltage not impedance. The transformers function as voltage stepdown transformers. Volume level of each speaker can be adjusted individually by selection of transformer taps. If the line voltage is kept at 70 volts and the stepdown ratio of the transformer at the selected tap is 10:1, seven volts will be fed to the speaker. If the speaker impedance is 8 ohms, the speaker will consume 6.1 watts equals voltage-squared divided by the speaker impedance ($W = E^2/R$).

In Fig. 15 the secondary of T1 is tapped (see Fig. 16), the primary of T2 is tapped



Constant-voltage line transformers.

and T3 is a tapped autotransformer. All provide the same basic function, a voltage-stepdown transformer. By selecting different taps at the various locations, one speaker could be set to operate at 10 watts, another at 5 watts and still another at one hundred milliwatts. However, the total power consumption of all of the speakers must not exceed the power capability of the amplifier.

Constant Level Amplifiers. The above techniques can be used successfully when the amplifier is designed to deliver audio at a constant level. A good hi-fi amplifier, which has plenty of negative feedback, has a much lower output impedance than indicated by the speaker-terminal markings. When the amplifier is fed from a record or tape player or a radio tuner, the volume level will remain fairly constant. But, when a microphone is to be used, the signal level will vary all over the place unless gain control is adjusted constantly. In some public-address amplifiers, this problem has been overcome by employing AGC (automatic gain control) or level limiting. Fig. 17 is a block diagram of an audio amplifier with AGC. A portion of the audio-output signal is rectified, through a voltage-doubler, to derive a negative DC voltage whose level varies with the audio-output signal level. It is prevented from following the rapid audio-signal fluctuations by capacitor C2 which provides delayed action. As the audio output signal increases, the negative DC voltage, which controls bias on the first AF amplifier stage, also rises and reduces the gain.

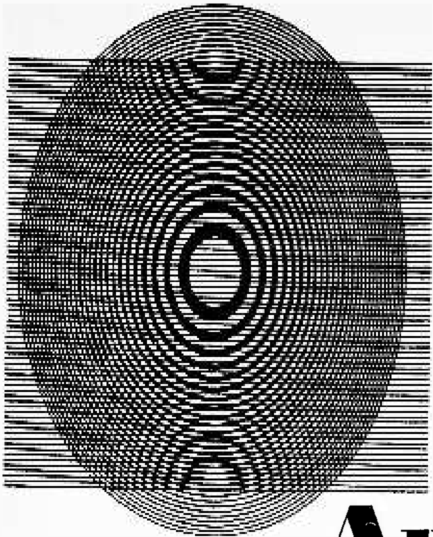
Other techniques for automatically controlling audio levels have been developed. A thermistor, for example, can be used at the output of an amplifier, as shown in Fig. 18. Resistors R1 and R2 and the thermistor form a voltage divider. When the audio-output signal level rises, the thermistor is warmed by the increased current flowing through it and its resistance decreases, altering the ratio of the voltage divider at the junction of R1 and R2.

The audio-output signal can be used to vary the level of the audio-input signal by feeding the output signal to a lamp inside of a dark enclosure also containing a photo-sensitive resistor, as shown in Fig. 19. When the audio output signal increases, the lamp burns more brightly and the resistance of the photo-sensitive resistor drops causing a change in the ratio of the voltage divider at the junction of R1 and the photo-sensitive resistor in the amplifier input. R2 is used for setting the desired output signal level.

In Fig. 20 a transistor (Q1) is used as one leg of a voltage divider. The input signal is fed to the amplifier through the other leg (R1) and to the amplifier input through C1. The audio output signal is rectified by D1 and then fed back to the base of the transistor. The desired audio-output level is set by the adjustment of R3. The rectified audio is filtered into smooth DC by R2 and C2. When the output signal rises, the base of the transistor sees a more negative voltage (forward bias), causing its collector-to-emitter resistance to fall, thus reducing the level of signal fed into the amplifier.

Limiters. Another way to provide audio output at a constant level is to use a limiter stage in the amplifier, as shown in Fig. 21. The limiter may employ a pair of diodes as in Fig. 22. Some circuits use a pair of diodes. In the circuit shown here, both diodes are forward-biased so that they conduct normally and pass audio. When the audio signal rises above a certain level the diodes stop conducting during part of the time. When the signal swings positive enough to offset the forward bias on D1, this diode stops conducting and opens the audio circuit. When the signal swings negative, forward bias for D1 increases and it continues to conduct. But, the negative signal, when

(Continued on page 111)



Controlling Audio Tone

BY LEO G. SANDS, W7PH/KBG7906

Variable controls are not the only ways of making audio behave. Some conditions must be constant.

■ Early phonographs had no audio controls. You merely turned it on and the music went 'round and 'round and came out the horn. The first phonograph audio control was a venetian blind type shutter in front of the horn which reduced the volume by muffling the sound. When electronic phonographs became available, a pot (potentiometer) took the place of the shutter. Since then the controls on home-entertainment music systems have become more numerous and more sophisticated. We find loudness controls, level controls and gain controls. We also have treble controls, bass controls and balance controls. Bass and treble controls are called tone controls—actually they are volume controls that affect just some of the audio frequencies—not all.

Tone Control. The frequency response of an audio system can be improved, modified or limited by connecting a capacitor of appropriate value in series with or shunted across the audio signal path. For example, the low-frequency response of an audio amplifier can be reduced by using smaller capacitance interstage coupling capacitors. High-frequency response can be reduced by connecting a capacitor from the grid or plate of one of the amplifier stages to common ground.

In a P. A. system where only voice reproduction is required, the unwanted lows can be attenuated by connecting a capacitor in series with the speaker. The reactance of the capacitor becomes high at low audio frequencies but is negligible at high frequencies. Since a rather large value capacitor is required, a pair of electrolytics are often used instead of a single, much more costly oil-filled capacitor. The electrolytics are connected in series-opposing as shown in Fig. 1. For instance, when a pair of 20-mfd capacitors are used, their effective capacitance is 10 mfd. It is necessary to use two electrolytic capacitors (of double the required value) and connect them as shown

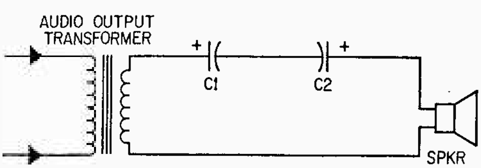


Fig. 1. Capacitors in series with speaker reduce the low-frequency output: low C values = few lows.

in the diagram because they are polarity-sensitive. By connecting them in series-opposing as shown, they can be used in AC (audio) circuits.

A bandpass filter can be connected between the signal source and the amplifier input to limit the range of frequencies passed through the amplifier. More often, the frequency response is made variable by adding a tone control into the amplifier itself. This can be a potentiometer and a capacitor as shown in Fig. 2. With the full resistance in

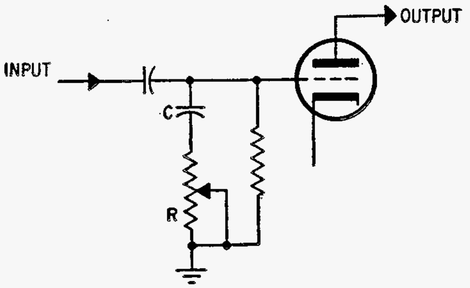


Fig. 2. Resistance R limits high frequencies that can be bypassed through series capacitance C.

the circuit, there is only slight attenuation of the higher audio frequencies. As the series resistance is reduced, the effective reactance through R and C becomes lower and the attenuation of high frequencies becomes greater. This is an artificial way to improve bass response. By attenuating the highs and increasing the volume, the lows become more predominant.

Low frequencies can be attenuated by connecting a potentiometer and capacitor as shown in Fig. 3. When the pot is adjusted so

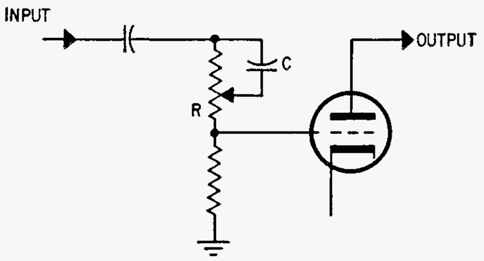


Fig. 3. Capacitor C bypasses high frequencies around resistance R without affecting bass notes.

that the capacitor is out of the circuit, essentially all frequencies are passed with the same amount of attenuation. But, as the pot is adjusted so that there is more resistance in parallel to the capacitor, the high frequencies find a lower-reactance path through the capacitor. Hence, the low frequencies are attenuated more than the high frequencies.

Feedback. Degenerative (negative) feedback is used in many amplifiers to improve frequency-response characteristics. One of the simplest techniques is shown in Fig. 4. When cathode resistor R2 is bypassed by C2 (switch S closed), there is no audio signal voltage across R2, only DC, if the capaci-

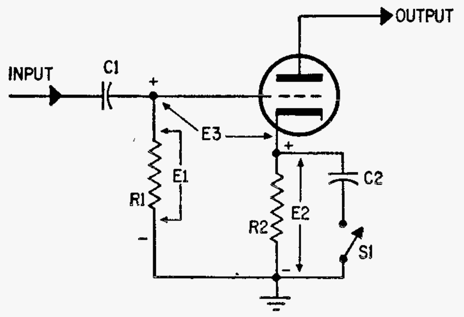


Fig. 4. Signal voltage E1 is reduced by opposing cathode-bias voltage E2 when C2 is not in circuit.

tor is sufficiently large. But, when R2 is not bypassed (S open), a signal voltage is developed across R2 which is in series opposing (180° out of phase) with the input signal voltage. The gain is reduced by the amount of this voltage and the frequency response is not dependent upon the reactance of a cathode by-pass capacitor—it isn't in the circuit.

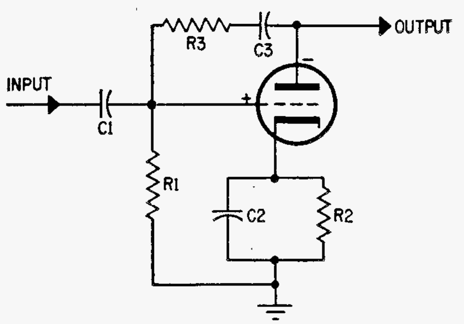


Fig. 5. Feedback voltage through R3-C3 opposes the voltage change at the grid of triode tube.

Negative feedback can be introduced by feeding back the signal from the plate of a tube to its grid as shown in Fig. 5. The signal at the plate is 180° out of phase with the signal at the grid. The signal at the plate is fed back to the grid through C3 (which blocks the passage of DC) and R3 to the grid. The amount of feedback depends upon the ohmic value of R3. If C3 has low capacitance, the feedback will be greater at the higher frequencies than the lower frequencies.

Overall degenerative feedback is used in many amplifiers. The audio-output signal is fed back to the input of the amplifier as shown in Fig. 6. By taking a little of the audio from the secondary of the output transformer, even the transformer is included in the negative feedback loop and some of the distortion it would otherwise introduce is reduced. Overall feedback can be tricky. The idea is to feed back a signal which is 180° out of phase with the input signal. But, if there is phase shift (which varies with frequency) in the amplifier, the feedback signal may be in phase with the input signal at some frequencies and produce positive feedback—and unwanted oscillation.

Simple Bass Boosters. The bass response of small radios can be markedly improved even when using a small speaker by adding feedback as shown in Fig. 7. The ground end of the grid resistor (R1) of the first audio stage is lifted from ground and connected to ground through an added resistor (R2). The audio signal from the plate of the power-amplifier stage is fed through C1 to the junction of R1 and R2. By also adding switch S to the circuit along with choke L1 and capacitor C2, three choices are made available. With the switch open, fairly linear feedback is provided. With the switch set to cut L1 into the circuit, the bass response is improved since the low frequencies find a low-reactance path through L1 to ground and the amount of negative feedback rises with frequency. By setting S to cut in C2, high-frequency response is improved since the high frequencies pass easily to ground through C2 and there is more negative feedback at the lower frequencies. The values of L1 and C2 vary with the radio's characteristics. The primary of a small output transformer may be used for L1.

Bass response can be improved without attenuating the high frequencies significantly by employing a resonant circuit as shown in Fig. 8. Capacitor C and inductor I form a series resonant circuit. At frequencies near resonance, a large signal voltage is developed across L. The same technique can be used with an interstage audio transformer as shown in Fig. 9. By using a value for C which resonates with the primary of the transformer at a low audio frequency,

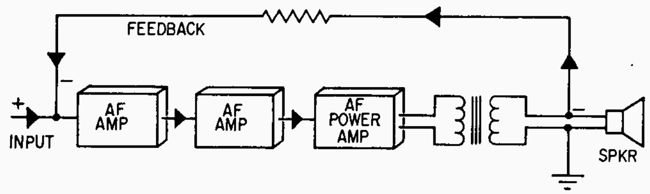


Fig. 6. Feedback loop can be from secondary of output transformer to input circuit. Without capacitor in circuit feedback is approximately the same for all frequencies.

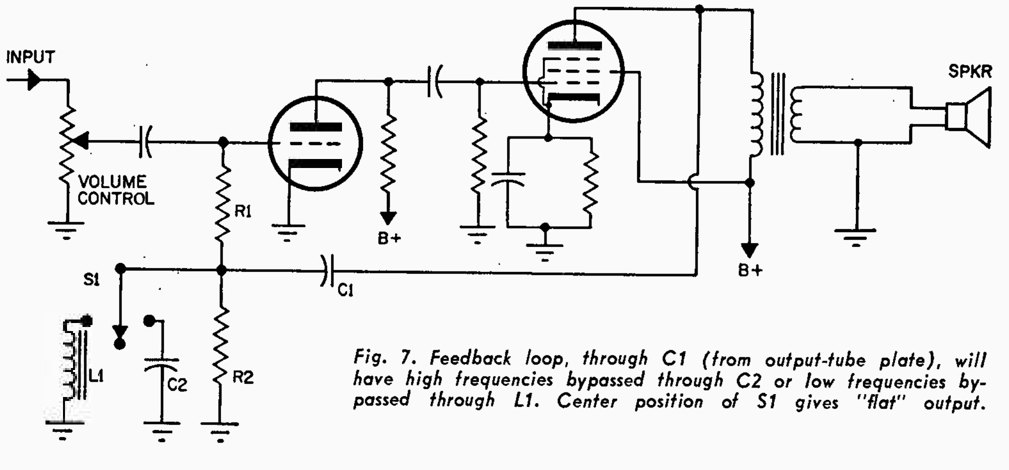


Fig. 7. Feedback loop, through C1 (from output-tube plate), will have high frequencies bypassed through C2 or low frequencies bypassed through L1. Center position of S1 gives "flat" output.

considerable bass boost can be obtained. Or, by making C a low value, bass response can be attenuated. Resonant tone control circuits, such as these, may *ring*. That is, they oscillate briefly at the frequency of resonance. The effect may be pleasing to many, but some may not like it since it is a form of distortion.

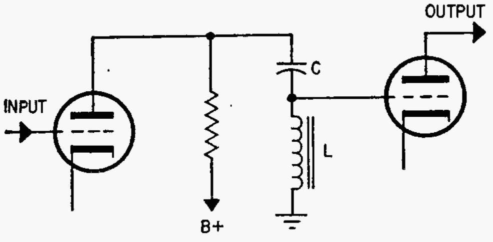


Fig. 8. C and L form tuned circuit that will distort the frequencies near resonance by "ringing."

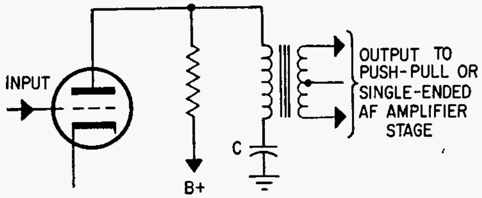


Fig. 9. Interstage transformer can be tuned for bass boost by adding resistor and capacitor C.

Impedance Matching. It is commonly understood that maximum power is transferred when the load impedance is equal to the signal source impedance. For instance, it is said maximum sound is delivered by an 8-ohm speaker when it is fed from the 8-ohm amplifier output terminals. It will work fine, but at reduced level, if the amplifier has good output-voltage regulation. But, an 8-ohm speaker should not be connected to the 16-ohm output terminals.

When it is necessary to feed a signal from a high-impedance source into a low-impedance load, or vice versa, a stepup or stepdown transformer is usually employed. Sometimes tubes, transistors or resistive pads are used to raise or lower impedance. A stepup transformer steps up both the impedance and the voltage, but does not amplify as far as power is concerned. In fact, a transformer introduces a small power loss since no transformer is 100% efficient. A stepdown transformer steps down both the impedance and the voltage, but the power remains the same except for the small losses due to transformer inefficiency.

Input Impedance. A magnetic phono pickup is usually fed to an amplifier which has a high-impedance input and is loaded by a resistance of from 50,000 to 100,000 ohms. No impedance changing device is required. But, to feed the output of a 5-ohm microphone, for example, to a high impedance (50,000 ohms or higher) input of an amplifier, a stepup transformer is used to raise the impedance from 50 ohms to 50,000 ohms (or higher) and, at the same time, to step up the voltage. The transformer, however, does not amplify even if it steps up the voltage since there is no power gain.

Output Impedance. At the output of the amplifier, the output transformer provides several thousand ohms load impedance for the tubes and steps down that impedance to a low value (4-16 ohms) for the speaker. At the same time it steps down the voltage—but not the power. The transformer is required in order to feed maximum power into the speaker which is a low-impedance device.

Power Gain. Suppose a crystal pickup furnishes a 2-volt signal into a 100,000 ohm load at the input of an amplifier, as shown in Fig. 10. The input power will be equal to

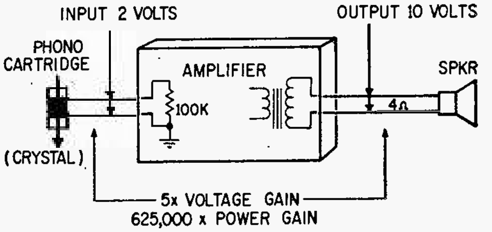


Fig. 10. Voltage gain from input to output is low. Power gain, needed to drive speaker, is very high.

E^2/R or 4 divided by 100,000 which is equal to 0.00004 watts (40 microwatts). If the amplifier delivers 25 watts into a 4-ohm speaker system, the output voltage across the speaker will be equal to the square root of the power times the speaker impedance or 10 volts (square root of 25 times 4). Hence, the voltage has been stepped up only five times from two volts to ten volts, but the power has been stepped up from 40 microwatts to 25 watts.

Cathode Follower. A cathode follower amplifier stage can be used to reduce impedance. In Fig. 11, a very small signal is fed from a magnetic pickup to the grid of the tube which is shunted by a 100,000-ohm

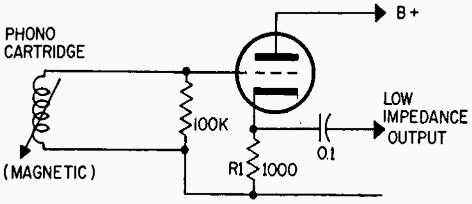


Fig. 11. Low-impedance output eliminates matching transformer and its frequency response limitations.

resistor. The output signal is developed across R1, the cathode resistor. The output impedance is quite low, usually 1000 ohms or less, depending upon the type of tube and value of the cathode resistor.

A cathode follower provides impedance transformation but essentially no voltage gain. A tube can also be used for stepping up impedance. The signal from a low-impedance source can be fed to the cathode of a grounded-grid amplifier, as shown in Fig. 12. The output signal is derived at the high impedance plate circuit.

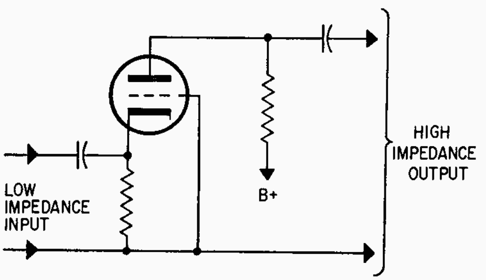


Fig. 12. Grounded-grid circuit acts as step-up transformer with less space and much lower cost.

Long Audio Lines. To transmit audio signals over relatively long wire circuits, the impedance is usually stepped up or down, as shown in Fig. 13. The high-impedance output of a microphone preamplifier is stepped down to 75 ohms when a coaxial cable is used or to 600 ohms when telephone circuit lines are used as the transmission medium. By transmitting low-level audio at relatively low impedances, pick up of hum and noise is reduced.

The low-impedance output of an audio amplifier is generally stepped up from 4, 8 to 16 ohms to 600 ohms (unless the amplifier has a 600-ohm output) to minimize transmission losses due to the DC resistance of the wires. At the speaker locations, a transformer is used to step down the impedance from 600 ohms to the speaker impedance. (With constant level amplifiers, described earlier, impedance is not considered).

Reasons for Audio Control. When the first audio amplifier was developed by Dr. Lee DeForest in Palto Alto, California (the birthplace of the electronics industry) way back in 1911, too much gain was obtained and the electronic oscillator was accidentally discovered. There arose a need for a volume control.

Besides control of volume, it is necessary to be able to control frequency response. To get clear, penetrating speech reproduction in industrial sound systems, the frequency response is deliberately limited to the voice range (300 to 3000 cps). In music systems, the frequency response is made as wide as possible and the highs and lows are often boosted to overcome the deficiencies of speakers.

While only a few milliwatts of sound will provide room level sound, many of us buy 100-watt and even higher powered amplifiers so we can bring Dick Liebert's pipe organ into the living room and so we won't miss the instantaneous peaks. Yet, in the huge Radio City Music Hall, an 85-watt stereo P.A. system pumps sound into a cavern big enough to hold more than 1000 living rooms. ■

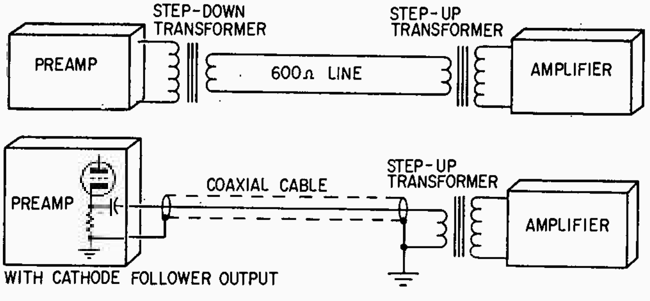


Fig. 13. Impedance matching will affect tone quality of audio signals—particularly when amplifiers are separated by great distances. Broadcast stations often mismatch, with special equalizers, to improve sound quality from distant pickups.

Won't you please help us?

We'd like to learn a little bit more about the readers of ELEMENTARY ELECTRONICS. Nothing personal of course, just some general information which will assist us in the planning of a better magazine for you.

When you've completed the questionnaire, just put it into an envelope and mail it back to us. If you wish, you needn't even tell us your name. Thanks for your help.

—*Julian M. Sienkiewicz, Editor*

1 — First, please indicate your age group.
- ☐ under 18
- ☐ 18 to 24
- ☐ 25 to 34
- ☐ 35 to 44
- ☐ 45 to 54
- ☐ over 55

1a — ☐ Male ☐ Married
☐ Female ☐ Single
No. of Children ☐ one ☐ two ☐ three ☐ more

2 — What is your present occupation? (if you go to school part time and work part time, please indicate both)
- ☐ armed forces
- ☐ business owner
- ☐ clerical
- ☐ craftsman
- ☐ official (gov't)
- ☐ professional
- ☐ student
- ☐ technical
- ☐ sales
- ☐ other__________ (SPECIFY)

3 — What was the last school you attended?
- ☐ grade school
- ☐ high school
- ☐ college
- ☐ graduate school

3a — Did you graduate? ☐ yes ☐ no

4 — Have you ever taken a correspondence course?
☐ yes ☐ no

4a — Do you intend to take a correspondence course?
☐ yes ☐ no

if yes, what type of course?
- ☐ electronic technician
- ☐ electronic computers
- ☐ basic electricity
- ☐ TV & radio servicing
- ☐ communications
- ☐ other__________ (SPECIFY)

5 — Would you indicate the approximate total annual family income?
- ☐ under $3000
- ☐ $3000 to $4999
- ☐ $5000 to $6999
- ☐ $7000 to $9999
- ☐ $10,000 to $14,999
- ☐ $15,000 and over

6 — How often do you buy ELEMENTARY ELECTRONICS?
- ☐ this is my first issue
- ☐ whenever I see it
- ☐ regularly
- ☐ I subscribe

6a — How long do you keep your copy of ELEMENTARY ELECTRONICS?
- ☐ about 1 month
- ☐ more than 1 month
- ☐ more than 3 months
- ☐ as permanent library reference

6b — How many people, other than you, will read this copy of ELEMENTARY ELECTRONICS?

__________ (NO. OF PEOPLE)

7 — What other electronic magazines do you read?

regularly		once in a while
☐	Electronics Illustrated	☐
☐	Electronics World	☐
☐	Popular Electronics	☐
☐	Radio Electronics	☐
☐	Radio-TV Experimenter	☐

8 — What is there about electronics that interests you the most?
- ☐ hi-fi
- ☐ CB
- ☐ ham radio
- ☐ construction
- ☐ experimentation
- ☐ servicing
- ☐ SWL
- ☐ other__________ (SPECIFY)

9 — Do you own any equipment of your own, such as,
- ☐ oscilloscope
- ☐ V.O.M.
- ☐ V.T.V.M.
- ☐ signal generator
- ☐ soldering gun
- ☐ soldering iron
- ☐ other__________ (SPECIFY)

10 — How much money have you spent on equipment in the past year?

$_____ on test equipment

$_____ on Hi-Fi equipment

$_____ on communication equipment (ham, CB, SWL)

$_____ other__________ (SPECIFY)

11 — What type of equipment do you expect to purchase this year?
- ☐ test equipment
- ☐ Hi-Fi equipment
- ☐ communication equipment (ham, CB, SWL)
- ☐ other__________ (SPECIFY)

11a — How much do you expect to spend on your new equipment purchases?
- ☐ under $50
- ☐ $50 to $99
- ☐ $100 to $199
- ☐ $200 to $299
- ☐ $300 to $399
- ☐ over $400

Please mail to: JULIAN M. SIENKIEWICZ, Editor, Elementary Electronics, 505 Park Avenue, New York, New York 10022

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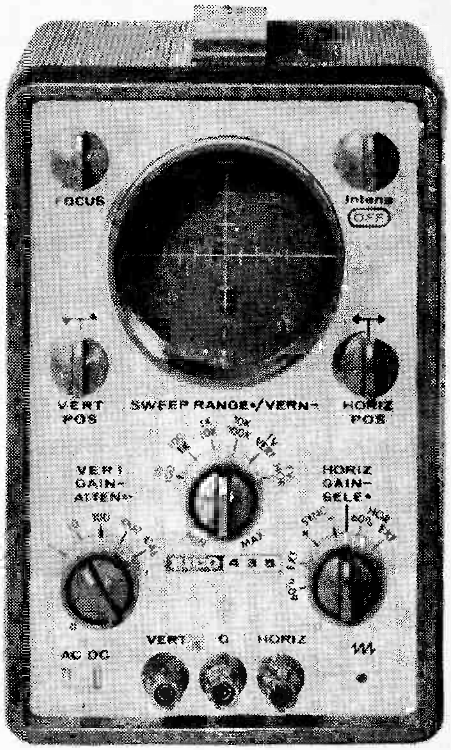
e/e TEST BENCH

EICO MODEL 435
Wide-Band
3-inch Oscilloscope

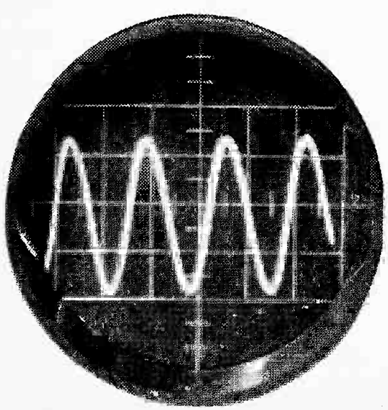


■ In this, the era of the complex waveform, the oscilloscope is perhaps the most important service instrument next to the VTVM. In addition to indicating voltage and current in terms of voltage, an oscilloscope gives you a picture of what's going on. And what with everything from TV receivers to voice-controlled tape recorders using *spikes, sawtooths* and *square waves* it's often more important to be exactly sure of the shape of things than their exact magnitude. Yet, while the scope is the only instrument that gives you a picture of what's happening as it happens too often the hobbyist places it down at the bottom of the test equipment list because of high price or complexity of operation; but in fact, a modern scope such as the EICO 435 kit is not only competitively priced at $99.50, it is essentially as easy to operate as a VTVM.

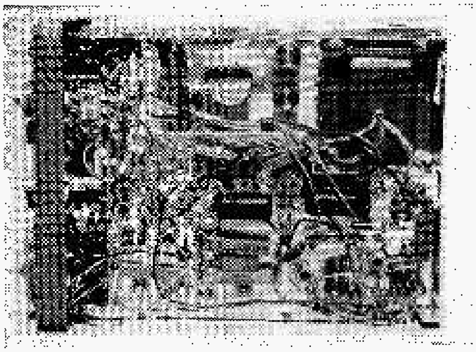
Why It Stands Out. First off, the EICO 435 is really a compact, ideally sized for the hobbyist—let alone the pro. About a foot long, less than 6 inches wide and about 8 inches high it takes up next to nothing in valuable bench space.

The 435 utilizes a flat 3-inch CRT (which we'll tell more about later); a four-position 1000:1 stepped attenuator backed up with a variable attenuator for the vertical input; an automatic sync limiter and amplifier; a fully adjustable 10 cps to 100 k.c. sweep range plus fixed frequencies of 30 cps and 7875 cps for TV servicing; a Zener regulated calibration voltage and a DC to 4.5 mc. vertical amplifier response. In addition to the usual front panel controls there is an *astigmatism* control available through the side of the cabinet. (Since the rest of the features are usually common to most quality scopes you can look them up in EICO's brochures.)

"Well", you might ask, "what makes the 435 different from any other scope as far as the hobbyist is concerned?". To start with there's the assembly itself and the assembly manual. While the kit is by no means a one evening project, or for that matter one weekend (it takes about 20 hours), it is not a difficult assembly. Wiring is primarily on both sides of a "Z" shaped



Unretouched photograph of sine wave on scope face illustrates the brightness of trace; calibration graticule is edge lighted.



Underside of oscilloscope with cover removed shows packed, but neat wiring; top of chassis is equally dense—as you'd expect in compact wide-band scope.

vertical chassis, plenty of room between connections and single-layer style. For some reason the manual makes mention of multiple layer wiring but there really is none—at no point are components packed on top of other components.

As far as the newcomer to construction is concerned it is really the assembly manual that means success at the first try. The manual is first rate, notably excellent. There are no pictorials in the manual, each pictorial is on a separate sheet about six times the size of this page and each one represents a very small part of the total wiring. At no point is it necessary to follow a lead with a pencil in order to trace it through a maze of wires; as example, the average number of individual steps per pictorial is only thirteen. The construction steps themselves are printed in oversize type and it's almost impossible to run one step into another.

As far as the components themselves are concerned they appear to be of the highest quality. With few exceptions 5% resistors and silver-mica capacitors are used throughout.

As far as performance is concerned the CRT display is the most striking. In combination with the astigmatism control the trace can be focused razor-sharp from edge-to-edge. In fact, because the entire face can be used the useful working area of the 3 inch flat faced CRT is almost equal to that of a convex 5 inch CRT. As for brightness, just look at the photograph, and remember that *it is not retouched*. The trace, under typical bright shop illumination, appears "painted on"—it is actually brighter than the *power on* light. Note also the sharp and bright edge-lit calibration grid which is calibrated in centimeters; note the calibration extends to the top and bottom of the tube.

Spec Check. Unusual for kits, where performance is generally better or worse than specs, our 435 was right-on-the-button. The frequency response checked out to exactly +1, −3db from DC to 4.5 mc., and the vertical sensitivity was exactly the claimed 18 rms mv./cm while the horizontal sensitivity was 0.7 V/cm. The decading accuracy of the vertical attenuator was exactly 5%; usually it is a little better because resistor tolerances cancel; in our model they didn't cancel but 5% is still good.

The calibrating voltage of 200 mv. peak-to-peak is actually adjustable over a very wide range and the user can set the calibration to any reasonable value. For example, we preferred to use 500 mv. so that the vertical sensitivity at full gain each centimeter on the grid represented 10 mv. instead of 8 mv.—but each user can set his own calibration (we found this feature very convenient though the operating manual was a little muddy on its usage). The calibrating trace is a very sharp square-wave with no vertical overshoot, so whether collapsed or expanded the top and bottom of the trace always represent the extremes of the calibrating wave-form.

Retrace blanking was very good—fast with virtually no loss of the end of the trace.

In fact, electrically we have no complaints; mechanically, there is one: the vertical and horizontal inputs utilize a common ground terminal, and one cannot use two standard ¾ inch plugs at the same time. If you use a plug for the vertical input while simultaneously using the horizontal input the horizontal ground lead must be wrapped around the ground terminal. If the sawtooth output jack is removed—as it's only used to adjust the vertical input frequency correction—a separate horizontal ground terminal can be added. And wonders of wonders, you can buy the terminal direct from EICO. Call it a breakthrough (if we must use the word) but EICO provides the price of every single part in the scope, right down to the cardboard sleeve for the grid illumination bulb (price 3 cents).

Other than the remarkably brilliant and sharp CRT it's difficult to single out any specific outstanding features as the DC Wideband Oscilloscope does exactly what EICO claims—and does it well. For further information and specifications write to EICO, Dept. HA, 131-01 39th Ave., Flushing, N. Y. 11352. Tell 'em RADIO-TV EXPERIMENTER touted you on the 435. ■

■ This year, CATV is the most talked about development in electronics. While it is not new, CATV is headline news because: (1) it is "big" business, (2) TV broadcasters are concerned about it, and (3) the FCC has just taken over regulation of CATV.

CATV means "Community Antenna Television." For more than a decade, CATV has been making good television reception possible in extreme fringe areas and in areas not served by TV stations. Now, CATV is being extended into areas where there are several TV stations, even into New York City where there are seven VHF stations, two UHF stations plus a Coast Guard Ratan UHF station and another new UHF TV station being readied.

There are approximately 2,000 CATV systems in operation serving an estimated 5,000,000 TV viewers. Many more are being planned. A typical CATV system serves 1500 subscribers for which it receives $80,000 per year for its services. Some are much larger, serving as many as 20,000 subscribers.

In many areas beyond the range of TV stations, TV programs are piped-in via CATV. In other areas where there may be a local TV station the CATV system brings in programs from out of town stations. CATV also eliminates the need for individual tall, expensive TV-antenna systems in fringe areas.

TV Pipe Line. The CATV company pipes in TV signals, usually from several stations, via coaxial cable to the homes of its subscribers. A small monthly fee is charged for the service. The TV signals are picked up off-the-air at a receiving station located on a distant hilltop or other good receiving site. There, the TV signals are amplified by what is called "head-end" equipment and then transmitted through coaxial cables and intermediary amplifiers to one or more communities where the signals are distributed through coaxial cable to subscribers.

CATV Today

By Leo G. Sands, W7PH/KBG7906

Cable-connected TV reception brings you the finest picture possible without unsightly masts and some special features unique to CATV.

CATV TODAY

While all of the New York Metropolitan area is saturated with TV signals, TV reception is sometimes poor. It is particularly poor in Manhattan where signal reflections from the hundreds of tall buildings distort TV pictures. Two CATV systems are to be installed in New York City, one serving Manhattan and the other serving the Bronx. Subscribers will get clear pictures and will be able to receive programs of some out-of-town stations as well as from the local stations. And not to worry about roof-top antennas that are ruined by soot and weather.

Simple System. Let's look at a simple, single-channel CATV system which could be privately owned and operated to serve a farmhouse (or motel) in a valley where good off-the-air TV reception is not possible. Fig. 1 shows a TV receiving station on a hilltop where the antenna is able to pick up good TV signals. The antenna feeds the TV signals through a balun (matching transformer) to a broadband head-end amplifier tuned to the desired channel.

The RF output of the head-end amplifier is fed to a coaxial cable (suspended on poles or buried in the ground) which feeds TV signals to the house or motel. One or more line amplifiers are inserted in the coaxial cable to make up for cable losses. At the far end of the cable the signals go to a distribution amplifier and then to individual TV sets. Operation of the TV sets is normal except that a roof top antenna is not required.

Commercial Systems. Commercial CATV systems are similar except they serve a large number of houses, as illustrated in Fig. 2. Here, we have a single antenna feeding several head-end channel amplifiers. Each head-end channel amplifier is tuned to a different TV channel. The combined signals are transmitted through coaxial cable to line and distribution amplifiers. From the distribution amplifiers the TV

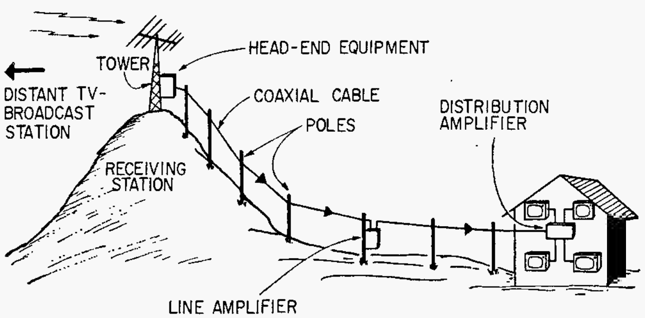


Fig. 1. Hill-top tower and a long run of coaxial cable can be a big expense for an individual, or even a family, for recreation. It is a business necessity for motel or a resort hotel that must compete with facilities offered by others.

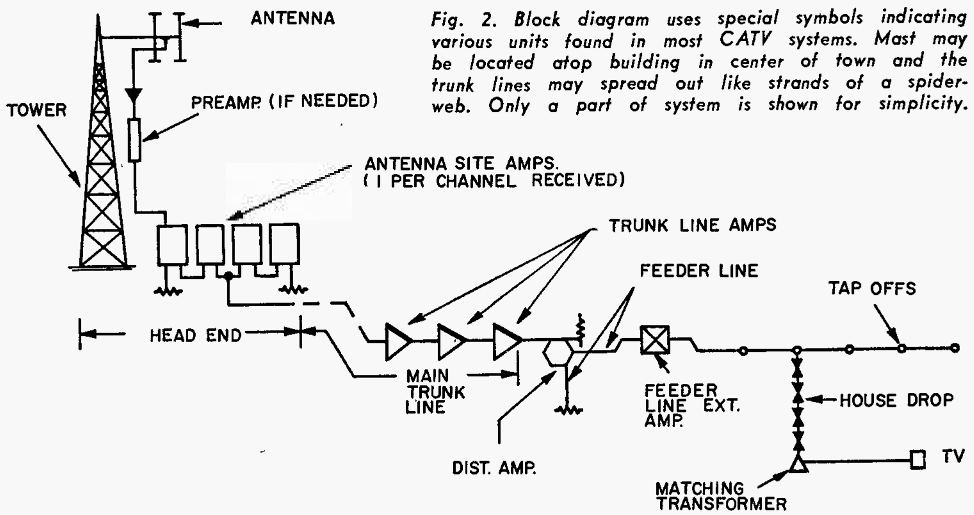


Fig. 2. Block diagram uses special symbols indicating various units found in most CATV systems. Mast may be located atop building in center of town and the trunk lines may spread out like strands of a spider-web. Only a part of system is shown for simplicity.

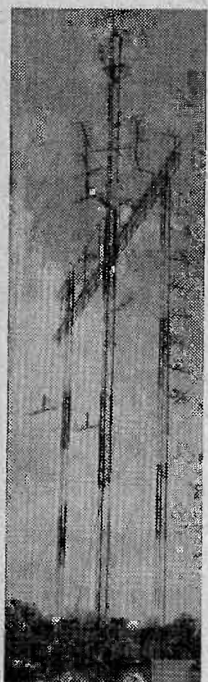
signals are fed to subscribers through feeder coaxial cables, usually attached to telephone or power line poles. The feeder cables are tapped near each subscriber's home and a coaxial house-drop line is run to the subscribers premises where one or more TV sets may be served.

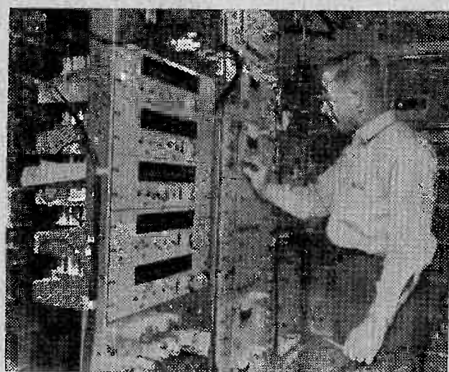
Some CATV systems employ microwaves or G-Line instead of coaxial cable to feed TV signals from the head-end equipment to the distribution center. A G-Line is a single-conductor transmission medium, suspended on poles, which does the same job as coaxial cable but has much lower losses and fewer amplifiers are needed.

Pick-up Antennas. Only one antenna is needed when all of the signals are picked up from the same direction. To permit reception from various directions two or more antennas are used—each feeds its own channel amplifier. The outputs of the amplifiers are combined and then fed into the coaxial trunk line, as shown in Fig. 3.

FM and CCTV Too. CATV systems are also used to bring in FM programs. This requires an 88-108 mc head-end amplifier.

ELEMENTS OF THE CATV SYSTEM—FROM PICKUP TO DELIVERY





Starting at the antenna (upper left) and going clockwise you can follow the signal path of a CATV system. Many antenna are used to pick up signals from different directions. For reliability more than one antenna may be used for each channel. The signal goes to head-end equipment—which is checked frequently to maintain signal quality—fed through coaxial cables and trunk line amplifiers mounted on poles. House drops make the connection between the feeder-line tap offs and the subscriber's equipment. Matching transformers must be used to mate the 300-ohm inputs to the 50-ohm line.

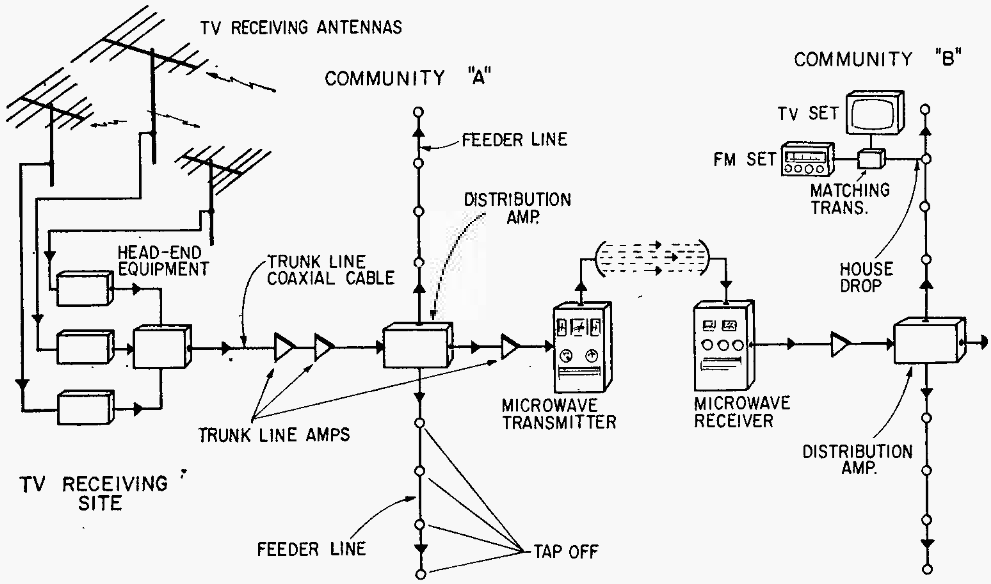


Fig. 3. Microwave link in CATV system can be cheaper to install and produce better signals, over distances of several miles, than possible with coax and many trunk-line amplifiers.

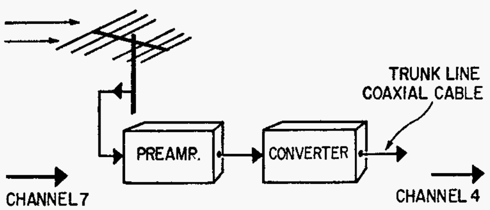


Fig. 4. Converting Channel-7 signal to Channel-4 reduces coax-line losses of higher frequencies.

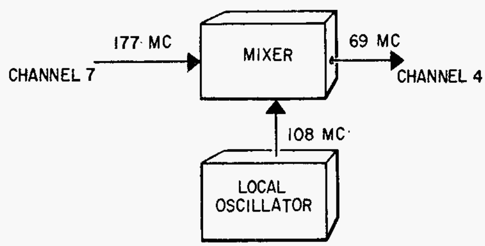


Fig. 5. Block diagram of converter is just like that used in front-end of broadcast receivers.

Besides off-the-air TV and FM programs, some CATV systems originate their own programs. These special closed-circuit channels are used for transmitting weather and other information. For example, a camera is trained on a weather instrument panel. The camera's video output is fed to a TV modulator which is tuned to an unused channel. Subscribers merely select that channel to get the latest weather scoop. Some also have an automatic programming device which prevents simultaneous transmission of the same program on two CATV channels when the same program is being broadcast, at the same time, by two of the TV stations being picked up.

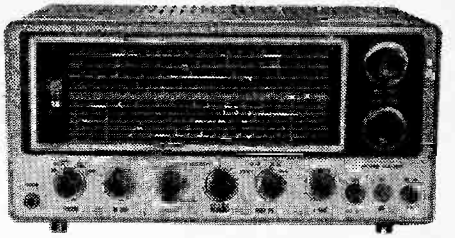
Head-End Equipment. The TV signal is fed into the coaxial trunk on the same channel as received off the air, or it can be transposed to a different channel. For example, if channels 2, 3, 4 and 5 are picked up, they can be amplified and fed into the coaxial trunk on their same frequencies.

Sometimes, the channel frequencies are transposed for the sake of better transmission. The attenuation losses through coaxial cable rise with frequency. Therefore, when picking up Channel 7 off the air, the signal can be transmitted with lower losses by transposing it to say Channel 4, if that channel is not in use on the CATV system (Fig. 4.).

(Continued on page 106)

e/e COMMUNICATIONS

LAFAYETTE HA-230 Amateur/SWL Communications Receiver



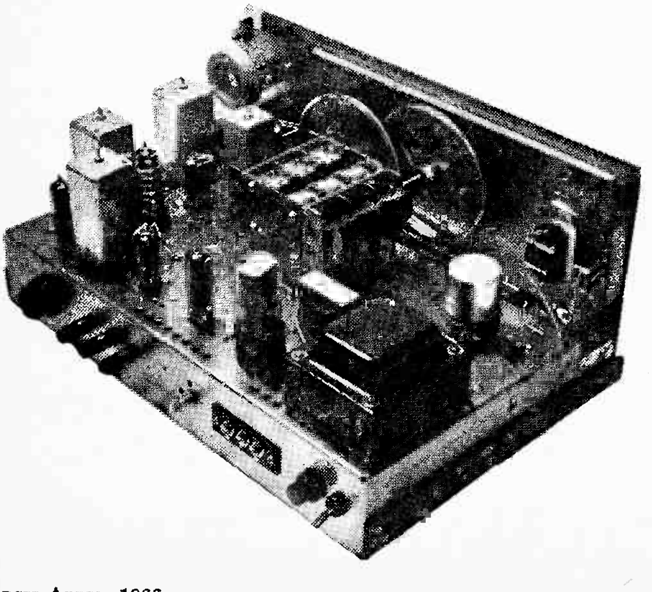
■ It's often difficult to find a really good budget communications receiver because most of them priced under $100 are nothing more than a table radio with a fancy front panel and short-wave coverage *added-on*—basically it's still a table radio; usually AC/DC type.

On the other hand, though Lafayette Radio's HA-230 is priced well under $100, it is a true communications receiver in practically all respects, right down to the transformer power supply and *always-on* mixer and oscillator filaments. From the antenna trimmer, to the Q-multiplier/BFO, to the IF gain control, S-meter and AVC disable switch, the HA-230 has all the features of communications receivers selling for considerably more than $100.

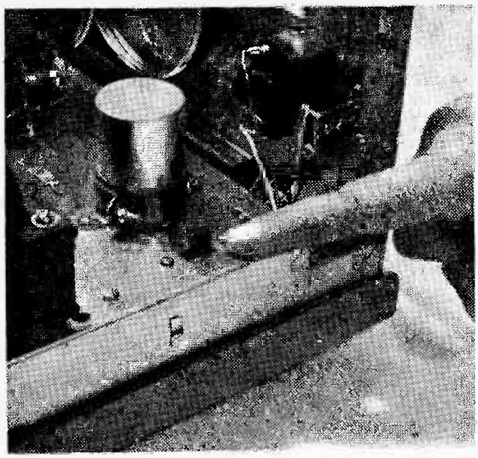
The HA-230 covers 550 kc. to 30 mc. in four bands. Calibrated bandspread is provided for the 80/75, 40, 20, 15 and 10 meter amateur bands as well as a 0-100 logging scale for short-wave listeners (SWL's). The amateur bandspread is calibrated 5 kc. per division on 80/75 and 40 meters; 20 kc. per division on 20 and 15 meters; and 50 kc. per division on 10 meters.

The Big Extra. The Q-multiplier is the two control type. The selectivity control varies the overall selectivity for *phone reception only* from ±800 cycles at 6 db down to the normal IF bandwidth (we'll get to the normal selectivity later). The second control functions as a variable BFO for CW and SSB reception; it is also used to move the peak when the Q-mult is being used and allows the operator to place an interfering station outside the IF passband. The Q-mult checked out very good, and unlike some earlier budget receiver Q-multipliers which often *growled*, the HA-230's produced a very *clean and stable* CW note.

More Extras. The antenna input accommodates balanced or unbalanced lines of 50-400 ohms or the common SWL "longwire." The receiver has no built-in speaker



The Lafayette HA-230 is obviously not a stripped down receiver. Fully shielded subassembly partly hidden by tuning capacitor houses the Q-multiplier/BFO circuits. Large pulleys make wide-band and bandspread tuning fingertip easy.



Slide switch on chassis changes power transformer connection to match low line voltage about 100 VAC.

and a 4 and 8-ohm speaker output is provided. The headphone jack is connected in series with the 8-ohm speaker output so low impedance (Hi-Fi type) phones can be used. An accessory socket on the rear apron is prewired for standby/receiver control from the transmitter with three extra pins provided for a converter power take-off. Of unusual interest is a low voltage power transformer switch; if you suffer from chronically low line voltage of about 100 VAC you can "boost" the operating voltages back to normal by setting the power transformer primary connection to the 100-volt position with just the movement of a slide switch (no soldering needed).

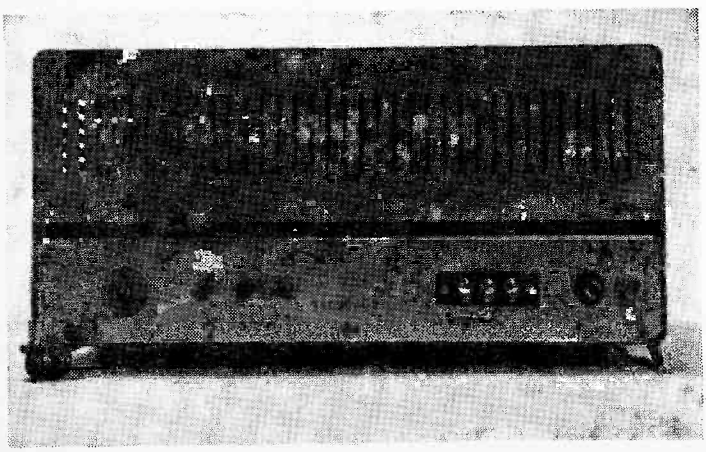
Sensitivity is about 1 uv. for a 10 db S/N ratio on the lower SW bands. Typically, sensitivity falls off on the high band, but unlike many budget receivers which are virtually dead above 15 mc. the HA-230's sensitivity is at least equal to that of receivers selling for twice the price.

Normal IF selectivity, without the Q-mult, is ±10 kc. at 60 db down—a respectable figure, somewhat better than many budget receivers.

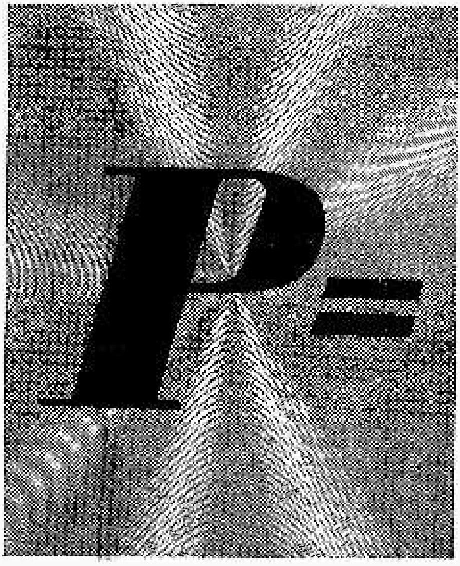
The notably outstanding feature of the HA-230—particularly when one considers its low price of $79.95—is the frequency and BFO stability. After a 15 minute warm-up the local oscillator stability is good enough to allow rapid tuning of SSB signals even on the 15 meter band. (For those of you who have never suffered through tuning SSB even on 80 meters with a drifting receiver you may believe this is a notable accomplishment in a budget priced receiver.) Similarly, the BFO stability is just as good—SSB signals stay tuned in and CW doesn't slide up and down the scale. However, on our model at least, the BFO injection was a little weak and very strong SSB and CW signals of the *30 over 9* variety could be satisfactorily tuned in if the overall sensitivity was reduced via the *antenna trimmer.*

The excellent frequency and BFO stability is achieved by always leaving the mixer and Q-mult filaments *on* (a unique application in low cost receivers), even when the power switch is *off*. The constant generation of moderate tube heat prevents the drastic frequency changes common when components get a "cold start." Cost of continuous filament operation is virtually negligible.

Considering its rather good all-round performance and ease of operation, at $79.95 the HA-230 shapes up as an ideal choice for the newcomer to amateur radio or short wave listening. For additional information write to Lafayette Radio, Dept. SI, 111 Jericho Turnpike, Syossett, L. I., N. Y. ■



Matching plug for power take-off socket (left) is supplied as the antenna shorting bar. Control between antenna and speaker terminals is the S-meter zero adjustment potentiometer.



Maximum Power Transfer Theorem

By Andy Martin

If you recall the water analogies for visualizing *E*, *I* and *R*, you might visualize a funnel as a symbol for the impedance match necessary for maximum transfer of power

■ Why must an 8-ohm loudspeaker be matched to the 8-ohm winding of an audio power-output transformer? And why must a car's starter motor have an internal impedance to match the battery's resistance? In both cases it's important to deliver to the load *maximum power* rather than *maximum voltage* or *maximum current*. The reason is simple—only power can do useful work and we want to obtain the maximum possible power at the load (loudspeaker and starter motor) when we need it most—at peak audio passages of a symphony and during a sub-zero winter night when the crankcase oil is thick as tar.

Proving a Point. It is well and good to say that the load impedance must equal the electromotive force's (battery, transformer, generator, etc.) internal resistance for maximum power transfer, but let's prove the point. Fig. 1 shows a simple circuit consisting of one battery and two resistors, R_L and R_B. Resistor R_B's value is equal to the internal resistance of the battery and its terminal and lead resistances that are always present in any circuit. R_L is the load resistance and is made variable for this discussion so that it can be varied to find the resistance value whereby maximum power is dissipated in it.

The voltage drop across R_L in Fig. 1 is equal to

$$E_L = \frac{R_L}{R_B + R_L^{2}}\ E_B \qquad (1$$

Since E_B is equal to 10 volts and R_B is 10 ohms—

$$E_L = \frac{R_L}{10 + R_L}\ 10\ volts. \qquad (2$$

We know that power P_L dissipated in R_L is equal to E_L^2/R_L. So we must square both sides of equation (2) and divide by R_L to obtain an equation for power P_L dissipated in load resistor R_L.

$$P_L = \frac{E_L^2}{R_L}$$

$$P_L = \frac{(10)^2 R_L^2}{R_L(10+R_L)^2} = \frac{100R_L}{(10+R_L)^2} \quad (3$$

Now we insert numbers into equation (3) for different values of R_L and observe how the values for P_L vary for each change of R_L. To do this handily, the table below compares the value of R_L in ohms against P_L in watts. The tedious calculations have been performed by the author, but don't take his word, check a few values yourself. Fig. 2 plots the values for R_L and P_L given in the table.

It is obvious from the table and Fig. 2 that maximum power is dissipated in R_L when R_L *equals* R_B. This mathematical proof is commonly referred to as the *Maximum Power Transfer Theorem.*

What's with AC. Fig. 3 is a simple series circuit in which we have assumed that the generator is inductive by nature introducing an inductive reactance, X_A, into the circuit. Also, we have assumed that the load impedance exhibits a capacitive reactance, X_B. Now, recalling our AC circuit theory, when the inductive reactance is equal to the capacitive reactance at the generator's output voltage frequency, both reactances will be equal in magnitude but of opposite sign. Hence, the reactances shown in Fig. 3 add up to zero: $X_A + X_B = 0$.

More simply, a resonant condition exists when the inductive reactance is equal to the capacitive reactance. As far as the generator is concerned it cannot "see" X_A and X_B at resonance since they cancel one another. Hence, the generator is supplying power *only* to pure resistances, R_G and R_L. If we use the *rms* value for the generator's output voltage, we can determine the resistance value for R_L for maximum power dissipation. The computations will be identical to those given in the table discussed earlier.

To put our last conclusion into the words of engineers, . . . for an AC power source to deliver maximum power to a load, the load impedance must be the *conjugate* of the generator impedance. This means that the resistance of the generator must equal the resistance of the load, and the reactance of the generator must be equal in numerical value (magnitude) but of opposite sign to the load's reactance. Therefore, when the generator has an inductive reactance property, the load must be capacitive. Converse-

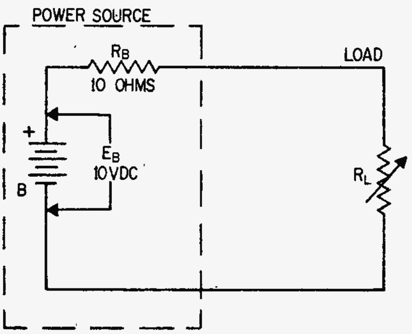


Fig. 1. Schematic diagram at the left illustrates the circuit used in computing the Maximum Power Transfer Theorem in the text above. The condition necessary for maximum power transfer is $R_L = R_B$.

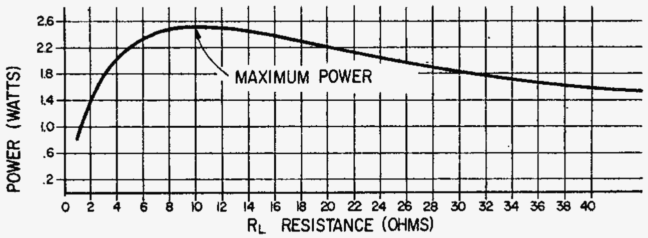


Fig. 2. A plot of the values obtained by varying R_L in the circuit in Fig. 1 shows point of maximum power transfer. It is, naturally, when R_L equals R_B. See table opposite for coordinates of curve.

ly, when the generator is capacitive in nature, the load must be inductive. Inductive reactances are stated as positive quantities and capacitive reactances are negative.

Using Calculus. Eighth grade students are now being introduced to the operations of the calculus. No longer is it a mystery to second year mathematical students in Universities. So why not give the proof of the *Maximum Power Transfer Theorem* as students in their first AC theory course would learn it.

Fig. 4 represents a battery with internal impedance R_B and its load resistor R_L. The battery voltage is E_B. Then the load current is

$$I_L = \frac{E_B}{(R_B+R_L)}. \qquad (4$$

The power delivered to the load is

$$P_L = \frac{E_B^2 R_L}{(R_B+R_L)^2}. \qquad (5$$

Since R_L can be varied until P_L is maximum, the rate of change of P_L with respect to R_L may be expressed mathematically and set equal to zero. This is the condition for maximum P_L.

$$\frac{dP_L}{dR_L} = 0$$

$$\frac{dP_L}{dR_L} = \frac{E_B^2(R_B+R_L)^2 - 2E_B^2 R_L(R_B+R_L)}{(R_B+R_L)^4} \qquad (6$$

We know from observation that (R_B+R_L) is not a negative number because R_B and R_L are finite positive numbers. Then the fraction in equation (6) must have a numerator that is equal to zero in order for the fraction to equal zero. Therefore:

$$0 = E_B^2(R_B+R_L)^2 - 2E_B^2 R_L(R_B+R_L). \qquad (7$$

Then

$$E_B^2(R_B+R_L)^2 = 2E_B^2 R_L(R_B+R_L). \qquad (8$$

Now divide both sides of the equation (8) by E_B^2 and (R_B+R_L).

$$0 = (R_B+R_L) - 2R_L$$
$$R_B - R_L = 2R_L$$
$$R_B = R_L$$

Thus, we prove that the load resistance must equal the battery resistance for *maximum power transfer*.

Those readers knowing how to use calculus should have no problem solving the Maximum Power Transfer Theorem for AC circuits. ■

Table of Values for P_L Calculated from Selected Values of R_L

R_L (ohms)	1	3	5	7	8	9	10	11	12	13	15	17	20	30	40
P_L (watts)	0.83	1.78	2.22	2.42	2.47	2.49	2.50	2.49	2.48	2.46	2.40	2.33	2.22	1.88	1.60

Fig. 3. Schematic diagram of the circuit used to illustrate the maximum transfer of power in an alternating current circuit.

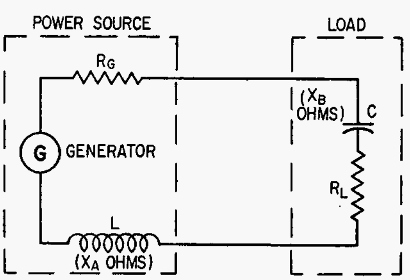
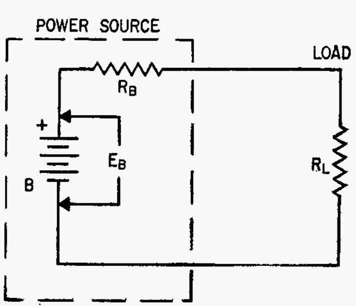


Fig. 4. Refer to this circuit when following the differential calculus in text above; it proves R_L must = R_B.



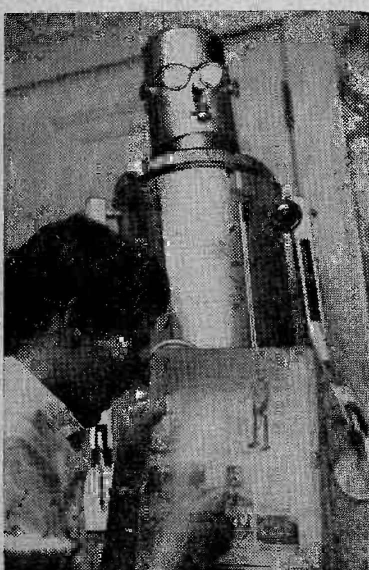
High School Co-ed Builds Robot

■ Mary Ann, who plans to some day attend Massachusetts Institute of Technology, is now working on a device to move the legs so "Herbert," her home-brew robot, can exercise out of the house and stop scaring visitors at her home. Mary's parents don't mind her wanting to be a scientist, but Herbert with his buzzing and lighting up, and recorded voice, etc., is not an ideal house guest. Herbert cannot walk and must be "unsnapped" for easy transportation. Herbert's fetal period was only two months and parts cost less than ten dollars. Now if Herbert can only help with the housework.

Mary Ann has a number of other interests and hobbies which belie her feminine appearance. Included in these are a membership in the Quincy Civil Air Patrol, and also the Radio-TV club at school. She likes fishing and shell collecting, and has a pet parakeet which she teaches to talk, and probably says words like "nuclear fission" or "thermodynamics."

Herbert Thomas Jr., for whom the robot was named, is her current beau, and he heartily approves of Mary Ann's activities, for he plans to be a scientist himself. So "Herbert" the tin man, will always have a home even if he doesn't take a prize. ■

Herbert's eyes glow with jealousy (left) as he watches Mary Ann and beau, Herbert, discuss some personal plans and the projects of the future.

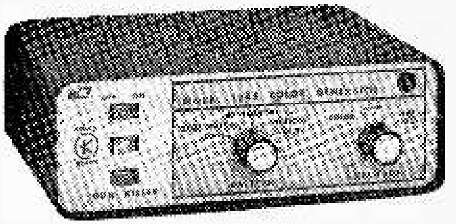


Photos by Three Lions

Making final adjustments (above) before Science Fair exhibition. Going over plans of Herbert's anatomy (left).

e/e TEST BENCH

B&K MODEL 1245
Crosshatch-Bar
Color Generator



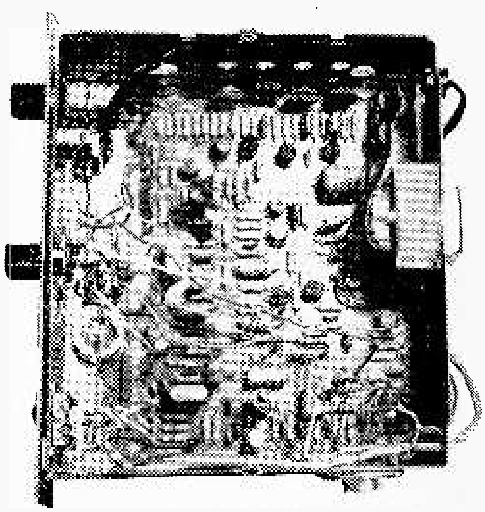
■ Unlike black and white, where virtually anything that remotely resembles a picture is considered good by 9 out of 10 viewers, color TV reception dictates that receiver adjustments be absolutely optimum—for no one will accept green faces, three-tone hair, or a wavering red tint when the picture is supposed to be in spectacular true life color.

Unlike black and white telecasts where you can just tune in a station and rotate the controls for what *appears* to be a "good picture," color receiver adjustments require special *stabilized* test signals such as provided by B&K's Model 1245 Color Generator.

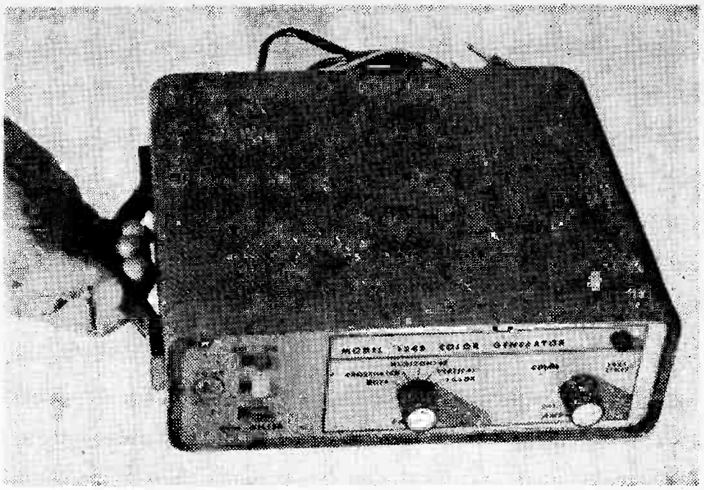
Inside the Case. The B&K Color Generator provides 5 patterns, has a gun killer, and adjustable output level for the vertical lines and color subcarrier sync. Three of the patterns are basic to both b&w and color adjustments; these are the vertical and horizontal lines, and the *crosshatch* which is a combination of the H and V lines. There are exactly 10 vertical and 14 horizontal lines, all equally spaced. To adjust any receiver for linearity in the absence of a transmitted test pattern (and you can hardly find one of those during working hours) the receiver's linearity controls can be adjusted by literally measuring the distance between lines with a ruler.

Width adjustments for proper aspect ratio is similarly a "snap" with the B&K 1245 as the 10 to 14 line ratio is for all practical purposes the standard 3 to 4 aspect ratio. In the case of a color receiver's adjustments for slight overscan, the receiver is adjusted to produce a space between the edge lines and the edge of the CRT of approximately one-half the distance between two adjacent H or V lines. In a sense, the finite and equally spaced H and V lines and the cross hatch is superior to a transmitted test pattern because the service technician obtains reference points across the entire face of the CRT; particularly so with color where dynamic convergence checks must be made across the entire CRT face.

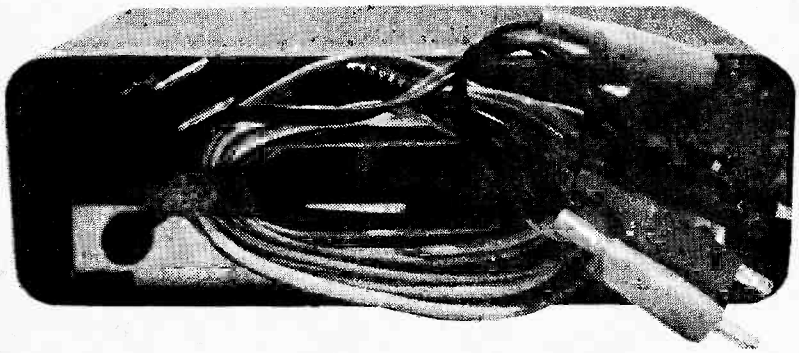
The B&K 1245 utilizes an "and" circuit to obtain the dot pattern; the generator's output is cut-off at all times except when both the H and V output is present—this occurs only at the intersections, or dots. The dot pattern produces the reference needed for static convergence of the color guns. In order to obtain a black and white picture (also a good color representation) the three beams must hit the same spot on the CRT at the same time. When proper static adjustment is obtained the central dot—the one in the center of the screen—appears white, while adjustments for dynamic convergence generally result in proper convergence of the dots in the central H and V areas.



Cover slides off the B&K color generator revealing the fully transistorized circuits of this AC powered test gear. The entire unit weighs in at only three pounds making it easy to take on home service calls.



The B&K color generator is easily carried using the handle on the side of the unit. The leads, below, can be coiled around the clip designed into the cover for even additional convenience.



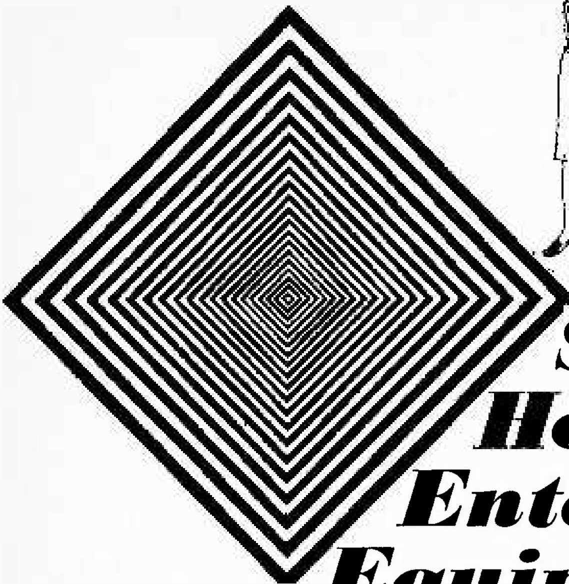
The three gun killers—which reverse bias the grids by connecting them to ground through a resistor—allows each gun to be cut off as required in the convergence alignment as well as purity adjustment procedure.

Of special note is the fact that the B&K 1245 produces horizontal lines—and hence dots—exactly one scanning line in height. When the receiver's focus and/or convergence is properly adjusted the H lines appear to be sharply "etched" on the CRT; smearing, blurring or improper convergence is immediately apparent.

Viva La Chroma. The final function is the color signal. Gating of the *generated rainbow* produces an output which consists of 10 color bands equally spaced 30 degrees apart. The color signal serves two purposes: it permits testing the receiver's color sections in the absence of a transmitted signal and it permits rapid and accurate adjustment of the color phasing control. The color pattern starts at the left with yellow-orange, progresses through blue at the center and is green at the extreme right.

RF Output. The B&K Color Generator's output is modulated RF which is connected directly to the receiver's antenna terminals. This is a superior method to the video output type which requires that you go into the receiver's wiring. The RF output is of further advantage in that the signal feeds through the entire receiver and phase shift in the IF or RF stages will affect the test signal in the same manner as a transmitted signal. (A video output type of generator is connected after the IF amplifier so phase shift in the preceding stages do not show up on the test signal—obviously an RF signal is to be preferred). While the 1245's RF output is set to channel 3 it can be easily user adjusted to channels 2 or 4.

Fully transistorized and AC powered, B&K's Color Generator is rather compact and exceptionally light—easily tucked into a tube caddy with little extra weight—it weighs only three pounds. Priced at $134.95, additional information is available from B&K Manufacturing Co., Dept. HS, 1801 W. Belle Plaine Ave., Chicago, Illinois 60613. ■



Servicing Home Entertainment Equipment

By Leo G. Sands
W7PH/KBG3321

You can learn much about electronics when you repair radios, hi-fi's, and television sets

YOU CAN often diagnose and repair troubles in your radio and television receivers, or hi-fi system. There are some repairs that should be tackled only by a competent technician. Since it costs money to have a technician diagnose the trouble, it would be cheaper if you were to do the preliminary diagnosis and perform the easy and simple repair tasks.

The only test equipment you need is a volt-ohm-milliammeter, called a VOM by engineers and technicians. It is a multi-purpose meter that will measure AC and DC volts, current in milliamperes and resistance in ohms and megohms. They range in price from $10 for an import to as much as $75 for a domestic-made instrument.

AC/DC radios. Most radio sets, except transistor portables, are of the so-called AC/DC type. The AC/DC radio was devised some 30 years ago by Barnet Trott who saw a need for a radio that could be operated either from AC house current or DC power, which was still in use in some cities at the time. Today, nearly all homes and apartments have AC power and the AC/DC radio still exists mainly because it is cheaper to build, since a power transformer is not used.

● ● ● **Tubes don't light.** In radios of the AC/DC type, the heaters (filaments) of the tubes are connected in series in Christmas tree light fashion. If one tube burns out, none will light. This is the most common cause of failure.

If your radio fails to play when turned on and plugged in, and no hum is heard when your ear is held close to the loudspeaker, suspect a burned out tube. If the set is left turned on for several minutes and the cabinet does not get warm, and you see no light at any of the tubes (dull red glow), the trouble can be a defective switch, broken connection at the power plug, or a burned out tube.

Disconnect the power plug and connect the leads of an ohmmeter (volt-ohm-milliammeter set to measure ohms) to the prongs of the power plug. See figure 1 with the switch turned on, the meter should indicate less than 1000 ohms. If it indicates that the circuit is open (meter needle does not move), examine the power plug to determine if one of the wires has been pulled loose from its prong. If this is the case, cut the cord an inch or so from the plug and install a new plug.

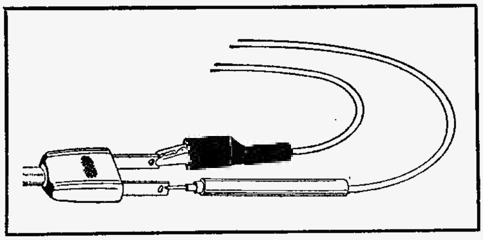


Fig. 1. The ohmmeter is the best instrument for checking out the appliance's major Nemesis—the open line cord. Wire breaks are common. Look for weak spots in wire near chassis and close to plug.

If this does not cure the trouble, remove the set's rear cover carefully, the chassis holding screws and the knobs, and remove the chassis from the cabinet. With the power plug disconnected, connect the ohmmeter leads to the ends of the power cord inside the chassis, and short circuit the power plug prongs with a screw driver blade with the switch in the "off" position. The meter should now indicate zero ohms (full-scale meter deflection). If this does not happen, the cord is defective and should be replaced with a new one. If the cord is OK, you are ready to check the on-off switch by connecting the ohmmeter across its soldered terminals. With the switch turned on, the meter should indicate zero ohms.

Depending upon which is handier for you, take the tubes out of their sockets and have them tested, or use the ohmmeter to measure

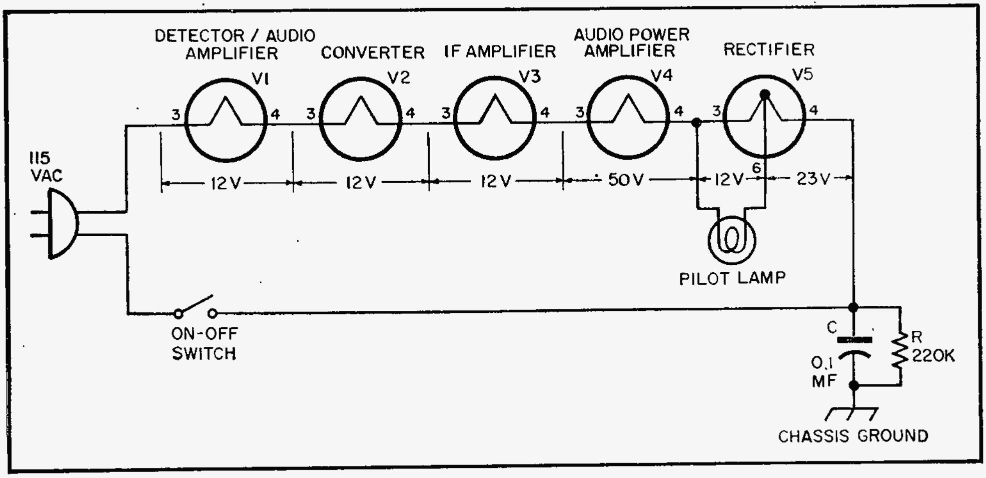


Fig. 2. Filament line-up for most "all American five" AM superhet radios. Pin 3, of V1, is often connected to chassis ground to keep hum voltage to V1's cathode low.

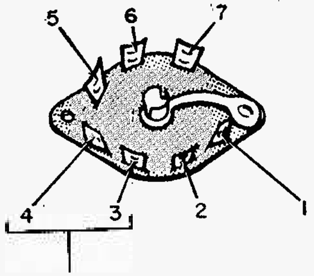


Fig. 3. Bottom view of a 7-pin miniature wafer socket. Printed-circuit sockets are similar.

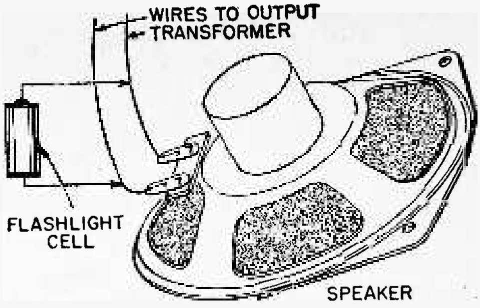


Fig. 4. An ohmmeter, or leads connected to a dry cell, will make a "good" speaker thimp or click.

the continuity of the heater of each tube with the tubes in their sockets. You have to know which socket terminals to check.

A schematic diagram of the heater circuit of a typical AC/DC radio is given in figure 2. In this case, terminals 3 and 4 of all of the tubes are the heater connections. The terminals may be numbered. If not, see figure 3 for the numbering arrangements used for common types of tubes, looking at the bottom of the socket.

Touch the ohmmeter leads to the heater connections of each tube, one at a time. If you get an open circuit reading (meter needle does not move) at one of the sockets, the tube in that socket is apparently burned out. Replace the tube with one of the same type. Now, you should not get an open circuit indication.

Turn on the radio switch and plug in the power plug. The tubes should light and, if nothing else is wrong, the set should operate. Make sure that the set chassis does not make contact with any metallic grounded object. Don't touch the chassis unless you are standing on a dry insulated surface, in order to avoid possible shock.

To test the set while it is out of its cabinet, put the knobs on the shafts (with power plug disconnected) and touch only the knobs when adjusting the set. If it works OK, disconnect the power plug and reassemble the set.

On the other hand, if you choose to take all of the tubes out for testing, make a chart noting which tube belongs in which socket so you will know where to reinstall them after testing.

● ● ● **Pilot lamp.** Most AC/DC radios no longer have a pilot lamp which glows when the set is turned on. When a set is equipped with a pilot lamp, it is usually connected as shown in figure 2, across part of the heater of the rectifier tube. The set will continue to play even if the pilot lamp burns out since the series circuit is not broken, although slightly changed in total resistance.

The pilot lamp should be replaced only with one of the same type number as originally installed in the set by the manufacturer, usually a number 47 lamp. When the set is first turned on, the lamp may glow brightly and then dim as the tubes warm up. The resistance of a tube heater is quite low when it is cold compared to its resistance after it has reached operating temperature.

● ● ● **Tubes light—set doesn't play.** While a burned out tube is the usual cause of trouble, there are many other defects that can prevent a radio from operating. A tube can be defective even if not burned out. So, have them tested and replace any bad ones.

If the tubes light and the cabinet gets warm, listen for a slight hum in the loudspeaker. If none is heard, disconnect the power plug and pull the chassis. Momentarily connect a 1.5-volt flashlight cell across the speaker terminals as shown in figure 4. A click should be audible as the battery leads touch the speaker terminals. If no click is heard, the speaker voice coil circuit is probably open and the speaker should be replaced with one of the same physical size and impedance rating.

Presence of hum indicates that the speaker is live and that the trouble is elsewhere. With the chassis out of the cabinet, the power plug connected, the switch turned on, and the volume control set wide open, touch a test lead (not connected to anything) to the center volume control terminal. A buzz should be heard. If not, the trouble is in the audio section of the receiver, in any one of the many components, including either of two tubes.

Among the possible troubles in the audio section are an open coupling capacitor from the plate of the first amplifier tube to the grid of the audio power amplifier, a shorted capacitor across the primary of the output transformer or an open first amplifier plate resistor or open power amplifier resistor.

A buzzing sound caused by touching a test lead to the center volume control terminal indicates that the trouble is ahead of the audio amplifier. If the set can't be made operative by replacing one or more tubes, further diagnosis should be made by a technician, unless you want to attempt it yourself. But, don't touch the IF transformer alignment screws since you will need a signal generator to get them back on the correct frequency.

Look for a charred resistor and for swollen capacitors or chemical oozing out of a capacitor and replace such components with exact equivalents. In the case of a charred resistor, a capacitor in the same circuit may have blown causing the resistor to overheat.

● ● ● **Excessive hum.** A loud hum may be caused by a shorted tube or a dehydrated filter capacitor. The set may or may not play. The first step is to test the tubes and replace defective ones. If the hum persists, chances are the filter capacitors need replacement. Note the ratings marked on the filter capacitors and buy an exact equivalent. See figure 5. Unsolder and remove the old ones and install the new ones, being careful to observe color coding or polarity marks. If this was the cause, the hum should be gone or diminished. After the set has been played a while, the hum may get weaker as the capacitor forms.

● ● ● **Distortion.** Highly distorted sound, often accompanied by hum, is often caused by a shorted tube or electrically leaky coupling capacitor between the plate of the first audio amplifier and the grid of the power amplifier. Disconnect the old one and solder in an exact equivalent. At the same time, as added insurance, replace the capacitor between the plate and screen of the audio power amplifier tube (bridges output transformer primary).

● ● ● **Lack of sensitivity.** Inability to pick up as many stations as in the past may be due to aging tubes, dehydration of filter capacitors or change in the characteristics of a resistor or capacitor. Test and replace weak tubes first. If the set hums, replace the filter capacitors. These steps usually restore performance. Further diagnosis should be made by a technician.

● ● ● **Fading.** The sudden rise or fall in the volume of a radio is often caused by inadequate pick up by the built-in antenna. In some cases, the volume drops or falls when a light switch is turned on or off. The lighting circuit changes its characteristics as a switch is opened or closed, and may re-inforce or attenuate the level of the signal reaching the radio's antenna. The simplest cure is to move the radio to another location in the room, or to re-orient it to change its antenna position with respect to the stations to be received.

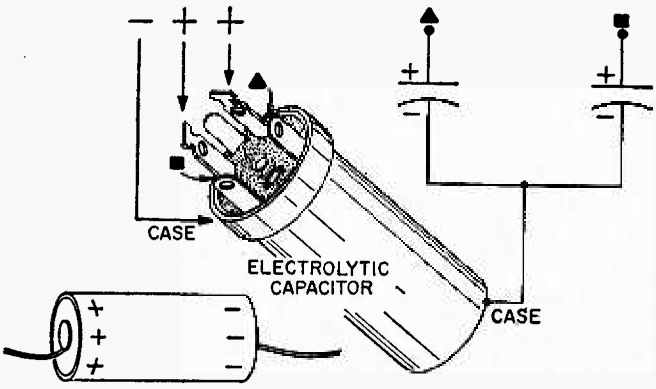


Fig. 5. Electrolytic capacitors are of two basic types. Tubular units (extreme left) and miniature units for transistor circuits usually have wire leads. Can types may have one, two, three or four sections. The can does not have to be grounded—it can be mounted on a phenolic wafer and be "hot." Cardboard-sleeves insulators are often left off during replacement.

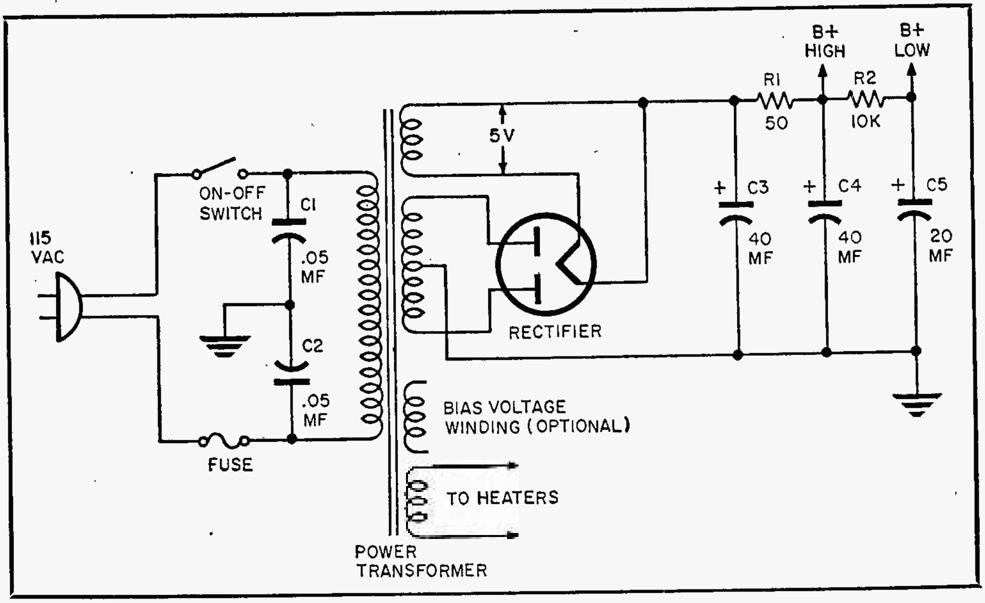


Fig. 6. Typical full-wave rectifier circuit, used in vacuum-tube hi-fi, is just about identical to those used in first transformer-powered radios more than 30 years ago.

A loose connection inside a tube or capacitor can also cause sudden changes in volume. Slow fades on all stations are generally caused by a tube with an intermittent heater. Fading of volume when listening at night to stations more than 50 miles away, but with nearby programs remaining steady, is due to cancellation of the ground wave radio signal by its sky wave, which is not the fault of the radio.

Transformer type radios and hi-fi tuners. Nearly all hi-fi radio tuners and some radio receivers employ power transformers, particularly those inside of large console cabinets, and particularly those that were manufactured several years ago. In these sets, the tube heaters are generally wired in parallel and the plate and screen voltages are usually much higher than in AC/DC radios.

● ● ● **Tubes don't light.** Failure of the pilot lamp to light when the tubes light is generally due to a burned out pilot lamp. Failure of all the tubes to light is most often caused by a blown fuse, if the set has a fuse. Generally, the fuse is at the rear of the chassis and can be replaced by merely turning the fuse holder counter clockwise and pulling it out. It can be checked with an ohmmeter to determine if it is open, if it isn't obvious when looking at it that it is burned out. Replace the fuse only with one of the same type and rating as specified by the manufacturer of the set.

Should the fuse blow when the set is plugged in and the switch is turned on, there is trouble inside the set.

If the fuse is Ok, or a new fuse does not blow, pull out the power plug and connect the ohmmeter leads to its pins with the radio switch turned on. If an open circuit condition is indicated, inspect the power plug connections to the cord and replace the plug if one of the wires has pulled loose from its prong. Pull the chassis if the trouble is not at the plug.

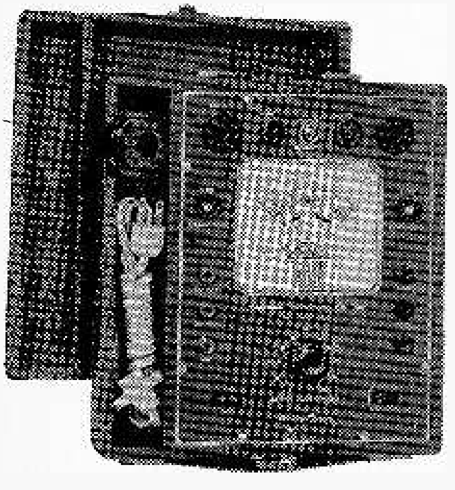
Touch the ohmmeter test leads to the ends of the power cord inside the chassis and short the power plug prongs with a screw driver blade with the switch in the "off" position. You should get a short circuit indication. If not, replace the cord and plug. Now, check the switch with the ohmmeter. A short circuit (zero Ohms) condition should be indicated when the switch is in the "on" position, and open circuit when in the "off" position.

Then connect the ohmmeter leads to the power transformer primary leads. One is usually connected to the fuse (or to one wire of the line cord when there is no fuse), and the other to one terminal of the switch. An open circuit reading indicates that the power transformer primary is open, which means that the transformer must be replaced by an exact equivalent.

e/e SERVICING

● ● ● **New Fuse Blows.** Blowing of a newly installed fuse of the proper rating usually indicated that there is a short circuit within the set. If the set is connected to an external ground, remove the ground connection. Now, if the fuse does not blow when the set is plugged in and turned on, chances are that one of the line filter capacitors (C1 and C2 in figure 6) is shorted. Disconnect the power plug and touch one ohmmeter test lead to the chassis and the other to either power transformer primary lead. You should get an open circuit indication. If not, replace the line filter capacitors with new ones of equivalent value and rating. However, if you still get other than an open circuit reading, the power transformer primary winding may be grounded to its core and replacement of the transformer is indicated.

Trouble on the other side of the power transformer, which causes the fuse to blow, could be due to a short or ground in one of the transformer secondary windings, or a short circuit or ground in the tube heater winding. Pull out the rectifier tube and turn the set on. If the fuse does not blow now, but does blow when the rectifier tube is re-installed, the trouble is probably due to a shorted filter capacitor.



"Utility Tester" Model 161 measures current drawn by AC-operated appliances. It quickly pays for its modest cost ($22.50, from Accurate Instrument Co., Dept. JMS, 911 Faile Street, Bronx, N. Y. 10474).

The shorted filter capacitor can be identified by measuring the resistance with an ohmmeter from the hot terminal of each filter capacitor to the chassis. Sometimes two or more capacitors are inside the same container. If a very low resistance or short circuit condition is found, disconnect the wire at the capacitor terminal and check it again with the wire removed. If the short isn't cleared now, replace the capacitor with an equivalent type. Observe color coding or polarity marks.

● ● ● **Tubes light—set doesn't play.** When the tubes light, but the set is inoperative, any of dozens of components could be defective. If there is an odor and the power transformer gets hot, it could be transformer trouble or a short circuit elsewhere. Look at the rectifier tube for reddening of its plates which is indicative of a shorted filter capacitor.

On the other hand, if the set does not give off an odor and does not seem to overheat, the trouble could be a defective tube. All should light. The light in some may be difficult to see. After the set has been turned on for a while all tubes should feel warm to the touch. Nevertheless, have all the tubes tested and replace any defective ones. Check the loudspeaker as explained earlier about AC/DC sets.

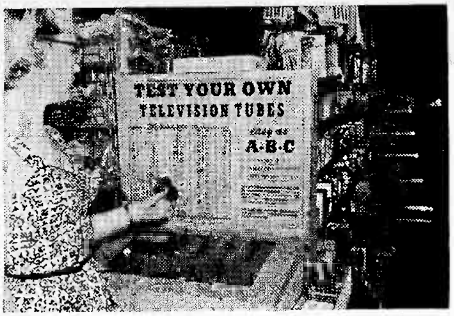
Other troubles, such as hum, distortion, lack of sensitivity and selectivity and fading can be due to the same causes as explained earlier, regardless of whether the set is of the AC/DC type of transformer type.

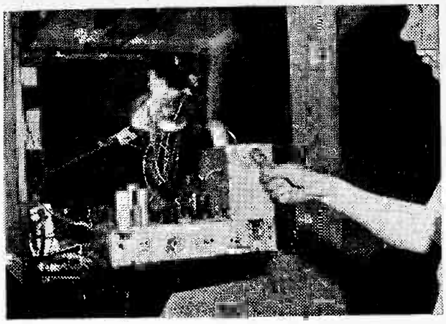
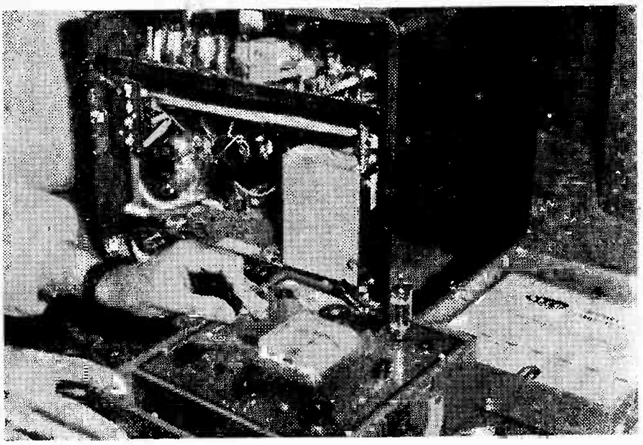
Hi-fi amplifiers. The power input circuits of hi-fi and other audio amplifiers, as well as AM/FM tuners, are similar to those of transformer type radios and the same check-out procedures can be used.

● ● ● **Excessive hum—volume control turned down.** Some amplifiers are equipped with a hum control at the rear or top of the chassis which can be adjusted with a screw driver. With the volume control turned to minimum volume, adjust the hum control slowly for minimum audible hum. If the hum cannot be reduced to a satisfactory level in this manner, have the tubes tested and replace any defective ones.

The audio power amplifier tubes may have to be closely matched in order to minimize hum and distortion. When buying new tubes, have them checked and take those which check most alike.

While it may not be specified in the user instruction book, a ground connection may



Some servicemen claim that 95% of all radio and TV set faults can be eliminated by replacing a vacuum tube. This kind of service anyone can do, including a housewife (upper right). If you have your own tube tester (left), you can cut out those trips to the corner drug store. Remember, in TV sets there are one or more tubes hidden in the HV cage (upper right). Be careful! Be sure to short out the high voltage to ground.

reduce hum level. Get a ground clamp and fasten it to a freshly cleaned spot on a cold water pipe and run a wire from it to a screw on the chassis. (Don't do this if the amplifier is of the transformerless type).

The hum could be caused by dehydrated filter capacitors. This can be checked out by turning the chassis over to gain access to the wiring. Take a 20-ufd, 450-volt tubular electrolytic capacitor and temporarily bridge it across each filter capacitor or section, one at a time, making sure that the + terminal of the test capacitor is connected only to the positive terminals of the capacitors in the amplifier, and note any reduction in hum. Be careful to hold the test capacitor by its insulated housing and avoid touching any of the wires, terminals or test capacitor leads, to avoid shock.

An appreciable reduction in hum level, when the test capacitor is tried, indicates that the filter capacitors should be replaced.

● ● ● **Excessive hum—volume controls turned up.** Hum, which increases in intensity when the volume control is turned up, in any position of the function selector switch (phono-tape-tuner, etc.) indicates amplifier trouble. It could be an improperly seated tube shield or a defective tube.

However, if the hum rises when the function selector switch is set to one particular position, the trouble could be in the particular pre-amplifier selected, in the lead from the selected input device (tuner, record player, etc.), or in the input device itself.

Check the amplifier input lead and plug, looking particularly for a broken shield at the plug at each end of the lead. Make sure that the plugs are firmly seated in their sockets.

When separate line cords are used for each hi-fi system component, try reversing the positions of their respective power plugs in their sockets.

Record changers. A record changer is an intricate and touchy mechanism which should be adjusted only by an expert. However, it can be lubricated by anyone who has available an instruction book spelling out when and where to lubricate and what kind of lubricant to use.

Rubber rimmed drive wheels and idlers wear out and cause rumble. Replacements can be purchased at radio parts stores, which you can install if you exercise care not to disturb other parts of the mechanism.

The stylus of many types of stereo and mono cartridges can be easily replaced. The new stylus is generally furnished with specific installation instructions. Sometimes it is necessary to replace the entire cartridge, or you may want to replace your cartridge with one of a type more suited to your requirements.

Portable Transistor Radios. Servicing portable transistor radios is a job for an expert with the proper tools, test equipment and spare parts. The most common trouble is worn out batteries, which you can easily replace. Symptoms of worn out batteries are lack of volume, a motorboating sound or a rapid fade out shortly after switching on.

Replace the battery or batteries (all of them at once) with exact equivalent types, being very careful that the new ones are inserted or connected in the same polarity as the original ones. If necessary, clean the contacts with a pencil eraser and bend the clips slightly to ensure firm contact.

Television sets. Numerous books have been published about how to repair your own TV sets. While many professional TV service shops have initially lost business as a result, they have gained additional revenue undoing the damage done by some do-it-yourself TV owners.

When your TV set acts up, it will cost you several dollars to get a pro to come to check it over, quite a few dollars to get it repaired if more than a new tube is required. Some shops charge a minimum of five dollars to look over your TV set even when you bring it to the shop.

There are several things you can do before you call in an expert. Before touching the TV set, as long as it is operating, even if not satisfactorily, check out the antenna system. Look for loose, bent, broken and corroded elements and carefully examine the connections to the twin-lead transmission line. If the antenna has been in use more than five years, it might be a good idea to replace it and the transmission line, which gradually deteriorates, downgrading reception as it does. Also check the antenna connections at the set.

● ● ● **No picture—no sound.** Sudden failure of a TV set to operate is usually due to a burned out tube or fusible resistor inside the cabinet. The first step is to remove the rear cover. The power cord is automatically disconnected when the cover is removed.

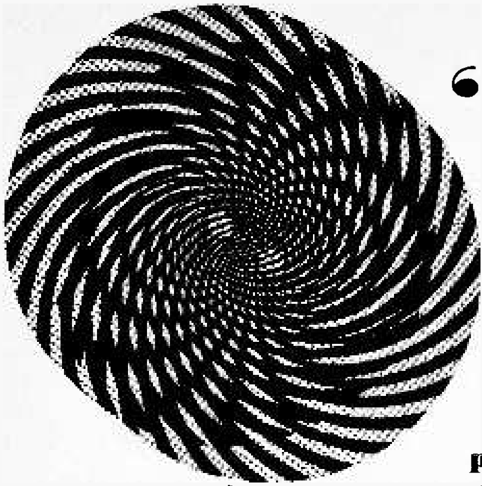
Before you take out the tubes for testing, look for the label that shows the locations of the various types of tubes. If there isn't one, make one noting the locations of the tubes and the number of each tube as you remove it from its socket. Have the tubes tested and replace any defective ones.

Many TV sets have their tubes connected in series as in AC/DC radios. Hence, one burned out tube can prevent the others from lighting. Also, the fusible resistor in such sets, if burned out, can prevent the tubes from lighting. Usually, the fusible resistor is a two-wire plug-in device which can be pulled out of its sockets and replaced with a new one of the same value. You can check it with an ohmmeter.

● ● ● **Picture Troubles.** Vertical and horizontal picture instability can often be corrected by adjustment of the horizontal and vertical controls. Sometimes, replacement of a weak tube will cure the trouble. Absence of a picture, but with the screen lighted, is often caused by a defective tube. Unclear pictures and ghosts are usually caused by antenna trouble, improper tuning and antenna orientation.

● ● ● **Sound Troubles.** One of the commonest troubles is buzz in the sound which can be due to any number of causes. A screw driver adjustment is provided in some sets which is set for minimum buzz. There is also a tuning slug in the gated beam detector coil which can be adjusted with a special tuning wand. But, both of these controls are usually inaccessible unless the rear cover is removed, and adjustment cannot be made satisfactorily unless the set is turned on.

● ● ● **Tuner Troubles.** After a few years of use, the contact points inside the tuner (controlled by channel selector switch and fine tuning knob) get dirty causing unstable picture and sound. You can get a can of TV tuner cleaning fluid which you can spray into the tuner through the holes, with the set's rear cover removed. Rotate the channel selector knob as you spray. ■



"Unitize" Your Home-Brew Projects

Space-Age techniques for experimenters makes electronic-project construction easier, faster, neater and more enjoyable.

BY HOWARD S. PYLE, W7OE

■ How often have you been flustrated trying to make a solder connection to a terminal deep in a chassis? Did you ever have trouble trying to insert a machine screw or start a nut in an awkward corner? If you're a typical home-brew artist you're only too familiar with these all-too-frequent situations. But there is a better way to build your elecronic projects—UNITIZE!

Perhaps this is a new word for you—UNITIZE simply means to make your project in subassemblies; small units that are joined on a larger chassis to complete the project. Manufacturers of automobiles, airplanes, household appliances and most electronic equipment manufacturers use subassemblies in many of their products to speed production and save money.

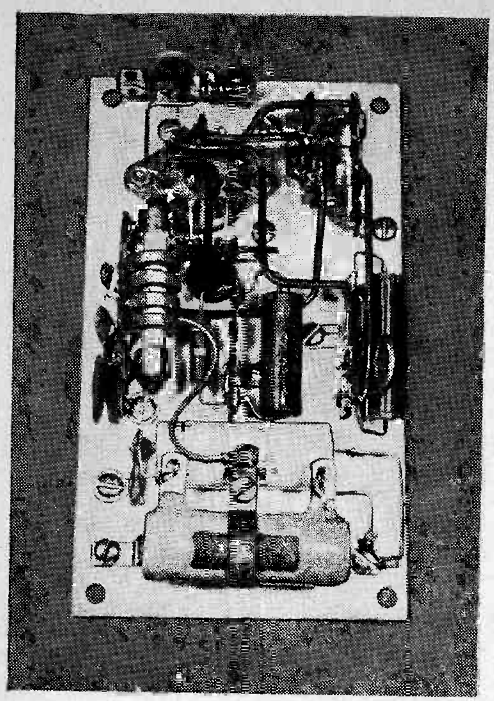
This is not a construction article. It will not tell you how to build a particular project. Instead you will be shown how to make a few, simple changes in your present way of laying out your project to make the assembly and wiring much easier, simpler and faster.

The Old Way. For an example suppose we use a simple regenerative receiver which you, or anyone else, may decide to build as a home-brew project. First you very carefully (we hope) lay out the chassis and panel. Then, just as carefully, drill the needed holes and make the necessary cutouts for sockets, etc. Mounting the various components seems to be the next logical step, so this is done. And now . . . the wiring.

The first few runs go rather well—no obstructions and things are generally simple with short, direct leads. Then a few more runs, one of which is slightly awkward as the solder terminal is in a spot a bit difficult to reach without burning the insulation of a wire previously placed. By a little maneuvering, and using a scrap of metal to protect the interfering wire, the connection is finally soldered. As the wiring proceeds, this situation has an annoying habit of repeating itself with increasing frequency until it reaches the flustrating point where the last wiring runs are made with great difficulty—the result: a project which is definitely not in the award-winning class for workmanship.

How much easier such assembly and wiring would become if it were done on a flat plate, outside the confining aprons of a chassis. In most cases it can!

The New Way—Unitize. Now take a look at Fig. 1. See how many components can be grouped on a 3½- by 5-inch flat aluminum plate without crowding. Planning the positions of the components around the socket keeps their leads very short—a good practice in RF-circuit wiring. Many of the other circuit components are mounted in the remaining area. Almost all of the wiring for the receiver can be right on this small base plate. As a complete assembly the plate is mounted inside the chassis, on spacers, with four easily placed machine screws, lockwashers and nuts. All that remains (in this case) is to connect seven wires—to the regeneration and volume controls, phone jack and B-plus and filament voltage connections. Just seven solder connections to be made within the con-



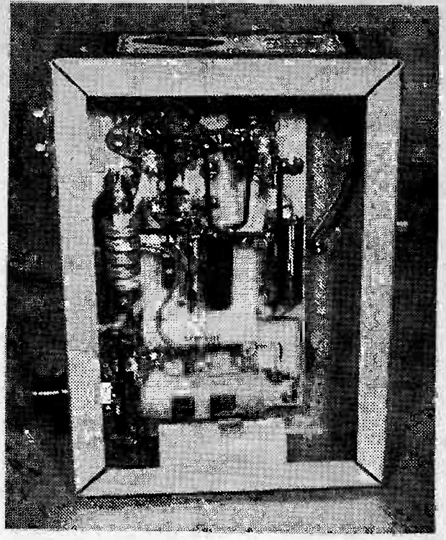


Fig. 1. (left) Receiver chassis before mounting in main chassis. Use ¼-inch spacers to prevent shorts.

Fig. 2. (above) Only soldering needed inside deep chassis aprons are for input, output and power.

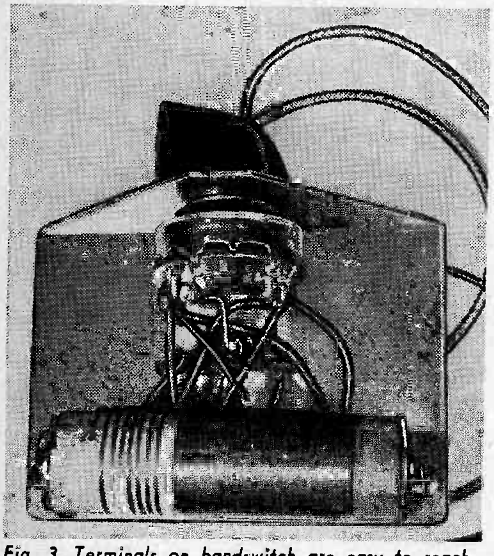


Fig. 3. Terminals on bandswitch are easy to reach. There is nothing to hinder wiring or obscure your view. Switch can be turned upside-down to prevent solder from running into silver-plated contacts.

fines of the chassis aprons—the rest of the wiring is finished. The hardest part of the wiring has been done on the 3½- by 5-inch base plate which could be moved around, stood on end, on edge or set in just about any other position that would make the job of wiring easier while producing a neat, professional job like that in Figs. 1 and 2.

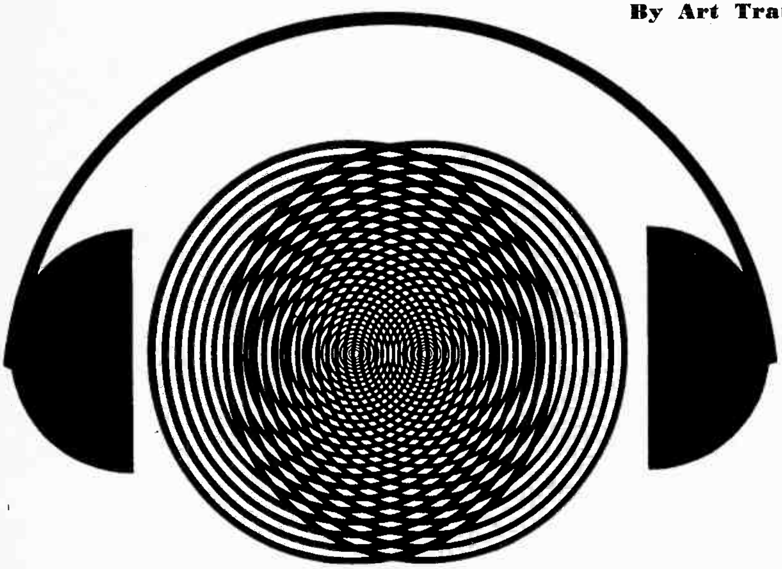
Don't Stop Now! Two more subassemblies are needed to complete the receiver. First let's look at the band switch and coil assembly in Fig. 3. To cover the 10-, 15-, 20-, 40- and 80-meter amateur bands a 5-position rotary switch and a coil with seven taps are needed. Another awkward, in-chassis wiring job is eliminated by mounting the coil and switch on a small piece of aluminum that has been bent to an angle of 90°. Here again, the hardest part of the wiring has been done before the components are mounted in the main chassis. A single nut, on the bushing of the rotary switch, is all that is needed to hold the subassembly in place. Then a few wires are soldered to other terminals and the bandswitch wiring is completed.

The power supply is the third subassembly. To reduce hum radiation from the power-transformer windings a shielded power transformer should be used. Since a shell-enclosed type was not available an open-type transformer was substituted and the whole power supply was mounted in a small steel box. *(An aluminum box will not give magnetic shielding to prevent hum voltages being induced in sensitive receiver circuits—Editor.)* The selenium rectifier, its surge-protective resistor and a terminal strip are mounted in the box along with the unshielded power transformer. The final position of the power-

(Continued on page 120)

Transistorized Stereo-Headphone Amplifier

By Art Trauffer



You don't need high power to enjoy your hi-fi when you listen privately to your records or tuner with high-fidelity headphones and this simple amplifier.

■ Here's a four-transistor stereo amplifier for use with stereo headphones. It is simple to layout, easy to build and it sounds great.

Besides listening to your favorite stereo or mono discs (or radio programs) at home, without disturbing others, this amplifier can be used for business purposes like auditioning stereo and mono discs in record stores, libraries, radio stations and for music-appreciation courses in schools. Use it with a stereo-FM tuner or with a mono-FM tuner and a multiplex adapter or for mono listening to an AM tuner.

The four transistors used (two in each channel) are powered by two D-size flashlight cells. A separate volume control in each channel compensates for possible sound-level differences in the two channels. This can be due to unbalance in the recording, the stereo pickups, unmatched transistors or earphones as well as the unmatched sensitivity of the listeners two ears. A *stereo-mono* switch lets you switch to *mono* when listening to monaural discs. This reduces surface noises and turntable rumble. A unique battery holder allows you to change batteries quickly and easily without opening the amplifier case.

In the schematic, Fig. 1, the two driver transistors (Q1, Q2) are RCA 2N217's (or RCA Top-of-the-Line SK-3003's). The two power transistors (Q3, Q4) are RCA 2N301/2N2869's (or RCA Top-of-the-Line SK-3009's).

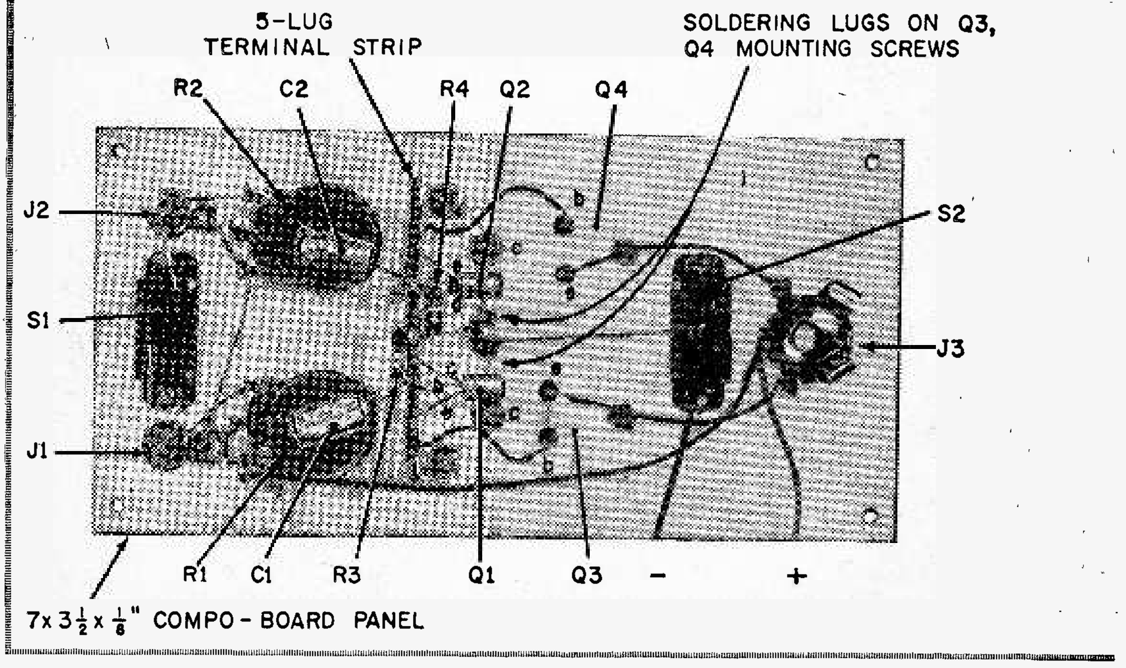
The Layout. Figs. 2 and 3 show how the parts are mounted and wired on a 7-inch by 3½-inch piece of ⅛-inch hardboard which is used as the front panel. (The back of the panel has been painted white, by the author, so the parts will show up better in the photographs.) Placement of parts isn't critical. Just space them for short, direct leads and nice appearance. Don't forget to allow space around the four edges of the panel for the ⅜-inch thick sides of the wooden case.

The two driver transistors (Q1, Q2) are mounted by their own leads soldered to a 5-lug terminal strip (Fig. 2). Clip the leads to about half of their normal length. (Grasp the leads with long-nose pliers, when soldering, to act as a heat sink). Do not solder leads directly to the base (B) and emitter

PARTS LIST

B1—D-size flashlight cells
C1, C2—25-mf., 15-volt electrolytic capacitor
J1, J2—phono jacks, single-hole mounting
J3—headphone jack, 3-contact stereo
Q1, Q2—2N217 transistor (RCA—See text)
Q3, Q4—2N301 or 2N869 power transistor (RCA)
R1, R2—50,000-ohm potentiometer (Volume control)
R3, R4—180,000-ohm, ½-watt resistor
S1, S2—S.p.s.t. slide switch
Misc.—Knobs for R1, R2; pressed hardboard for panel; wood stock ⅜-inch thick for cabinet; inexpensive flashlight (D-size cell)—see text; brass angle bracket; hardware; insulated hook-up wire; solder lugs, etc.

Estimated cost: $6.00
Estimated construction time: 4 hours



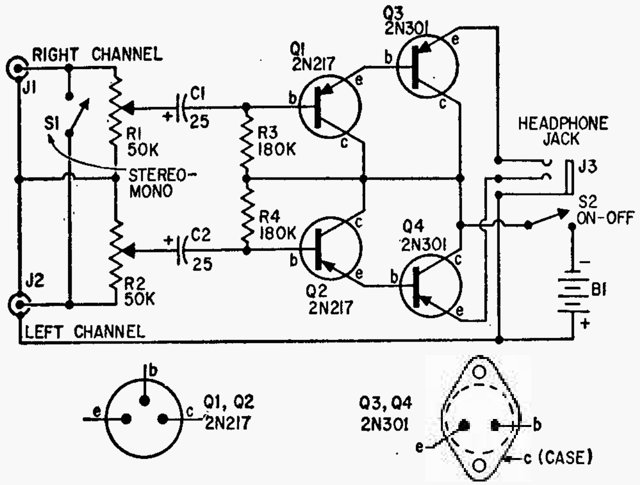


Fig. 1. Schematic for stereo-head phone amplifier shows simplicity of circuit. For mono use just cut amplifier in half across center. Do not attempt to parallel outputs for increased mono power output. Just use two speakers—one for each channel—or try a multiple impedance speaker with half of voice-coil winding as output load for each stereo channel amplifier.

(E) pins on the power transistors (Q3, Q4). Use small phono-cartridge pin clips or clips removed from a broken miniature-tube socket (if you do not use a standard power-transistor socket). Use insulated hookup wire, or pieces of spaghetti tubing, to avoid shorts that can quickly ruin transistors.

The Cabinet or Case. Make the panel from a scrap of ⅛-inch hardboard. For simplified operation, identify the switches as shown in Fig. 3.

The wooden-box cabinet is nailed and glued together using ⅜-inch stock (hard board, plywood or fancy hardwood). This

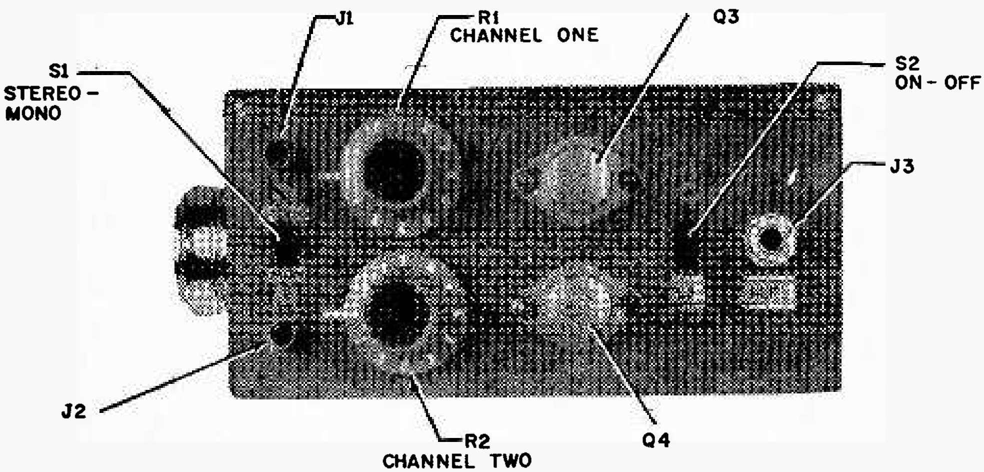
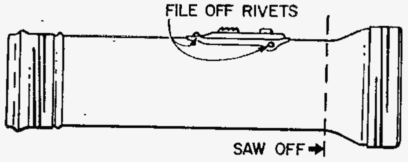
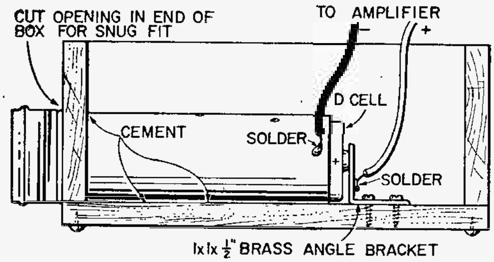


Fig. 2. (left) Underpanel view of amplifier shows simple layout duplicates that of schematic.

Fig. 3. (above) Power transistors mounted on outside of front panel dissipate heat better.

e/e HEADPHONE AMPLIFIER





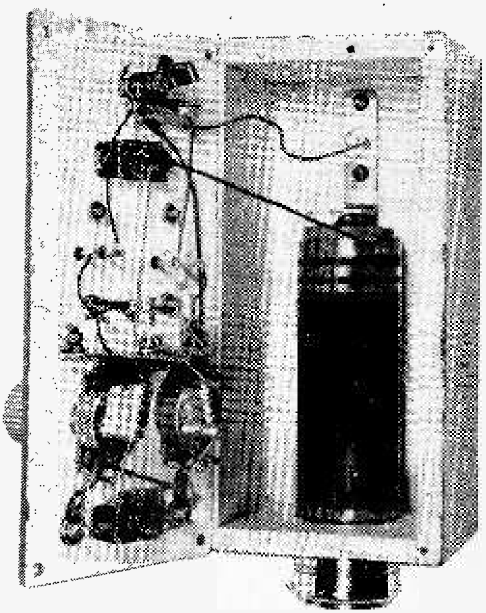


Fig. 4. (top, left) Indicated part of flashlight bell is cut off and discarded. Slide switch can be ignored since it is not really in the circuit here.

Fig. 5. (above) Roughen surface to be cemented to wooden case. Use cement suitable for metal, wood.

Fig. 6. (top, right) Battery holder in the amplifier.

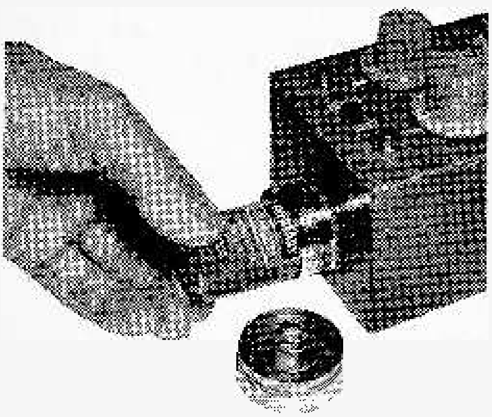


Fig. 7. Changing cells is as easy as replacing a couple in flashlight. Unscrew cap, shake out the old cells and drop in new ones and replace cap.

box measures 7-inches long, 3½-inches wide and must be at least 3-inches deep. The outside of the box can be painted, stained or left unfinished—whichever is best suited for its application.

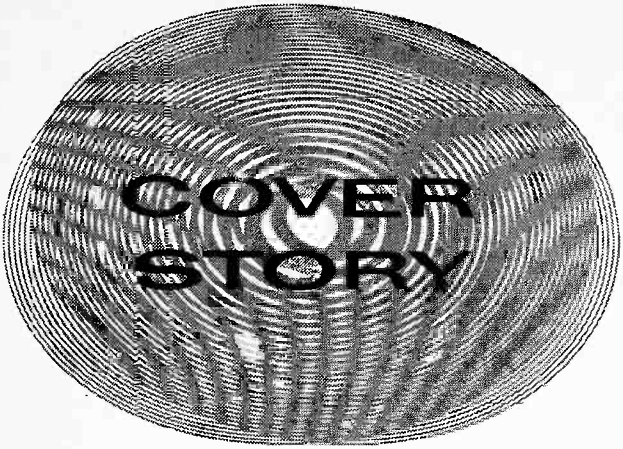
If you are not a very good carpenter you can make use of file-card boxes, cigar boxes, movie-camera cases or plastic boxes. Just make sure you change the size of the panel to fit the case.

Battery Holder. Figs. 4, 5 and 6 show how to make the battery holder from a metal-case flashlight which holds two D-size cells. The flashlight must have a removable cap on the end opposite the lamp and reflector. Do not use a flashlight with an aluminum case—aluminum is difficult to solder to. Fig. 7 shows how easy it is to change batteries.

How it Works. Both channels work exactly alike. The driver transistors (Q1, Q2) get their base bias through the 180K resistors (R3, R4). The driver transistors are direct-coupled to their power transistors (Q3, Q4). The base-input circuit of the power transistor serves as the emitter loads of the drivers while the emitter current of the driver transistors provides base bias for the two power transistors. The headphones are the power-transistor emitter loads.

Operation. One channel of the stereo phono pickup, or other source, is connected to input jack J1 and the other channel to input jack J2. (Only one input jack is used for input from an AM tuner or other mono source.) The *Stereo/Mono* switch is set to the stereo position for stereophonic inputs and the mono position for monophonic sources. (Stereo sources will be reproduced monophonically if the switch is left in the mono position.) Stereo headphones are plugged into the phone jack (J3) and the

(Continued on page 115)

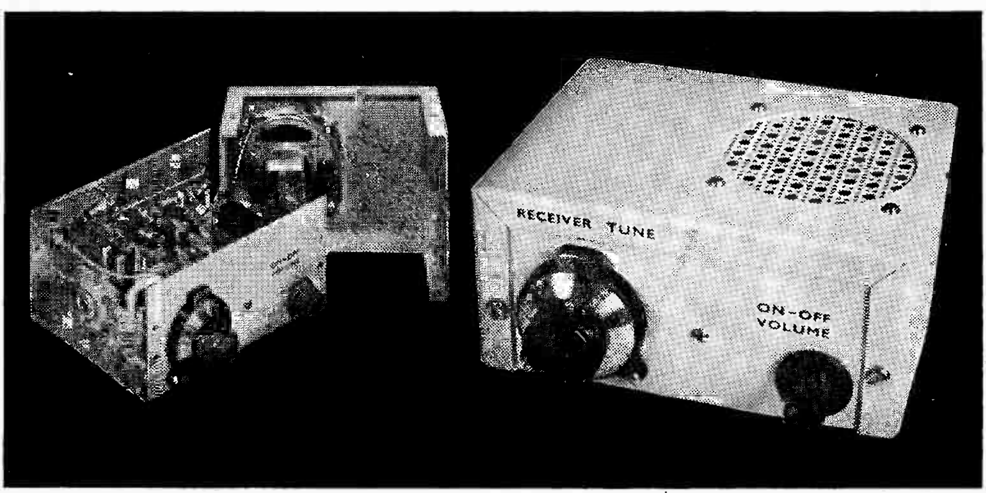


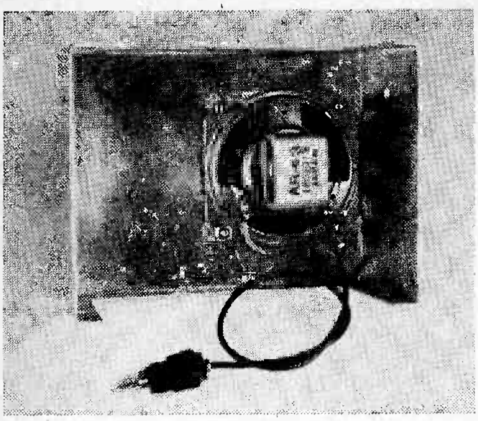
Build a Solid-State 6-Meter Receiver

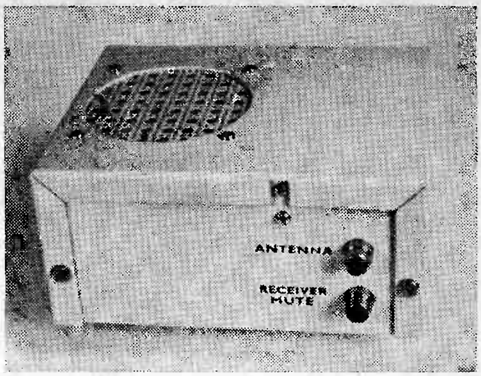
By Edward A. Morris, WA2VLU

First half of a 6-meter station is an easy project. Use it as a "first station," a mobile rig, for the next field day or just keep it on hand for emergencies.

■ Here is a solid-state, 6-meter, amateur receiver that's just great for beginners! Its super-regenerative detector provides for good over-all sensitivity and excellent noise limiting properties. Low in cost, you can build it for less than $18.00, and that's using all new parts too! Easy to build, a Novice could do the job in less than five hours. Construction is aided through the use of a 4-transistor pre-packaged audio amplifier, whose cost you couldn't beat if you built it yourself. The receiver is entirely self contained, except for an antenna. Power for the receiver is provided for by one 8.4 volt mercury battery, which can be expected to last for more than 25 hours when used with this receiver. Although completely self-contained, the receiver has a matching solid-state, 6-meter transmitter which is packed in a case of the same size as the receiver. Bolted







Rear of receiver case (above) shows location of antenna jack (J1) and receiver muting jack (J2). If flat-head screws are used it will not be necessary to notch lip of cover to clear round-head screws used by author to attach L-bracket for J3.

Inside of cover of receiver case (left) only has the 2½-inch speaker and length of single-conductor shielded wire terminated in plug (P3) going to J3.

together they comprise a 6-meter transceiver that can be mounted under your dash or hand carried for walking-talking operation. For further information, see "Build a Complete Station" on page 118.

How It Works. The receiver detector uses a single transistor, Q1, in a super-regenerative configuration. Signals picked up by the antenna are fed into the emitter of transistor Q1 through capacitor C1. Feedback in the detector occurs between the collector and the emitter of transistor Q1 via capacitor C2. Capacitor C7 together with coil L1 and tuning capacitor C8 resonate the receiver at the desired frequency.

The operating bias on transistor Q1 is set by resistors R2 and R3, which form a voltage divider network. The detector is stabilized by resistor R1, and is by-passed by capacitor C3. The quench frequency is largely determined by the value of capacitor C5, and in this case is well above audibility—about 25 kilocycles.

Resistor R5 and capacitor C6 decouple the detector from the audio amplifier. An 8.4 volt mercury battery, B1, is employed as the sole source of power for the receiver. Electrolytic capacitor C4 bypasses degenerative audio components. Audio is coupled to the prepackaged amplifier from the detector by way of transformer T1, a 10,000-ohm to 2,000-ohm interstage unit.

Capacitors C9 and C10 along with resistor R5 form a filter which prevents the quench frequency signal from being coupled into, and overloading, the amplifier.

Audio signals across the volume control, R6, which also serves the on-off control, are coupled into the input of the pre-packaged amplifier. This amplifier is prewired and contains all the components necessary to perform its job. The output of the amplifier is fed into the speaker.

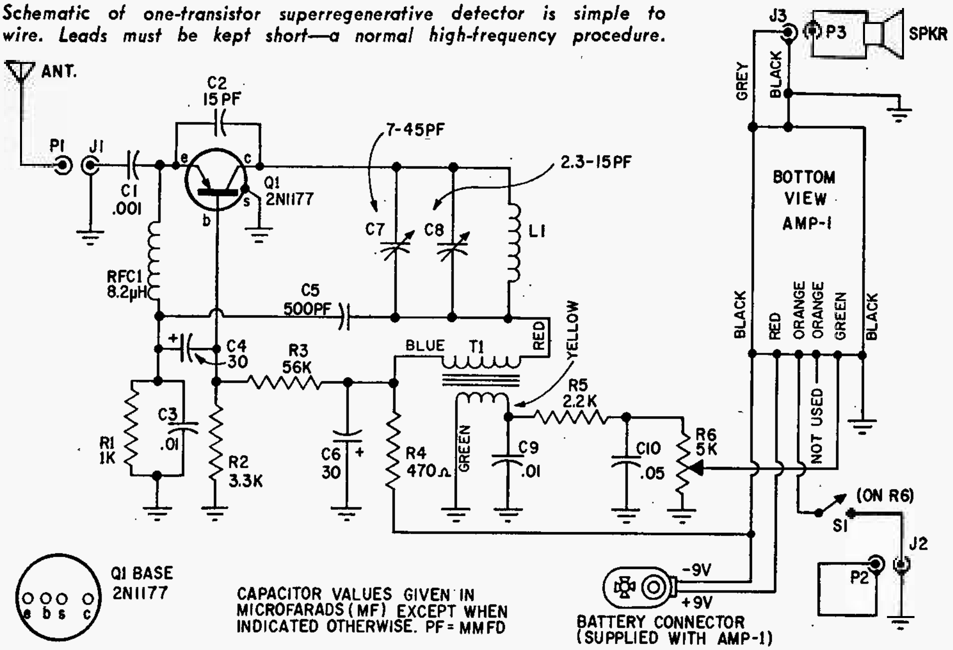
Notice that jack J2 is wired in series with the on-off switch S1. When the receiver is used by itself, a shorting plug, P2, is inserted into jack J2. When the receiver is used in conjunction with a transmitter, J2 connects to the mute terminals in the transmitter, through a cable terminated at the receiver and with an RCA plug. This turns the receiver off when the transmitter is keyed, preventing feedback and possible damage to the receiver.

Mechanical Construction. The case for the receiver is cut down from a standard 5x4x3-inch aluminum chassis box. The bottom ⅝ inch from each half of the box is cut off to obtain a box measuring 5x4x2⅜ inches when closed. The job can be done with a hacksaw in a few minutes, although a hand nibbler tool is certainly more convenient to use if you have access to one. Be sure to dress any rough edges with a file.

Lay out all holes to be drilled in the case with a T-square or carpenter's square. Center punch the spots where holes are called for before drilling. The hole for the speaker can be cut using a nibbler, or alternately, with a circle cutter.

If you do not plan to use the receiver with the companion transmitter, you need not drill the holes in the right and left hand sides of the case cover.

Schematic of one-transistor superregenerative detector is simple to wire. Leads must be kept short—a normal high-frequency procedure.



PARTS LIST

- AMP—Miniature 4-transistor amplifier (Lafayette Radio 99R9042 or equiv.)
- B1—9-volt mercury battery (Mallory TR-126 or equiv.)
- C1—.001-mfd., 75-WVDC miniature ceramic capacitor (Lafayette 99R6060 or equiv.)
- C2—15-pf., 500-WVDC dipped silvered mica capacitor (Elemeco type DM-10 or equiv.)
- C3,9—.01-mfd., 75-WVDC miniature ceramic capacitor (Lafayette 99R6063 or equiv.)
- C4,6—30-mfd., 12-WVDC miniature electrolytic capacitor (Lafayette 99R6084 or equiv.)
- C5—500-pf., 500-WVDC dipped silvered mica capacitor (Elemenco type DM-10 or equiv.)
- C7—7-45-pf. trimmer capacitor (Centralab type 822-BN or equiv.)
- C8—2.3-15-pf. miniature variable capacitor (Hammerlund type MAPC-15B or equiv.)
- C10—.05-mfd., 75-WVDC miniature ceramic capacitor (Lafayette 99R6068 or equiv.)
- J1, J2, J3—RCA type jack, single hole mounting (Lafayette 99R6234 or equiv.)
- L1—3 turns B&W miniductor #3002 (3 turns #16 wire spaced to 1/4 inch.)
- P1, P2, P3—RCA type phono plug
- Q1—2N1177 transistor (RCA)
- R1—1,000-ohm, 1/2-watt resistor
- R2—3,300-ohm, 1/2-watt resistor
- R3—56,000-ohm (See text)
- R4—470-ohm, 1/2-watt resistor
- R5—2,200-ohm, 1/2-watt resistor
- R6—5,000-ohm miniature potentiometer, with s.p.d.t. switch (Lafayette 32R7363 or equiv.)
- RFC1—8.2uh. RF choke (Miller type RFC-50, or equiv.)
- S1—S.p.d.t. switch, attached to potentiometer R6.
- SPKR—8-ohm voice coil, 2 1/2-inch square speaker (Lafayette 99R6097 or equiv.)
- T1—Miniature audio transformer: 10,000-ohm primary, 2,000-ohm, center-tapped secondary (Lafayette 99R6126 or equiv.)
- 1—Vernier dial mechanism, 36mm diameter (Lafayette 99R6031)
- 1—Aluminum chassis box, 5x4x3-in. (See text)
- Misc.—Nuts, bolts, hook-up wire, transistor socket, knob, spray paint, decals, flea clips, eyelets, 1/4-i.d., 3/8-o.d. plastic tube, 1/4-o.d. plastic tube, etc.

Estimated cost: $18
Estimated construction time: 6 hours

The necessary mounting brackets are, for the most part, cut from 1/16-inch hard aluminum sheet stock. Note that the shaft of tuning capacitor C8 is not grounded, and should not be allowed to contact the chassis at any point.

The battery clip for B1 is the center clip from a single "AA" size cell. The clip is easily removed drilling out two retaining rivets. The speaker grill from a piece of perforated do-it-yourself aluminum.

After all necessary mechanical work on the case has been completed, the case can then be prepared for painting. First wash it down to remove any surface dirt or grease, then rub it down with a fine grade of steel wool. Several light coats of spray paint can then be applied according to the manufacturers directions on the can. Take care to

(Continued on page 98)

How To Have Fun While

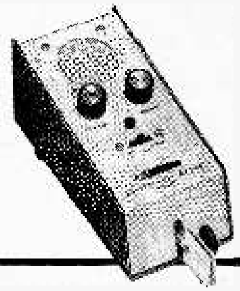
New 23-Channel 5-Watt All-Transistor CB Transceiver

Kit GW-14 $89.95

Assembled GWW-14 $124.95

23 crystal-controlled transmit & receive channels for the utmost reliability. Low battery drain . . . only .75 A transmit, .12 A receive. Only 2⅞" H x 7" W x 10½" D . . . ideal for car, boat, any 12 v. neg. gnd. use. "S" meter, adjustable squelch, ANL, built-in speaker, PTT mike, aluminum cabinet. 8 lbs. Optional AC power supply, kit GWA-14-1, 5 lbs. . . $14.95.

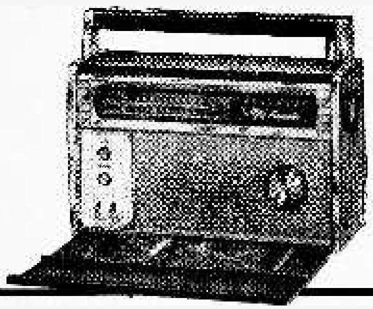
New Fully Automatic Electronic CW Keyer



Kit HD-10 $39.95

All-transistor circuitry. 15-60 words per minute. Solid-state switching—no relays to stick or clatter. Convertible to semi-automatic operation. Built-in paddle. Self-completing dashes. Variable dot-space ratio. Built-in sidetone. Keys neg. voltages only, such as grid-block keying. Transformer-operated power supply. Fused. 6 lbs.

New All-Transistor, 10-Band SWL Portable



Kit GR-43 $159.95

10 bands tune longwave, broadcast, FM and 2-22.5 mc shortwave. 16 transistors, 6 diodes, 44 factory-built & aligned tuned circuits. Two separate AM & FM tuners, two built-in antennas, 4" x 6" speaker, battery-saver switch. Operates anywhere on 7 flashlight batteries or on 117 v. AC with optional charger/converter GRA-43-1 @ $6.95. Assembles in 10 hours. 17 lbs.

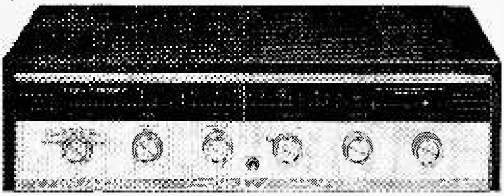
New Deluxe 5-Band SSB Ham Transceiver

Kit SB-100 $360.00

Full SSB-CW transceive operation on 80-10 meters. 180 watts PEP SSB—170 watts CW. Switch select for USB/LSB/CW operation. Operates PTT and VOX; VOX operated CW with built-in sidetone. Heath SB series Linear Master Oscillator (LMO) for true linear tuning. Mobile or fixed operation with appropriate power supply. 23 lbs. . . Accessory mobile mount, SBA-100-1 . . . $14.95.

You Save...Build A Heathkit®!

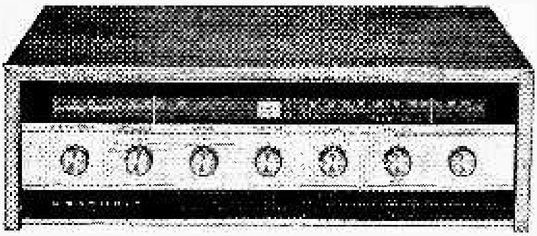
New 30-Watt Transistor FM Stereo Receiver



Kit AR-14 $99.95 (less cabinet)

31 transistors, 11 diodes for transparent transistor sound; 20 watts RMS, 30 watts IHF music power @ ±1 db, 15-60,000 cps; wideband FM/FM stereo tuner, two pre-amplifiers, & two power amplifiers; compact 3⅞" H x 15¼" W x 12" D size. Assemble in around 20 hours. Mounts in a wall, or optional Heath cabinets (walnut $9.95, beige metal $3.95). 16 lbs.

66-Watt Transistor AM/FM Stereo Receiver



Kit AR-13A Now Only $184.00

Just add 2 speakers for a complete stereo system. Boasts AM/FM/FM stereo tuning; 46-transistor, 17-diode circuit for natural transistor sound; 66 watts IHF music power (40 watts RMS) at ±1 db from 15-30,000 cps; automatic switching to stereo; preassembled & aligned "front-end" & AM-FM IF strip; walnut cab. 35 lbs.

"Beginner's" AM Transistor Portable . . . Includes FREE Tool Kit & Battery!

Kit GR-151A $20.65 Radio, Tool Kit & Battery

If you've never tried your hand at building a kit, then here's the perfect kit for you. Includes battery, all tools and parts you need to build it. Boasts 6 transistor, 3 diode circuit; large 4" x 6" PM speaker for a crisp, clear sound that can't be matched by miniatures; built-in ferrite rod antenna; and handsome tan simulated-leather case. Circuit board construction and prealigned coils and I.F. transformers assure top performance and simple 4 to 6 hours assembly. 5 lbs.

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Prices & Specifications subject to change without notice. CL-231

6-METER RECEIVER

Continued from page 93

allow for sufficient time for each coat to dry before applying the next.

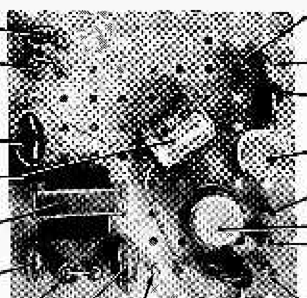
Decals or transfer lettering may then be applied according to the manufacturers directions. Suitable decals are both inexpensive and easy to apply. They lend a professional appearance to the finished receiver, and are well worth the small amount of extra effort to purchase and apply. Several coats of a clear spray plastic is then applied to protect both the paint job and the decals.

Electrical Construction. The superregenerative detector is built on a 1⅞x1⅞-inch piece of perforated board. Parts lay-out is clearly visible in the photographs. For best results, try to follow the lay-out as presented. Keep in mind that at 50 megacycles leads should be kept as short as is possible. The only components associated with the detector which are not mounted on the perforated board are capacitors C7, C8, and coil L1. Hollow eyelets inserted in the proper holes serve as lead anchors and terminals for individual components. Flea clips are also used as terminal points, as can be seen in the photographs.

If you carefully examine the photo of the detector board's underside, you will note a copper-clad surface on a portion of the perforated board. This copper surface serves as a ground return circuit quite handy and eliminates many unnecessary leads. There's no need to etch off the undesired copper. Just deep scribe along the borders of the wanted copper, then pry up and pull free the unwanted copper. Exact dimensions are not critical. Just be *dang* sure the copper surface does not short against circuit parts and terminals that are not to be grounded.

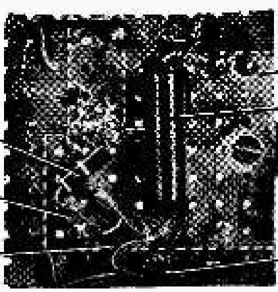
Although the author chose to use a transistor socket to mount transistor Q1, you can, if you wish, solder transistor Q1 directly into the circuit. If you choose to solder Q1 directly into the cicuit, use a low wattage, well tinned soldering iron. Complete the soldering operation as quickly as possible. Be sure to use a heat sink on each lead when soldering to prevent possible damage to the transistor.

After the detector board has been wired according to the schematic diagram, recheck your work for any possible errors and accidental shorts. Pay special attention to the polarity of the electrolytic capacitors and to the wiring of transistor Q1's socket.



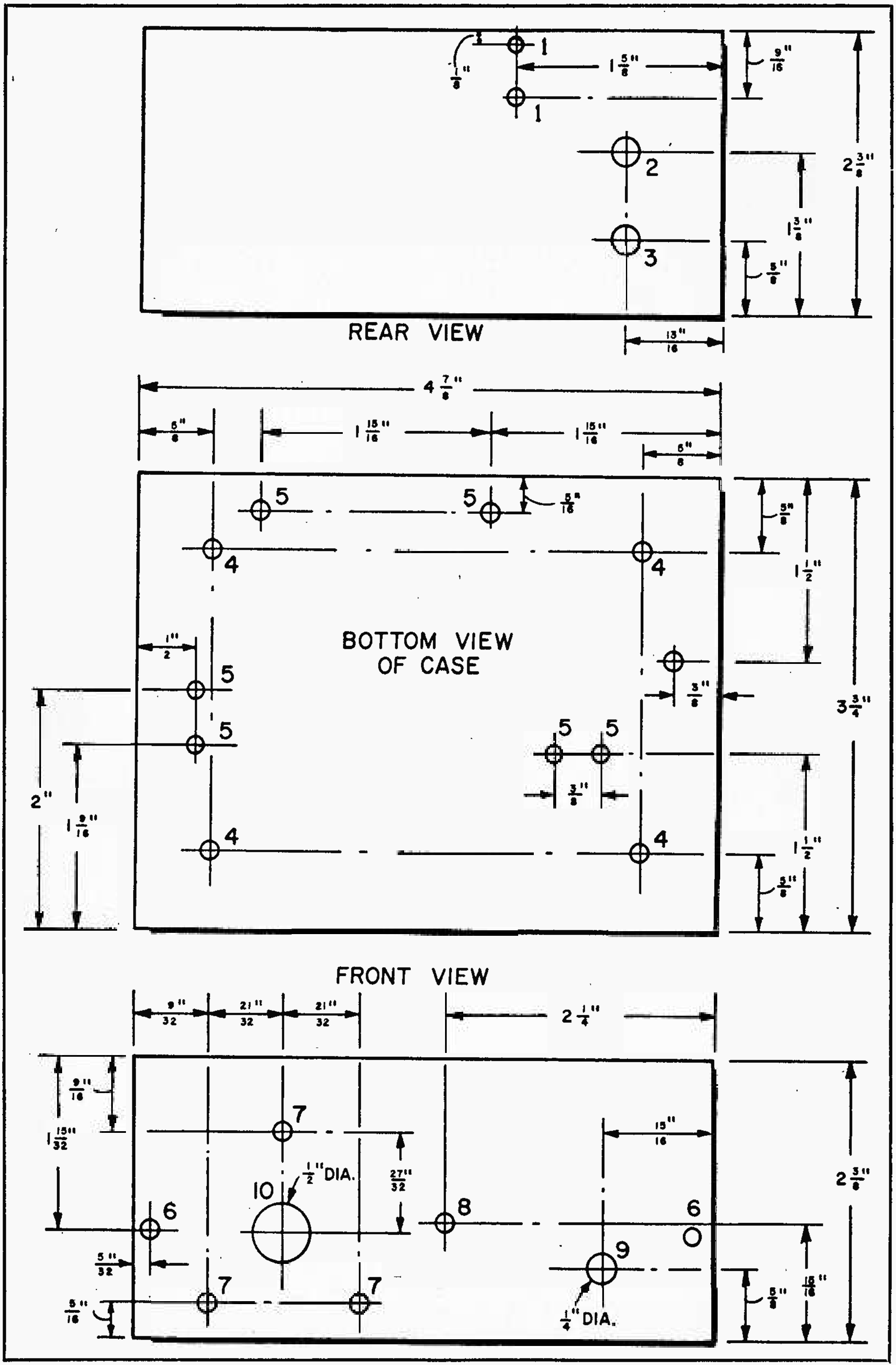
Top view of perforated board shows placement of most components. C4 should be anchored to the perforated board if building a mobile receiver.

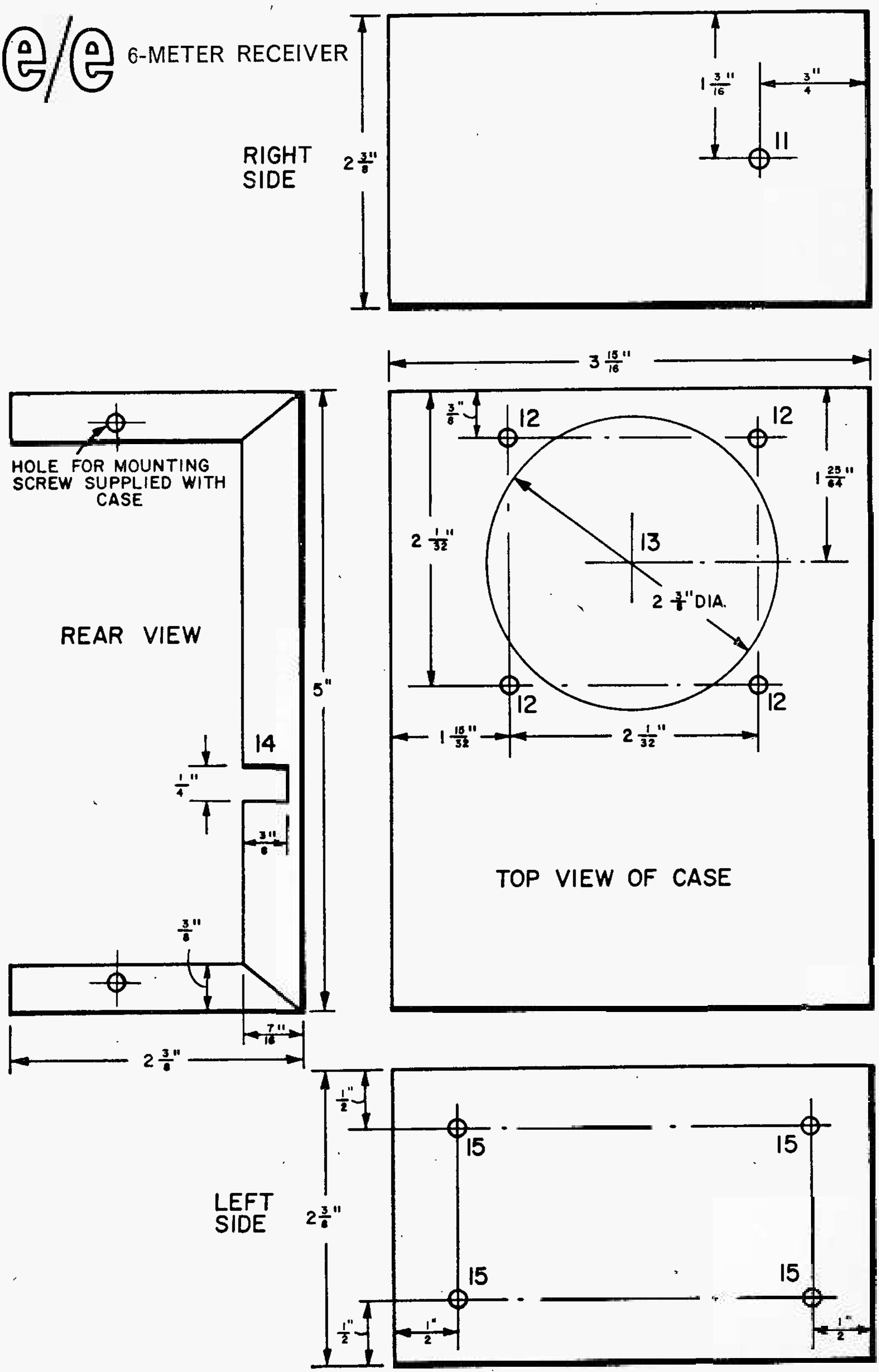
Copper-foil covered area on perforated-phenolic board (inside dotted lines) acts as RF shield.



NOTES ON CHASSIS DETAIL DRAWINGS ON PAGES 99 AND 100

1 *Holes for #4 screws.*
2 *¼" dia. hole for J1.*
3 *¼" dia. hole for J2.*
4 *Holes for #8 screws.*
5 *Holes for #4 screws.*
6 *3/32" hole for selftapping screw.*
7 *Holes for #4 screws to mount vernier.*
8 *Holes for #4 screws to mount circuit board.*
9 *¼" dia. hole to mount R6.*
10 *½" dia. hole for Vernier shaft.*
11 *Hole for #8 screw to mount handle.*
12 *Holes for #4 screws to mount SPKR.*
13 *13/16" hole for SPKR opening.*
14 *Slot to clear screw head.*
15 *Holes for #8 screws to mount receiver and transmitter together.*


REAR VIEW
BOTTOM VIEW
OF CASE
FRONT VIEW
1/2" DIA.
1/4" DIA.


RIGHT SIDE
2 3/8"
1 3/16"
3/4"
11
3 15/16"
12
13
2 1/8" DIA.
3/8"
1 25/64"
2 1/32"
1 15/32"
TOP VIEW OF CASE
HOLE FOR MOUNTING SCREW SUPPLIED WITH CASE
REAR VIEW
5"
14
1/4"
7/16"
LEFT SIDE
15
1/2"

Final Assembly. Capacitor C7 and L1 are mounted on a piece of perforated board as shown. Next mount tuning capacitor C8, it's insulated shaft, and the vernier dial mechanism. Check to make sure that capacitor C8's shaft does not contact ground at any point. The receiver will not operate if any part of capacitor C8 contact's the case.

Jacks J1, J2, and J3 along with the on-off/volume control R6 are mounted next. The audio amplier is mounted using two brackets as shown in the photographs. Mount the super-regenerative detecting board in the position indicated together with the other jacks, brackets, and clips.

After you complete the wiring of the receiver, carefully re-check your work again for possible errors.

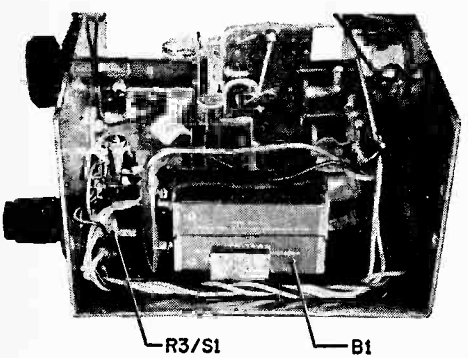
Testing and Alignment. After you've assured yourself that the receiver is wired correctly as is shown in the schematic diagram, proceed with testing the unit.

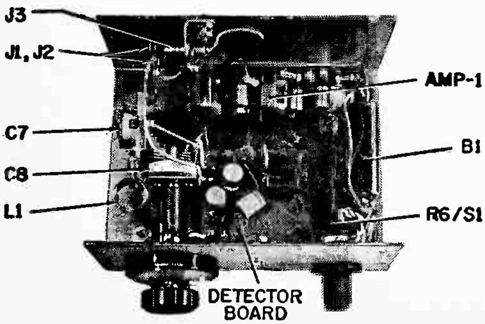
Set capacitor C7 to approximately it's mid capacity position. Adjust the vernier dial mechanism so as to read zero with the tuning capacitor C8 set to maximum capacity. Lock the vernier dial in this position. Insert a shorting plug, P2, into jack J2. Plug in the speaker, and battery B1. Plug some sort of 6-meter antenna into jack J1—a 55 inch piece of wire will suffice for testing. Turn the on-off/volume control to the on position. You should immediately hear a rushing noise, whose volume can be controlled by the volume control R6. If you can't obtain this rushing noise, recheck your work.

To align the receiver it's necessary to couple the output of a signal generator or a grid dip meter to 50 megacycles to jack J1. If your using a signal generator, simply connect the generators output leads to J1. In the case of a grid dip meter, connect a short antenna (10–15 inches) to jack J1. If your grid dip meter accepts crystals, use a 6-meter rock for alignment purposes. Enough signal will be coupled into the receiver by the antenna. Turn the receiver on. Adjust capacitor C7 so that the 50 megacycle energy appearing at jack J1 is detected by the receiver when the receiver vernier tuning dial is set to approximately "1". This completes the alignment of the receiver. The receiver will now tune the 6-meter band from the numeral "1" on the vernier dial upwards. Several crystal checks will give you an idea of your band spread.

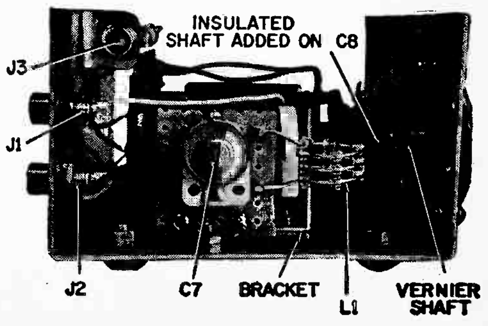
Due to variations between transistors, the optimum value for resistor R3, and the component parts used, the sensitivity of the receiver may vary from unit to unit. This is especially true when transistors of a different type are substituted for transistor Q1. A 56,000-ohm resistor proved best for the authors model. Typical values for R3 may range from 27,000 ohms to 100,000 ohms. The reader can determine the optimum value for his unit by connecting a 15,000-ohm resistor in series with a 100,000-ohm potentiometer, and wiring it into the circuit in place of resistor R3. The optimum value can then be easily determined by tuning to a weak

(Continued on page 118)





Top and end views of the completed receiver. When used for mobile operation all components must be securely mounted to prevent lead breakage from the bouncing and vibration of car. Battery can be replaced with Zener regulator for 12-volt operation.



STEREO PHASOMETER

■ In recent years the instruction manual accompanying hi-fi equipment—rather than being oriented to the electronics hobbyist—has been geared to the non-technical general consumer. And too often important electrical procedures are reduced to an absolute minimum. Such is the case with speaker phasing. Where formerly detailed instructions were common to all amplifier manuals, only a general reference that "speakers must be phased" is the present practice. (Naturally, there are a few exceptions to the simplified manual.) Yet, in a sense, proper speaker phasing plays a most important part in determining a hi-fi system's *delivered-to-the-ear* frequency response.

The Problem. When speakers are electrically in-phase such that both cones simultaneously move forward and back their output is additive. For example, if a single speaker is reproducing a 100-cycle tone and a second speaker fed from its own amplifier is turned on (such as a stereo amplifier), ignoring room resonances and beaming effects, the apparent loudness in the room will increase. On the other hand, if the speakers are out of phase such that one speaker moves out while the other moves in, under ideal conditions the speaker outputs would cancel and there would be no apparent sound.

Practically, in the home, total cancellation rarely exists except in small selected positions and only if the signal is of the same tone. But in almost all instances—while room resonances, speaker beaming and reflections tend to eliminate cancellation of the midrange and high frequencies when the signal source is program material—reversed speaker phasing will result in a *sharp* cancellation (attenuation) of the low frequencies.

Though, theoretically, in-phase speakers should deliver maximum bass, such is not always the case since room resonances play an important part in determining overall sound quality. And if you, the consumer, depend solely on the matching of speaker terminals and color coded wiring to determine proper phasing, *your* hi-fi system may be delivering sound quality far short of its capabilities.

A Case in Point. Refer to the floor plan (page 105) of an actual installation which shows the effects of speaker phasing. Keep in mind that the speaker orientation is not deliberately set to prove a point, but is the general layout of hi-fi installations in a rather large housing development. When the stereo speakers are positioned at A and B, and they are electrically in phase. Normal—good if you will—bass response is obtained anywhere in the room between line X and wall Z. But between line X and Y almost no bass exists. Listeners seated anywhere between X and Y hear a *thin* sound almost totally lacking in bass. (Moving speaker A to position C does not improve the situation).

If the equipment cabinet is along wall Z (where it generally is in this development),

Discover a simple listening test to identify speaker-phasing problems that mar fidelity. And then build a simple test instrument that is more accurate than your ear.

by Herbert Friedman, W2ZLF/KBI9457

STEREO PHASOMETER

phasing the speakers by using a "phasing switch" at the equipment cabinet results in no bass along wall Y. On the other hand, when the speakers are reverse phased such that the sound throughout most of the room is lacking bass, the sound between line X and wall Y is full and rich.

The unusual aspect of the measurements was that line X *actually was a line,* starting from about three feet in front of speaker B and running to the kitchen wall. When the speakers are in electrical phase a person starting from the center of the room walking towards wall Y actually passes through an imaginary line where the bass starts to decrease and suddenly gets *Lost.*

While the *double phase* condition is not necessarily normal to all rooms, you don't know if it exists until you actually install your equipment. And even then, if you follow typical recommendations for electrical speaker phasing your particular music room might require reverse phasing (*inverted* or *negative* phasing depending on the manual you're reading) for optimum bass response. To compound the problem, if you're a typical audiophile—the type who likes to try new equipment—the substitution of speakers or amplifiers, depending on their internal wiring, can easily change the speaker phasing from what you have decided is optimum for a specific location.

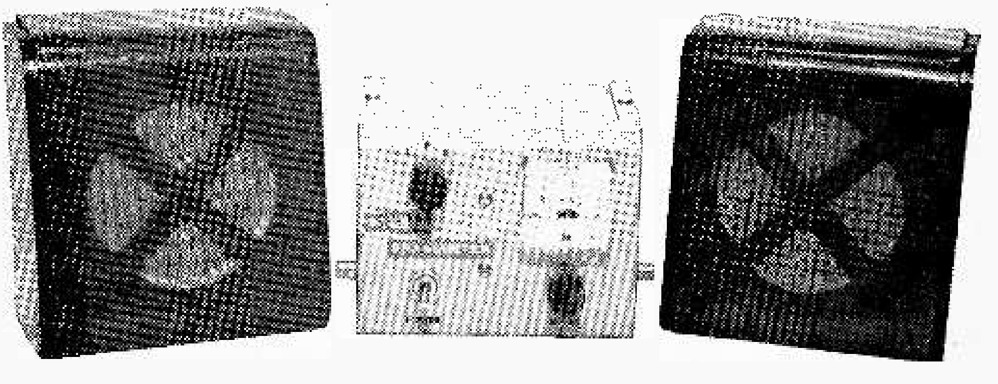
The Stereo Phasometer. To determine optimum speaker phasing, obtain electrical phasing, or even to match experimental equipment without the time and necessity for innumerable A-B tests, a Stereo Phasometer is the answer. Actually, it is nothing more than a portable transistorized amplifier with suitable speaker-mike switching; but it offers a quick and convenient method of solving speaker phasing problems, with precise channel balancing thrown in for extra measure.

The Phasometer shown in the photographs can be built virtually from the junk box. Transistors Q1 and Q2, (see schematic diagram) can be any general purpose type such as the RCA 2N217 or GE-2; even the *four-for-a-buck specials* offered by the surplus dealers will do. Just take care not to damage the transistors with soldering heat; use a heat sink, such as an alligator clip on each lead when soldering.

All capacitors can be the inexpensive imported type—no need to use high quality Tantalums. Take particular care that they are installed with the correct polarity. Reversing any capacitor polarity will make the unit inoperative.

While the wiring for S1 appears more complex than need be, it is the simplest way to wire the specified switch—it only requires two jumpers which don't cross so there's no possibility of shorting.

Power switch S2 is not ganged with sensitivity control R5 to allow leaving the Phasometer pre-set for gain measurements. If you



have no need or desire to have a fixed or preset gain control S2 can be combined with R5.

VU meter M1 will indicate correctly regardless of the wiring polarity, it makes no difference which terminal is connected to Q2's collector.

The speaker-mikes can be any pair of 4 or 8-ohm matched speakers in identical cabinets; use the complete speaker assemblies specified or *roll your own;* just make certain the same type speaker is used for both inputs.

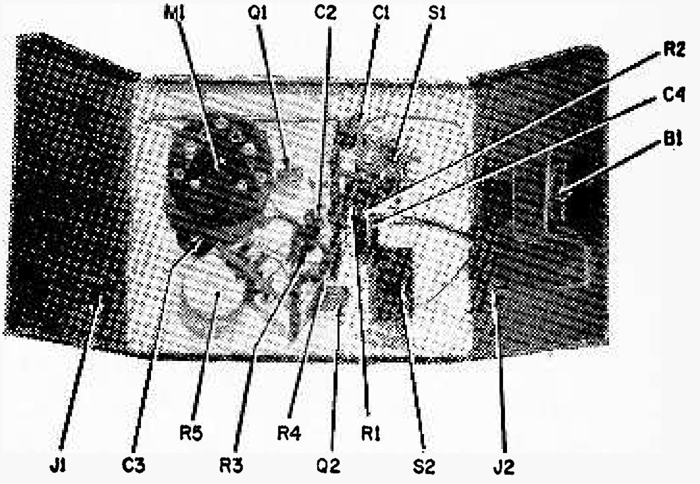
Calibrating the Phasometer. For both calibration and measurements a low level 100-cycle sine-wave tone is recommended. If you cannot borrow an audio generator a recording of reasonably constant-level wide range music can be used if the amplifier's bass boost control is set to full boost while the treble control is set to full cut. As a last resort any suitable music from the radio tuner can be used. In any event, set the amplifier's stereo-mono switch to *mono* so the same signal is fed to both channels.

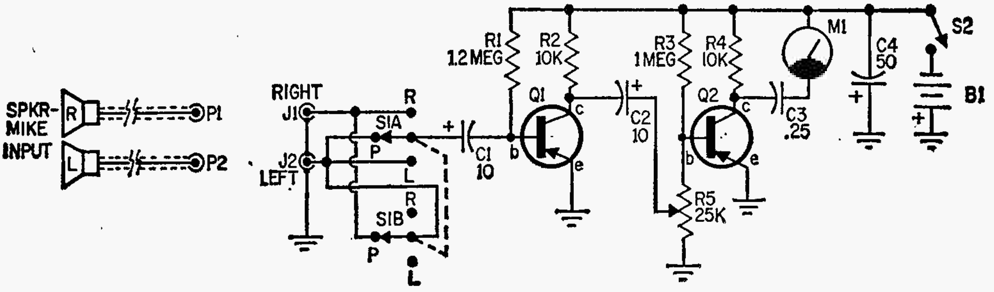
When we refer to "reversing the speaker phasing" either use the amplifier's stereo reverse switch (if there is one) or reverse the wiring connections to *one* speaker.

A simple setup in front of one speaker system checks out the unit. Special equipment is not needed for calibration but a signal generator, test record or tape can make tests easier.

Connect a speaker-mike to both J1 and J2 and position both mikes as close as possible to *one main speaker,* and disable the second channel. Set Phasometer switch S1 to the left channel, turn the power on (S2) and adjust R5 for any convenient meter reading, say 80 to 100%. Set S1 to the right channel just to see if the connections are okay, the meter should read essentially the same as for

The simple circuit in the schematic below results in an equally simple layout (at right). Only three of the five positions of the double-pole switch are used for the L, P and R positions of the function selector switch. Wiring is not as critical as it would be in RF circuits and there is no chance of power-supply hum because a battery is used. The low-current drain of the two-transistor circuit will assure long life for the battery.



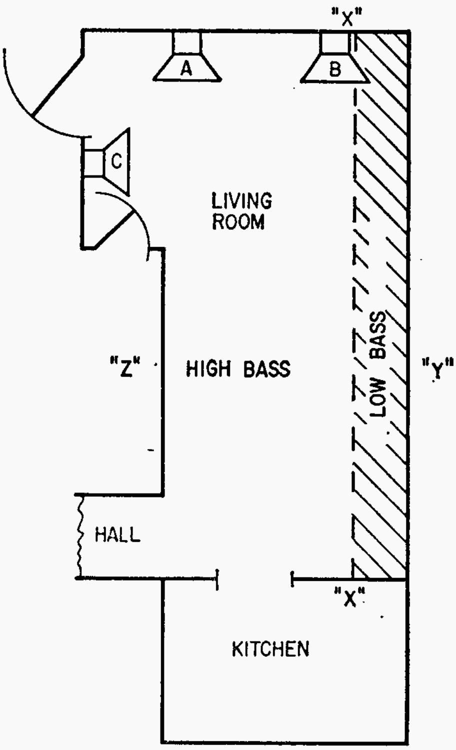


PRICE LIST

B1—9-volt transistor radio battery (Burgess 2U6 or equiv.)
C1, C2—10 mfd, 12VDC capacitors
C3—.25-mfd, 75VDC capacitor
C4—50-mfd, 12VDC capacitor
J1, J2—Phono jacks
M1—V.U. meter (Lafayette Radio 99R5024 or equiv.)
P1, P2—Phono plugs
Q1, Q2—General purpose transistors (RCA 2N217, GE-2, or equiv.; see text)
R1—1,200,000-ohm, ½-watt resistor
R2, R4—10,000-ohm, ½-watt resistor
R3—1,000,000-ohm, ½-watt resistor
R5—25,000-ohm, audio taper potentiometer
S1—D.p.5 t. subminiature rotary switch (Lafayette 99R6164 or equiv.)
S2—S.p.s.t. toggle switch (see text)
2—Speaker-mikes: 4-inch PM speakers in wood baffle (Lafayette 99R4551 or equiv.; Lafayette speaker includes 25-foot cable)
1—5″ x 4″ x 3″ aluminum cabinet (Premier 12R8389 or equiv.)
Misc.—Panel marking, hardware, solder, etc.

Estimated cost: $15.00
Estimated construction time: 4 hours

Even identical apartments will have differences in room resonances because of the upholstery on furniture and its style, the rugs on the floor, draperies and curtains or large pictures and mirrors change acoustics of a room.



the left channel. Now set S1 to The center or *phase* position; the meter reading should remain essentially the same—perhaps it will drop 1 or 2 db due to double speaker loading. If the meter drops sharply, say 10 db or more, when S1 is set to *phase*, the two speaker mikes are out of phase and the wiring to *one* speaker-mike must be reversed. (When M1's reading drops sharply it indicates that the signals from the speaker-mikes are cancelling each other—indicating they are connected out of phase.)

Checking Your Rig. Once the speaker-mikes are phased you can check your stereo gear. Place one mike near the right speaker and the other mike near the left speaker. Drive both channels to approximately the same level (but keep it low, the Phasometer is very sensitive). Note the meter reading on both the left and right channel; if they are not reasonably equal adjust the amplifier's gain or balance controls till they are equal. Then set S1 to *phase*. If the stereo speakers are in electrical phase M1 will indicate essentially the reference readings. If the speakers are out of phase M1 reading will drop sharply when switched to the phase test.

To check the speaker phasing in the listening areas connect only one speaker-mike to the Phasometer—say, to the left channel—and position the mike in the listening area. Disable one amplifier channel and set R5 for a convenient meter reading on the single speaker signal. Then switch in the second channel. If the meter reading drops sharply the speakers are out of phase for that particular listening area. (But make certain you are feeding a mono or stereo-to-mono signal to both speakers.) While it is possible that room effects can drop the meter reading regardless of the speaker phasing, it is extremely rare or well nigh impossible in the average home.

Amplifier tone balance can be checked by positioning each speaker-mike in the identical position in front of each main speaker and then adjusting each channel's tone controls for identical L-R meter readings at various frequencies (use sine-waveform).

Of course, once you run a room survey for speaker phasing the Phasometer will not be used until you change equipment or set-up a system for friends; it's not something you'll use everyday unless you're trying to prove a point to unbelievers. But if you pick up a few bucks by doing hi-fi installations on the side, the Phasometer is your gateway to extra jobs. ■

CATV Today

Continued from page 68

It is customary to transpose high-band VHF-TV channels (7-13) to low-band channels (2-6) when low-band channel space is available on the cable.

A TV channel can be transposed without demodulating it by passing the signal through a heterodyne up-converter or down-converter, as shown in Fig. 5. For example, by feeding a locally-generated 108-mc signal into the mixer to be heterodyned with a Channel-7 TV signal (177-mc center frequency), a Channel-4 TV signal (69-mc center frequency) is produced. CATV subscribers, of course, are advised as to what channel to tune in to receive programs from specific stations.

Controversy Over CATV. A big storm was kicked up when CATV became a multi-million dollar business. Some broadcasters complained that no one had the right to pick up their programs and rebroadcast them at a profit. Stations in areas served by CATV systems complained that bringing in programs from stations in other cities was an invasion of their proprietary rights to their specific market area. "Not so," others declared, pointing out that granting of a TV station license does not give the licensee any exclusive rights except the right to transmit on a given channel. Because of the many legal aspects, the FCC has taken over the regulation of CATV systems.

Untapped Potential. The capabilities of CATV are not yet being fully utilized. Mainly, this is because CATV operators are so busy serving their primary markets—TV viewers and FM listeners. For example, CATV facilities can be used to transmit educational television programs from school to school and to students confined to their homes because of prolonged illness or disability.

Since CATV amplifiers are available which cover the entire 10- to 220-mc segment of the radio spectrum, head-end equipment can be installed to pick up shortwave broadcasts, radio amateurs, standard frequency and time signals (WWV, etc.), weather bureau broadcasts on 162.55 mc, CB stations and commercial FM mobile radio communications, as illustrated in Fig. 6. Subscribers could tune in these signals by connecting appropriate receivers through matching transformers to the CATV coax line. Potential subscribers would then include law enforcement agencies, shortwave listeners, laboratories, newspapers, etc. You can't transmit back through a CATV system though.

CATV is only in its infancy. We can expect to see it continue to expand rapidly, particularly because of the need for better signals for color-TV and FM-stereo reception. And, as cited by the New York City example, CATV will infiltrate the big cities as well as the hinterlands. ■

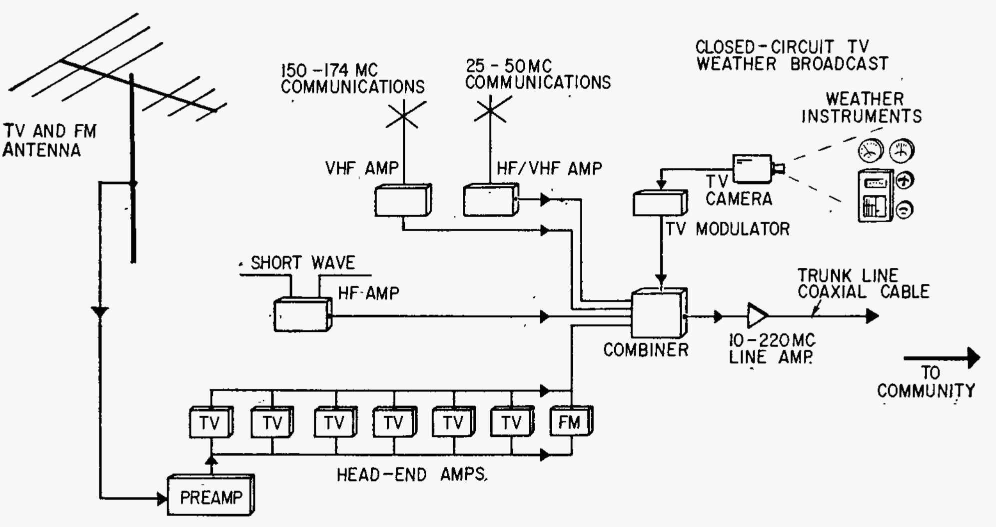
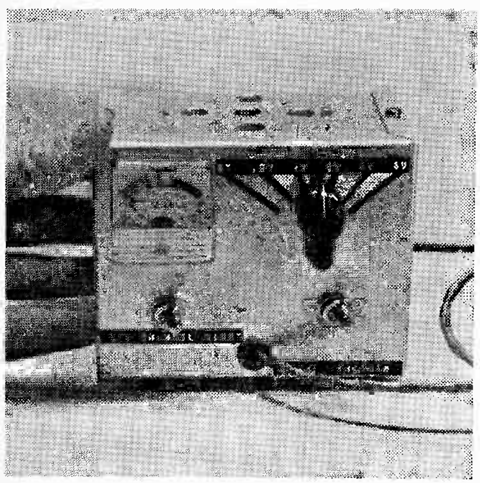


Fig. 6. The CATV system does not have to be limited to FM and TV reception. Other services such as communications can be added. Some of the economy-TV sets may pick up interference.

Miniature! Versatile!
A worthwhile addition to any audio test-bench setup; it measures pickup output voltage and doubles as handy signal tracer.

Homer L. Davidson

CRYSTAL CARTRIDGE CHECKER

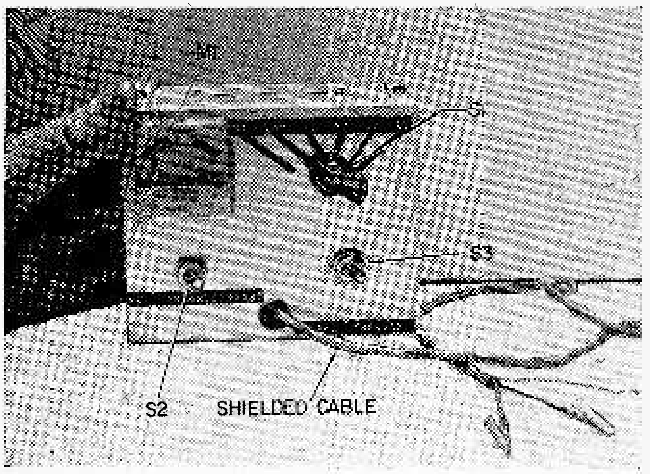


The five holes in the top of the cabinet are not for ventilation — they allow the sound from the speaker to get outside.

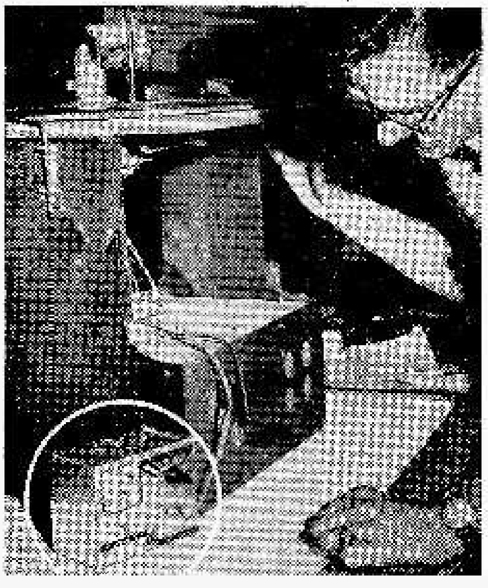
■ Here is a compact test instrument that shows at a glance the condition of a crystal phono cartridge. It works with all popular crystal cartridges, mono or stereo, and provides a convenient indication on a *good-fair-bad* scale. This unit works only with crystal or ceramic cartridges, not low-level types such as magnetic and variable reluctance. Construction is considerably simplified by use of a prewired transistor amplifier, and accurate test signals are provided by a hi-fi test record (both items are shown in the Parts List). To use the instrument, the phono cartridge is unplugged or disconnected from the hi-fi amplifier and connected to the tester.

Starting Construction. Wiring and parts layout are not critical. And it is possible to use a larger cabinet than the one specified, as long as it is made of metal. A major part of the job is wiring a large 6-position rotary switch, S1.

A close look at the schematic diagram



Completed instrument, at left, shows the compactness possible without really crowding any of the components mounted in case. Front-panel labelling has been done with self-adhesive plastic tape. With the record changer mounted on a test stand (center left) it is an easy matter to connect to the changer output leads. The Crystal Cartridge Checker takes up very little bench space. Being compact it can be stored in a drawer or hung on wall for a permanent installation.

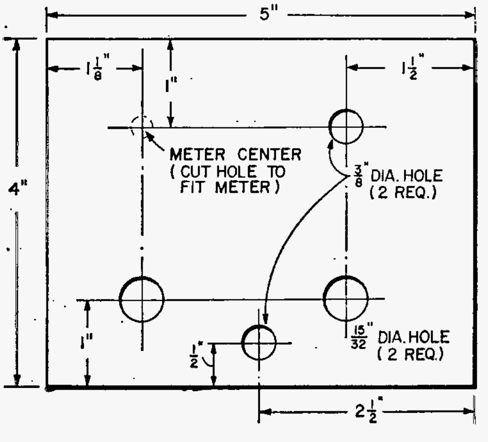


will reveal that one position of this switch, S1, is left open—with no wires connected to it. This is purposely done to permit the tester to double as a handy audio signal tracer or amplifier.

This is the *S.T.*, or Signal Tracer, position. The remaining switch positions are wired with a group of calibrating resistors which enables meter M1 to indicate various voltage ranges when testing different phono cartridges.

To begin construction, take the chassis box and mark off all dimensions, as shown in the Detail Drawing. Use a circle cutter to cut out the meter opening and drill all front holes. Then, mount small parts to the front panel. Do not mount the VU meter until *after* all wiring has been completed. Mount the 2-inch speaker at the back panel, using a screen mesh or grille cloth to protect the paper speaker cone.

Layout below will have to be modified if parts used differ from those specified.



CRYSTAL CARTRIDGE OUTPUT VOLTAGE CHART

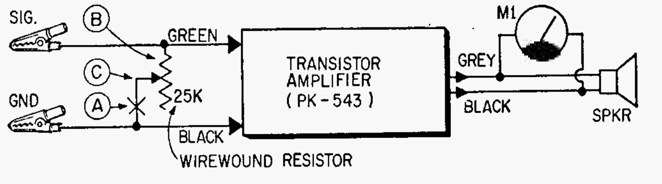
0.5-Volt		2.0-Volts	
Astatic	13TS	Astatic	70TS
	10T2-SD		74TS
	13TX		76TSB
	916TAF-SD		474
Euphonics	EV-26	RCA	74067
	EV-21D		75575
Sonotone	10T2-S	Ronette	106
	10T2-S77		92
RCA	106771		105
1.0-Volt		**3.0-4.0-Volts**	
Astatic	40T	Astatic	470
	40TB		L70
	40-2		L82
	2TAS		L92
	18TASD	Ronette	15
	140		18
	140D		21
Sonotone	18TAS	Vaco	45X
Zenith	EV11		55X

Wiring the Unit. Take about two feet of 2-conductor shielded wire and solder two small alligator clips to the wires at one end. Wrap a bare solid wire around the shield and solder it to the ground clip. Run the cable through the rubber grommet on the front panel (see photos) switch S2 and ground the shield to the case. Note that the wire from S1 to S2 is also shielded.

Solder all resistors in place and leave R1 long enough to go to ground. Solder the ground side of the resistors to this pigtail end. There is only one part of the transistor amplifier that needs to be modified. Remove the 100K resistor as shown in the drawing. This resistor normally feeds back signal from one of the speaker leads to the input circuit. In the tester, however, it will give a false meter reading; the pin will never be at an absolutely zero position.

Now mount the transistor amplifier in the chassis box using small metal spacers to hold the board about a ¼-inch from the metal case. Mount the VU meter and solder its leads into the circuit. Solder two 4-inch flexible leads to the speaker and solder them to the meter terminals. This can be done easily outside the case.

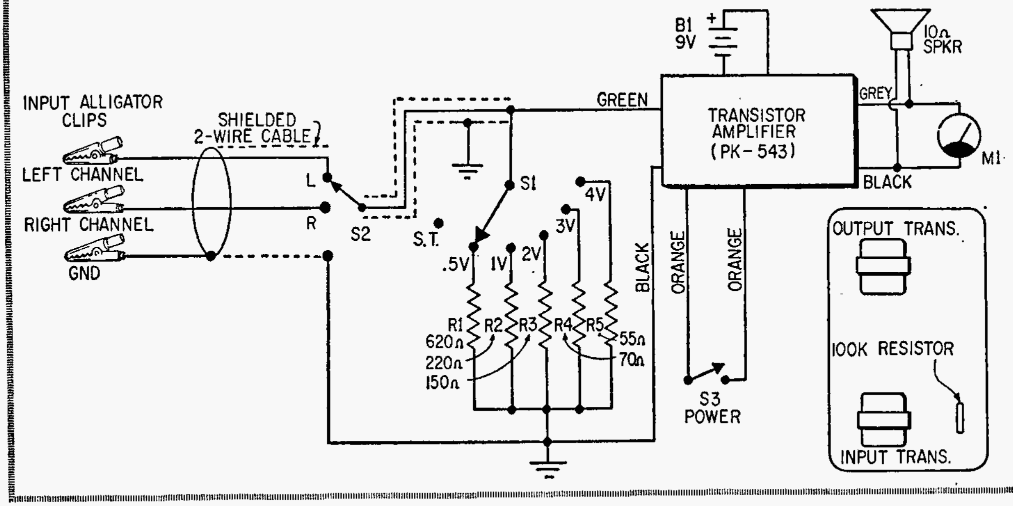
Calibrating the Tester. The original model was calibrated with a known voltage source and a test record. Also, five crystal cartridges, with known output voltages were used in calibration. The VU Meter was then marked with Good, Fair, and Bad segments. The Bad, or red, zone runs from 0 to 70 on the meter. The Fair, or yellow, zone runs from 70 to 100. The Good, or green, scale runs from 100 to the top end of the meter scale. These red, yellow and green scales can be marked with paint or marking pens.

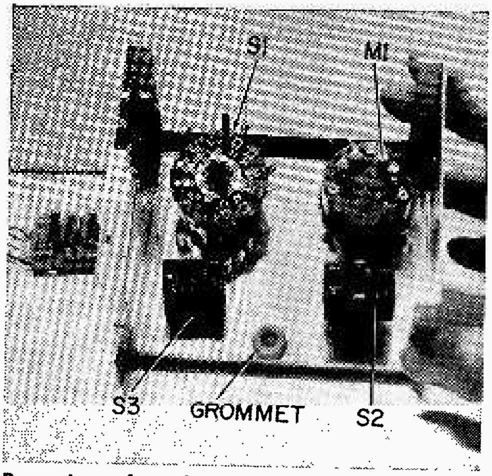


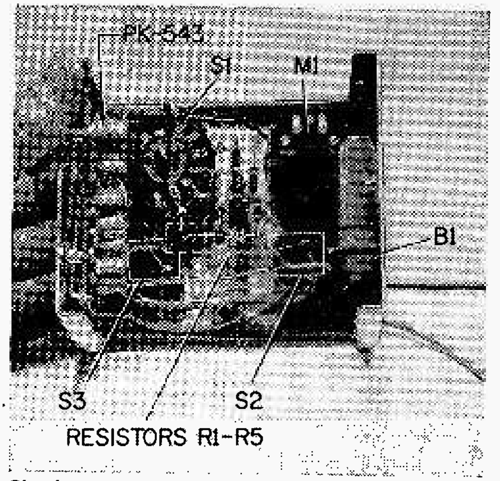
Calibration circuit (left) is a temporary hookup used to determine resistance values for R1, R2, R3, R4 and R5. Miniature pots can be used in place of fixed-value resistors on S1.

PARTS LIST FOR CRYSTAL CARTRIDGE CHECKER

- B1—9-volt transistor battery (Eveready 216 or equiv.)
- M1—VU panel meter (Lafayette Radio 99G5024)
- R1—620-ohm, ½-watt resistor, 5%
- R2—220-ohm, ½-watt resistor, 5%
- R3—150-ohm, ½-watt resistor, 5%
- R4—70-ohm, ½-watt resistor, 5%
- R5—55-ohm, ½-watt resistor, 5%
- S1—1-pole, 6-position rotary switch, non-shorting
- S2—S.p.d.t. toggle switch
- S3—S.p.s.t. toggle switch
- SPKR—10-ohm, 2-inch PM speaker
- 1—4-transistor push-pull amplifier (Lafayette PK-543 99G9042 or equiv.)
- 3—Alligator clips, 2 red and one black (Lafayette 99R6231—red and 99R6232—black
- 1—Chassis box, 4" x 5" x 3", aluminum
- 1—Test record for stereo-hi/fi (Lafayette PR-14)
- Misc.—Two-wire shielded cable, rubber grommets, hookup wire, solder, hardware, etc.
- Estimated cost: $14.00
- Estimated construction time: 4 hours







Rear view of partly assembled Crystal Cartridge Checker (left) and completely assembled unit.

In this tester, the calibration resistors (R1-R5) have 5% tolerance and the recommended values may not be available with single commercial resistors. In the 3-volt range, for R4, use either a 68-ohm resistor or one 47-ohm resistor in series with a 22-ohm resistor. The 4-volt range resistor (R5) can be obtained by putting two 27-ohm resistors in series.

The resistor values given in the Parts List should provide reasonable accuracy with this instrument. If, however, you have access to several new cartridges and wish to calibrate your own unit, the following procedure may be used. This step, however, is not necessary for operating the tester and is given only to illustrate how calibration was done in the author's model. If desired, you may skip this section and go on to the next step: "Testing Procedure."

Refer to the calibration circuit. Insert a 25,000-ohm wirewound variable resistor at the input side of the transistor amplifier. Select a new crystal cartridge with a known output voltage of .5 volts. Set the pickup arm down on the test record's Band 3, and on the 1000-cycle portion. (See Parts List.) Adjust the variable resistor so the reading reaches 100% on the VU Meter. You will note that frequencies higher than 1000 cycles produce greater output and signals below 1000 cycles produce lower meter readings. Use only the 1000-cycle tone during calibration. Do the same for 1- to 4- volt output cartridges. With a .5-volt cartridge under test, disconnect one arm of the variable resistor from the circuit (see "A" in Fig. 2). Measure the resistance between "B" and "C", insert a fixed resistor in place of the variable resistor. The same procedure applies to the other switch positions. With this method all crystal cartridges can be measured for correct output voltage from .5 to 4 volts. Note that a .47-volt cartridge will not register 100% on the VU Meter, but still reads in the good scale.

Testing Procedure. Install the battery and turn on switch S3. Grasp the two alligator clips of both channel test leads; the meter pin should move upward if wiring is correct. Now clip the leads to the phono cartridge or its cable. If the cartridge to be checked is a stereo type, clip both leads to each channel and the ground clip to cartridge ground. Turn S2 to the .5-volt position and set the phono needle on the 1000-cycle portion of the test record. You will hear the tone from the speaker and the meter should read in the green portion. If the cartridge is defective the reading will be in the lower, or "bad", portion of the meter scale. To check each side of the stereo crystal cartridge, flip S1 to each channel, in turn.

To check crystal cartridges with higher voltage output, just turn S2 to the appropriate voltage position. See the Crystal Cartridge Output Voltage Chart which gives output voltage for several popular phonograph cartridges.

If one side of a stereo cartridge seems to be weak or intermittent, press down lightly on the pickup arm while the record is playing. The voltage reading should vary and the tone may become louder if the cartridge is intermittent. A cracked cartridge usually operates intermittently or gives no reading whatsoever. A cartridge which reads in the Fair portion of the scale is generally still useable. ■

Controlling Audio Volume

Continued from page 56

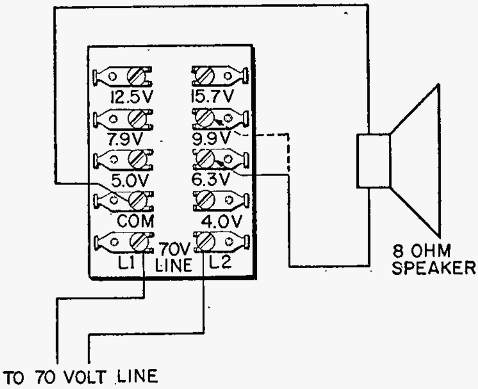
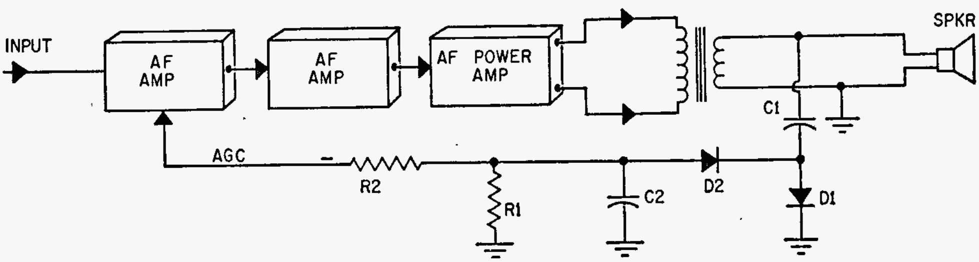
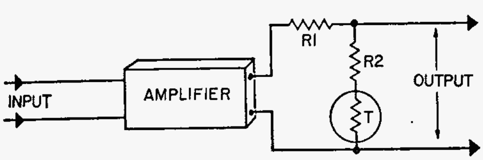


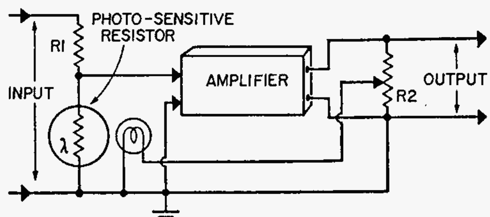
Fig. 16. (left) Typical terminal board of a constant-voltage line transformer. Screw terminals are usually used—to make speaker level adjustment easier for system setup.

Fig. 17. AGC circuit is quite similar to those used in most IF amplifier circuits.

Fig. 18. (lower left) Thermistor (T) is part of a voltage divider circuit. Thermistor gets warmer and its resistance gets lower causing greater drop to occur across R1 and signal output across R2 and T becomes lower too.







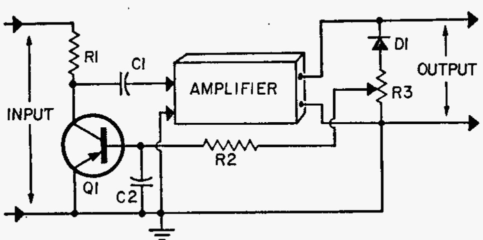


Fig. 19. Photo-sensitive resistor becomes lower in value as lamp becomes brighter with more current from output. The brighter the lamp glows the lower the resistance becomes.

Fig. 20. (left) uses transistor as a varying resistance. Q1's resistance becomes lower as its base becomes more negative across C2.

strong enough, offsets the forward bias on D2 and causes it to stop conducting. Hence, negative and positive signal excursions beyond a certain level can't get through. This is known as *speech clipping*. It is used in communications (radio equipment and some P.A. amplifiers) to limit audio output levels. Constant audio output level is maintained by driving the amplifier hard enough to make it limit. This creates some distortion.

Volume Expansion. Reverse AGC is used to obtain *volume expansion*. It provides pleasant effects with musics. The dynamic range of phonograph records or tapes, and particularly radio programs, are limited. Crescendos don't provide the thrilling effect experienced at a live concert. By using volume expansion, a small rise in audio signal level is made into a larger rise in audio level at the output of the amplifier. This can be

Fig. 21. (above) Limiter reduces maximum output peaks from AF amplifier. This is a form of distortion and is suitable for speech only.

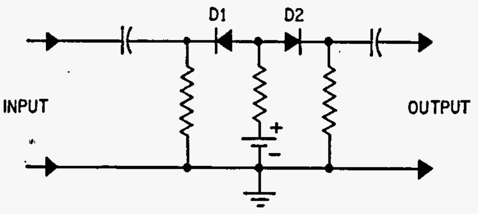
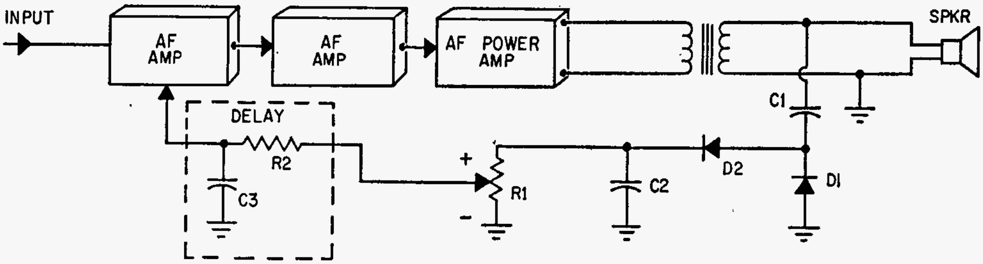


Fig. 22. (left) Simple circuit does a big job. Excessive voltage can ruin diodes if ratings are exceeded during transient peaks of signal.

Fig. 23. (below) Delay circuit reduces the distortion that results from fast limiting.



done, as shown in Fig. 23, by rectifying some of the audio-output voltage to produce a *positive* DC voltage which is used to reduce the *negative* bias on an amplifier stage. When the audio-signal input rises in level, the amplifier gain is automatically increased instead of decreased as when AGC is used.

Both volume expansion and compression are employed in an amplifier known as the Expressor amplifier. It is connected between a microphone and the input of an audio amplifier. It equalizes the final audio level. When a person speaks softly into the microphone and from a distance, the sound from the speakers is at the same level as when someone speaks loudly directly into the microphone. One particular application is in railroad yards. Now the changing of yardmasters for different shifts doesn't raise havoc with the system. Before, one yardmaster would speak softly and could hardly be heard throughout the area covered by the paging speakers. A new shift, and a new yardmaster, and the area would shake when he barked loudly into the microphone. The Expressor amplifier cured that problem.

Reasons for Audio Control. When the first audio amplifier was developed by Dr. Lee DeForest, in Palo Alto, California (the birthplace of the electronics industry), way back in 1911, too much gain was obtained and the electronic oscillator was discovered—accidentally. The need for a control of gain was obvious.

While only a few milliwatts of audio power will provide room-level sound many of us buy 100-watt, and even higher-powered, amplifiers so we can bring Dick Lieberts's pipe organ into the living room—without missing the instantaneous peaks. Yet, in the huge Radio City Music Hall, an 85-watt stereo P.A. system pumps sound into a cavern big enough to hold more than 1000 living rooms.

Besides controlling volume, it is necessary to be able to control frequency response. To get clear, penetrating speech reproduction in industrial sound systems the frequency response is deliberately limited to the voice range (300 to 3000 cps). In music reproduction systems, the frequency response is made as wide as possible and the highs and lows are often boosted to overcome the deficiences of the speakers.

The following article *Controlling Audio Tone* covers the many simple circuits that change the gain of different audio frequencies to compensate for component dificiencies. ■

Frequency Measurement

Continued from page 40

effect, incidentally, can be heard in "crystal check" position on an unmodified frequency meter; the modification isn't necessary to be able to calibrate this way.

All we need to know to use these "tweets" as check points in themselves is what frequencies have harmonics which are also harmonics of 1 mc. The answer, speaking strictly, is almost any frequency—but in practice, the points tend to space themselves out nicely since the higher-order harmonics become too weak to be heard.

To perform the calibration, start by ruling off a goodly number of sheets of paper. Then turn the instrument on, let it warm up for at least an hour, and zero the crystal standard to WWV. Start on the "low" band, and locate the first *loud* and relatively slow-tuning check point above a dial reading of zero. This point is the one most likely to be 125 kc; note the dial reading and enter it in your book opposite 125.0 kc.

Tune upward through the range until you come to the other end of the dial; you should find four more check points which are also loud and slow-tuning. Note the dial readings for each of the four; the corresponding frequencies will be 142.857 kc., 166.667 kc., 200,000 kc., and 250,000 kc. The last of these should be very close to 5000.0 on the meter's dial, and the three in between should be spaced out across the dial in *approximate* proportion to their frequencies.

With these five points identified, you can go back to the low end of the dial and set it to the reading for 125 kc.; if necessary adjusting for a true zero-beat by using the "corrector" knob. However, if adjustment is necessary, let the instrument warm up a while longer and then recheck all five marked points; when properly calibrated, the corrector should not be necessary.

Now, tune slowly up the dial, and note the reading at zero-beat of *each one* of the many "tweets". Table of tweet points lists exact frequency of most probable tweets—not all.

With the dial reading for each "tweet" written down, compare your list with the table to determine if you have a tweet for every combination shown in the table, or if you have more tweets than the table lists. In either case (the latter is more likely) you will have to discard some of the readings, so the next step is to determine which readings to discard.

Over the short interval between marked frequencies, the dial readings should be almost linear. That is, if you read 100 dial divisions between say 180 and 190 kc., then 10 dial divisions would be approximately 1 kc. and one dial division would be 100 cps.

Use this relationship to determine which readings to discard. Keep all the readings which come close to this relation, and ignore the ones which patently fail to fit.

When you have a frequency marker from the table to correspond to each "tweet" dial reading that you are retaining, you're ready to finish the calibration book. Determine how many cycles are represented by each dial division in the interval between each pair of adjacent tweets, by dividing frequency spacing of the markers (in cycles) by the difference between corresponding readings (in dial divisions).

For instance, if you have a dial reading of 1309.8 for the "tweet" at 155.8441 kc., and a reading of 1309.3 for the one at 155.5555 kc., then the frequency spacing is 288.6 cps and the difference between readings is 0.5 dial divisions. Thus the calibration in this region is 577.2 cycles per dial division.

Knowing the calibration in cycles per dial division lets you round off those odd figures of the "tweet" frequencies to nice even tenths of a kilocycle for the book. For instance, continuing our previous example, we have no "tweet" at 155.6 kc. but we know that this frequency is 44.4 cps higher than the marker at 155.555. The dial reading for 155.6 must, then, be 44.4/577.2 dial divisions greater than 1309.3, which comes out to be 1309.3768. The dial only indicates to tenths, so we round this off to 1309.4 and enter that in the calibration book opposite 155.6 kc.

For 155.7 kc., the reading will be 144.4/577.2 dial divisions above 1309.3, or 1309.55. We enter 1309.6. At 155.8 kc., the reading is 244.4/577.2 divisions high, or 1309.724; we enter 1309.7.

This process must be continued for every 100-cps segment in the calibration book; we said at the beginning it takes time. When it's finished, the low-band calibration is then used to obtain that for the high-band. This requires an external oscillator, but it need be nothing fancy so long as it can be set to frequencies between 2 and 4 mc. and will hold its frequency constant for a few minutes at a time.

This Is the Procedure. First, using the low-band setting of the frequency meter, adjust to a frequency which multiplies out to 2000 kc. The top end check point of 250 kc. is a good one. Then adjust the external oscillator to exactly 2000 kc by zero-beating.

Switch the frequency meter to high-band and locate the 2-mc. signal; note the reading (the even-megacycle spots can, of course, be found with the internal standard as well).

Go back to low-band and recheck the external oscillator's frequency to be sure it hasn't moved. Then set the frequency meter to 222.333 kc. Zero-beat its 9th harmonic to the external oscillator to calibrate the 2001-kc point on the chart.

Switch to high-band and find the signal; plot the reading. Now there are only 1999 more 1-kc. points to plot between 2 and 4 mc.

If you plan to use the high-precision measurement technique described earlier, you don't have to take so much trouble with the high-band calibration. Make the plots at 10-kc. or even 100-kc. intervals instead of at 1-kc. spacings, and draw "tuning graphs" similar to Fig. 5 to get the in-between dial readings. These will be close enough; you'll get the precision with the second reading, which is made with low band only.

In fact, for the high-precision technique you really don't even need a calibration book at all. You can use the tweet points in the table to locate your frequency anywhere on the dial, and interpolate between them as described for the calibration. Often, simply using the "nearest" tweet point will provide more than enough accuracy for your needs.

You may have noticed, in this regard, that the readings we determined with the aid of the "tweet" points were considerably more accurate than those we entered in the calibration book; this is an unavoidable degradation since the meter dial only reads tenths of a division, but we know the "tweet" points to better than 1/10 cycle per second. Thus, using the "tweet" points instead of the dial may be far more accurate in many cases!

Summing It Up. Either the comparison technique or the frequency meter can give you far more accuracy in RF frequency measurement than you're likely to ever need. Actually, the major requirement is patience. If you have that, your results can rival those of the most expensively-equipped labs. ■

Frequencies of "Tweet" Points

125.0000	132.6530	**142.8571**	152.9411	**166.6667**	182.9268	203.3898	224.4897
126.0504	132.7434	144.2308	153.0612	168.5393	183.0985	203.7037	224.1379
126.1261	**133.3333**	144.3298	**153.8462**	168.6746	183.3333	204.0816	225.0000
126.2136	134.0306	144.4444	154.9295	168.8311	183.6735	204.5455	225.8066
126.3157	134.1463	144.5783	155.1724	169.0140	184.2105	205.1282	226.4150
126.4367	134.3529	144.7386	155.5556	169.2307	184.6153	205.4794	227,2727
126.5822	134.6154	144.9275	155.8441	169.4915	185.1852	205.8824	228.0701
126.7606	134.8314	145.1613	156.2500	170.2127	185.7142	206.3492	228.5714
126.9841	135.1351	145.4545	156.6225	170.4545	186.4406	206.8966	229.1667
127.1186	135.4166	145.6311	156.8627	170.7317	186.6667	207.5471	229.5081
127.2727	135.5933	145.8333	157.1428	171.0526	187.5000	208.3333	**230.7692**
127.4510	136.3636	146.0674	157.3033	171.4286	188.4057	208.9552	232.1428
127.6596	136,8421	146.3415	157.8947	171.8750	188.6792	209.3023	232.5581
127.9069	136.9863	146.6667	158.5365	172.4138	189.1892	209.6774	233.3333
128.2051	137.2459	147.0588	158.7301	172.8395	189.6551	210.5263	234.0425
128.4404	137.5000	147.3684	159.0909	173.0769	189.8734	211.2676	235.2941
128.5714	137.6147	147.5410	159.4202	173.3333	190.4762	211.5384	236.3636
128.7128	137.9310	147.7273	159.5744	173.9130	191.1764	212.1212	236.8421
129.0323	138.2978	148.1481	160.0000	174.4186	191.4894	212.7659	237.2881
129.3103	138.4615	148.5148	160.4938	174.6031	191.7808	213.1147	238.0952
129.4117	138.6139	148.6486	160.7143	175.0000	192.3077	**214.2857**	240.0000
129.6296	138.8889	148.9362	160.9195	175.4385	192.9824	215.3846	240.7407
129.8701	139.2405	149.2537	161.2903	175.6756	194.0298	215.6862	241.3793
130.0000	139.5349	149.4252	161.7647	176.4706	194.4444	216.2162	241.9354
130.4348	140.0000	150.0000	162.5000	177.2151	194.8051	216.6667	242.4242
130.8411	140.1869	150.5376	162.7907	177.4193	195.1220	217.3913	243.2432
130.9523	140.3509	150.6849	163.2653	178.0821	195.6522	218.1818	244.4444
131.1475	140.6250	150.9434	163.6364	178.5714	196.0764	218.7500	244.8979
131.3131	140.8450	151.1627	163.9344	179.1044	196.4285	219.5122	245.2830
131.5789	141.0256	151.5152	164.1791	179.4872	196.7213	220.0000	245.6140
131.8681	141.1764	151.8987	164.3835	180.0000	196.9697	220.3389	245.9061
132.0755	141.3043	152.1739	164.5569	180.3278	197.1830	220.5882	**250.0000**
132.3529	141.4141	152.5424	164.7058	180.5556	197.3684	**222.2222**	
132.5301	141.5094	152.7778	164.8351	**181.8182**	**200.0000**	223.8805	

Boldface frequencies are check points in calibration book; all frequencies in kc

Static Electricity

Continued from page 32

breathe. Ozone can also be produced by an ultra-violet lamp but is more commonly produced by a spark gap with a dielectric material (glass, mica, etc.) between the electrodes.

Within a vacuum, dynamic electricity flows as an electron beam as in vacuum tubes. In tubes containing a gas (VR tubes, neon lamps and thyratrons), current flow is increased because the gas ionizes.

While it is usually considered that static electricity, in the form of lightning, travels through space, the main bolt travels along a conductor known as the leader. It is the leader, whose current is small compared to that of the main bolt, which bridges the gap first and then the main bolt flows on the leader which is a relatively low resistance path, known as a space charge. Lightning can also be a two-way proposition. One flash comes down from a cloud to earth and another returns from earth up toward the cloud, but it doesn't always make it all the way. Lightning also starts at the ground and goes up. The Empire State Building often initiates a lightning stroke upward towards the clouds. It has been found that a difference in potential is required to produce lightning or a static discharge, but it may originate from either the positively or negatively charged object. No matter how you slice it, stay indoors when those bolts go flying. ■

Headphone Amplifier

Continued from page 90

battery switch is closed—set to the *on* position. Set the audio gain (Volume) to about position 4—about ⅓ of the full rotation of the potentiometer shaft. Then you can adjust one control, or both for an equal, comfortable listening level. The volume controls are identified as R1 and R2.

Mono signals at either of the input jacks (J1, J2) are connected to both driver transistors (Q1, Q2) through the *Stereo/Mono* switch S1. But stereo signals (like those from a ceramic or crystal pickup) pass through their own channels and are heard separately in the headphones, thus reproducing a stereo sound for the listener. ■

Tape Bias

Continued from page 44

(Fig. 4). At this bias setting the high-frequency equalization was inadequate. Such a case is very unusual. It was a simple matter to change the bias circuit and adjust for peak tape output—and get proper high-frequency equalization.

The Bias Setting. Adjusting the bias to exactly peak output or just before (to the left) peak usually creates unneeded problems such as: low output; high distortion; frequency compensation problems (mentioned above). Again referring to Fig. 4, note that the curve is steep on the left of the peak while it is gradual on the right. Since, as a general rule, the aging of circuit components will reduce bias current, a recorder with bias set exactly at the peak (or to the left) will gradually slide right down the steep slope of the curve.

But on the other hand, if the bias current is adjusted to slightly past the peak (to the right) approximately ½- to 1-db down from peak tape output, component aging will cause the recorder to drift, slowly over months or years, toward the optimum output setting instead of drifting away from it at a much faster rate.

While it must be admitted that factory-set bias is generally adequate for the average recordist, periodic bias checks and adjustments can offer substantial improvements for the purist, or that extra-special recording that must be perfect.

Off on a Tangent. Within a given price range most brands of tape are interchangeable on most recorders as far as recording quality goes. (Forget about such things as tape lubrication, who makes a smoother oxide, etc., etc.) You can interchange tape brands, even splice them together, as long as you stick to the same grade of tape—the same list-price range (sales don't count). But don't try to interchange tape selling for $1 (list) with a roll of tape (of the same footage) priced at $2.95, or thereabouts. While this statement can be hotly disputed, the slight differences, such as noise level and print-through are rarely noticeable outside of the professional recording studio, where, admittedly, they can be of substantial importance. For the average recordist, however, tape has attained the ultimate of *assembly-line production*—interchangeability. ■

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8. Want a colorful catalog of goodies? *John Meshna, Jr.* has one that covers everything from assemblies to zener diodes. Listed are government surplus radio, radar, parts, etc. All at unbelievable prices.

10. *Burstein-Applebee* offers a new giant catalog containing 100's of big pages crammed with savings including hundreds of bargains on hi-fi kits, power tools, tubes, and parts.

11. Now available from *EDI (Electronic Distributors, Inc.)* a catalog containing hundreds of electronic items. *EDI* will be happy to place you on their mailing list.

12. VHF listeners will want the latest catalog from *Kuhn Electronics.* All types and forms of complete receivers and converters.

23. No electronics bargain hunter should be caught without the latest copy of *Radio Shack's* catalog. Some equipment and kit offers are so low, they look like mis-prints. Buying is believing.

25. Unusual surplus and new equipment/parts are priced "way down" in a 32-page flyer from *Edlie Electronics.* Get one.

75. *Transistors Unlimited* has a brand new catalog listing hundreds of parts at exceptionally low prices. Don't miss these bargains!

HI-FI/AUDIO

13. Here's a beautifully presented brochure from *Altec Lansing Corp.* Studio-type mikes, two-way speaker components and other hi-fi products.

15. A name well-known in audio circles is *Acoustic Research.* Here's its booklet on the famous AR speakers and the new AR turntable.

16. *Garrard* has prepared a 32-page booklet on its full line of automatic turntables including the Lab 80, the first automatic transcription turntable. Accessories are detailed too.

17. Two brand new full-color booklets are being offered by *Electro-Voice, Inc.* that every audiophile should read. They are: "Guide to Outdoor High Fidelity" and "Guide to Compact Loudspeaker Systems."

19. *Empire Scientific's* new 8-page, full color catalog is now available to our readers. Don't miss the sparkling decorating-with-sound ideas. Just circle #19.

22. A wide variety of loudspeakers and enclosures from *Utah Electronics* lists sizes shapes and prices. All types are covered in this heavily illustrated brochure.

24. Here's a complete catalog of high-styled speaker enclosures and loudspeaker components. *University* is one of the pioneers in the field that keeps things up to date.

26. Always a leader, *H. H. Scott* introduces a new concept in stereo console catalogs. "At Home With Stereo" the 1966 guide, offers decorating ideas, a complete explanation of the more technical aspects of stereo consoles, and, of course, the complete new line of *Scott* consoles.

27. An assortment of high fidelity components and cabinets are described in the *Sherwood* brochure. The cabinets can almost be designed to your requirements, as they use modules.

30. Tone-arms, cartridges, hi-fi, and stereo preamps and replacement tape heads and conversions are listed in a complete *Shure Bros.* catalog.

95. Confused about stereo? Want to beat the high cost of hi-fi without compromising on the results? Then you need the new 24-page catalog by *Jensen Manufacturing.*

TAPE RECORDERS AND TAPE

31. "All the Facts" about *Concord Electronics Corporation* tape recorders are yours for the asking in a free booklet. Portable battery operated to four-track, fully transistorized stereos cover every recording need.

32. "Everybody's Tape Recording Handbook" is the title of a booklet that *Sarkes-Tarzian* will send you. It's 24-pages jam-packed with info for the home recording enthusiast. Includes a valuable table of recording times for various tapes.

33. Become the first to learn about *Norelco's* complete Carry-Corder 150 portable tape recorder outfit. Four-color booklet describes this new cartridge-tape unit.

34. The 1966 line of *Sony* tape recorders, microphones and accessories is illustrated in a new 16-page full color booklet just released by *Superscope, Inc.,* exclusive U.S. distributor.

35. If you are a serious tape audiophile, you will be interested in the new *Viking of Minneapolis* line—they carry both reel and cartridge recorders you should know about.

91. Sound begins and ends with a *Uher* tape recorder. Write for this new 20 page catalog showing the entire line of *Uher* recorders and accessories. How to synchronize your slide projector, execute sound on sound, and many other exclusive features.

HI-FI ACCESSORIES

76. A new voice-activated tape recorder switch is now available from *Kinematix.* Send for information on this and other exciting products.

39. A 12-page catalog describing the audio accessories that make hi-fi living a bit easier is yours from *Switchcraft, Inc.* The cables, mike mixers, and junctions are essentials!

KITS

41. Here's a firm that makes everything from TV kits to a complete line of test equipment. *Conar* would like to send you their latest catalog—just ask for it.

42. Here's a colorful 108-page catalog containing a wide assortment of electronic kits. You'll find something for any interest, any budget. And *Heath Co.* will happily send you a copy.

44. A new short-form catalog (pocket size) is yours for the asking from *EICO.* Includes hi-fi, test gear, CB rigs and amateur equipment—many kits are solid-state projects.

AMATEUR RADIO

46. A long-time builder of ham equipment, *Hallicrafters* will send you lots of info on the ham, CB and commercial radio-equipment.

CB—BUSINESS RADIO SHORT-WAVE RADIO

48. *Hy-Gain's* new CB antenna catalog is packed full of useful information and product data that every CB'er should know about. Get a copy.

49. Want to see the latest in communication receivers? *National Radio Co.* puts out a line of mighty fine ones and their catalog will tell you all about them.

50. Are you getting all you can from your Citizens Band radio equipment? *Amphenol Cadre Industries* has a booklet that answers lots of the questions you may have.

52. If you're a bug on CB communications or like to listen in on VHF police, fire, emergency bands, then *Regency Electronics* would like to send you their latest specs on their receivers.

54. A catalog for CB'ers, hams and experimenters, with outstanding values. Terrific buys on *Grove Electronics'* antennas, mikes and accessories.

55. Interested in CB or business-band radio? Then you will be interested in the catalogs and literature *Mosley Electronics* has to offer.

90. If two-way radio is your meat, send for *Pearce-Simpson's* new booklet! Its 18 pages cover equipment selection, license application, principles of two-way communications, reception, and installation.

93. *Heath Co.* has a new 23-channel all-transistor 5-watt CB rig at the lowest cost on the market, plus a full line of CB gear. See their new 10-band AM/FM/Shortwave portable and line of shortwave radios. #93 on the coupon.

96. If a rugged low-cost business/industrial two-way radio is what you've been looking for. Be sure to send for the brochure on *E. F. Johnson Co.'s* brand new Messenger "202."

SCHOOLS AND EDUCATIONAL

56. *Bailey Institute of Technology* offers courses in electronics, basic electricity and drafting as well as refrigeration. More information in their informative pamphlet.

57. *National Radio Institute,* a pioneer in home-study technical training, has a new book describing your opportunities in all branches of electronics. Unique training methods make learning as close to being fun as any school can make it.

36. *Coyne Electronics Institute* offers home/resident training in electricity, radio-TV, electronics, refrigeration and air conditioning.

59. For a complete rundown on curriculum, lesson outlines, and full details from a leading electronic school, ask for this brochure from the *Indiana Home Study Institute.*

60. Facts on accredited curriculum in E. E. Technology is available from *Central Technical Institute* plus a 64-page catalog on modern practical electronics.

61. *ICS (International Correspondence Schools)* offers 236 courses including many in the fields of radio, TV, and electronics. Send for free booklet "It's Your Future."

74. How to get an F.C.C. license, plus a description of the complete electronic courses offered by *Cleveland Institute of Electronics* are in their free catalog. Circle #74.

94. *Intercontinental Electronics School* offers three great courses: stereo radio & electronics; basic electricity; transistor. They are all described in *Inesco's* 1966, 16-page booklet.

ELECTRONIC PRODUCTS

62. Information on a new lab transistor kit is yours for the asking from *Arkay International.* Educational kit makes 20 projects.

66. Try instant lettering to mark control panels and component parts. *Datak's* booklets and sample show this easy dry transfer method.

64. If you can use 117-volts, 60-cycle power where no power is available. the *Terado Corp.* Trav-Electric 50-160 is for you. Specifications are for the asking.

67. "Get the most measurement value per dollar," says *Electronics Measurements Corp.* Send for their catalog and find out how!

92. How about installing a transistorized electronic ignition system in your current car? *AEC Laboratories* will mail their brochure giving you specifications, schematics.

TELEVISION

70. *Heath Co.* now has a 25" rectangular-tube color TV kit in addition to their highly successful 21" model. Both sets can be installed in a wall or cabinet: both are money-saving musts!

73. Attention, TV servicemen! *Barry Electronics* "Green Sheet" lists many TV tube, parts, and equipment buys worth while examining. Good values, sensible prices.

72. Get your 1966 catalog of *Cisin's* TV, radio, and hi-fi service books. Bonus—TV tube substitution guide and trouble-chaser chart is yours for the asking.

29. Install your own TV or FM antenna! *Jefferson-King's* exclusive free booklet reveals secrets of installation, orientation; how to get TV-FM transmission data.

97. Interesting, helpful brochures describing the TV antenna discovery of the decade—the log periodic antenna for UHF and UHF-TV, and FM stereo. From *JFD Electronics Corporation.*

TOOLS

78. You can easily select the right tool for easy, speedy driving of Bristol Multiple Spline and Allen Hex socket screws from *Xcelite's* compact, interchangeable blade sets. Send for Bulletin N365 for details.

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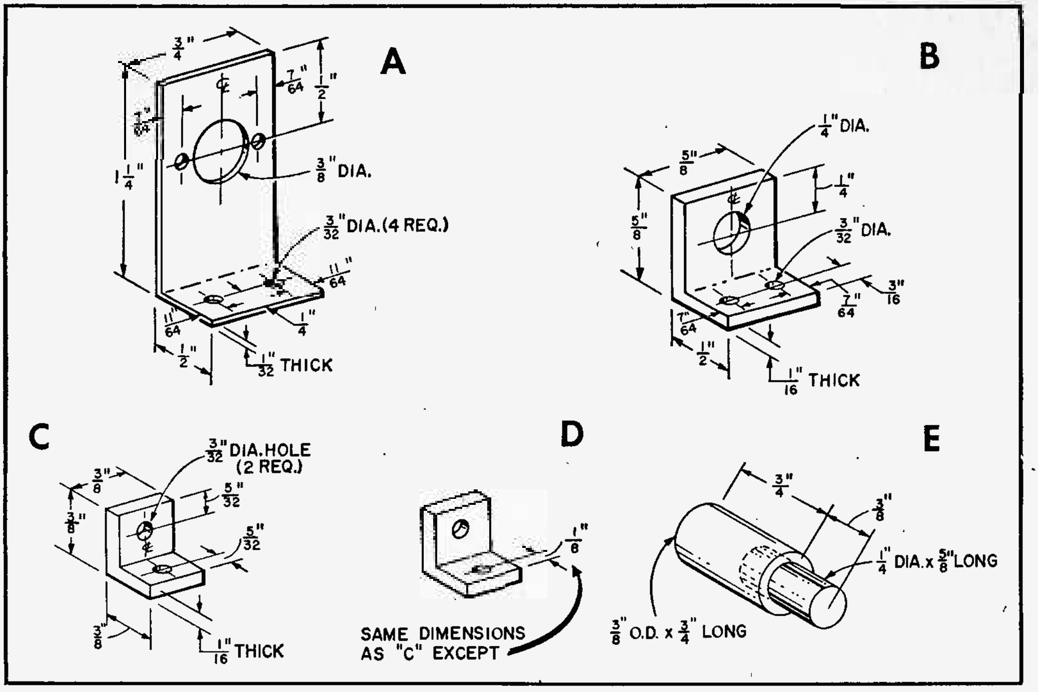
e/e 6-METER RECEIVER

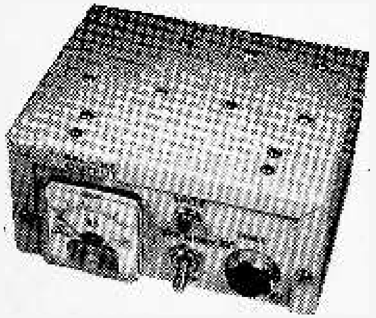
Continued from page 101



station, and varying the value of the potentiometer and noting the results.

Operation. Operating this receiver is as simple as "eating apple pie." The functions of the two controls are self-explanatory. As you tune in a station, with control C8, the rushing background noise will disappear. As the desired signal decreases in strength, the rushing background noise may not disappear entirely, and tuning may become somewhat critical. The inherent characteristics of the super-regenerative detector account for the excellent built-in AVC and noise limiting properties of this receiver. But don't take our word for it, build this 6-meter rig yourself. Get away from your ham appliance-buying trends and return to the fun *Hamdom* has given over the years. ■

BUILD A COMPLETE STATION



■ **The receiver** described on the previous pages was built as part of an all **solid state 6-meter amateur station.** The companion 6-meter transmitter was physically designed to match the receiver. The transmitter, built in the same size case, can be bolted onto the left side of the receiver to form a complete 6-meter station. Used together they form a lightweight, compact station that's just the thing for camping, vacationing, field days, mountain topping, and as a **first** station for the newcomer to 6-meters.

The transmitter itself uses a total of 7 semiconductors (6 transistors and 1 diode). The transmitter has a DC power input of 250 milliwatts. High level collector modulation is employed for good efficiency and ease of adjustment. Other features include:

- Push to talk operation
- Spotting switch
- Relative RF output meter
- Easy-to-build construction

An article describing the construction of the companion transmitter will be featured in the forthcoming April/May 1966 issue of RADIO-TV EXPERIMENTER on sale at your favorite newsstand February 24, 1966. Don't miss it if you want a low cost "walking-talking" transceiver. ■

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Classified Ads 55¢ per word, each insertion, minimum 10 words, payable in advance. To be included in the next available issue of ELEMENTARY ELECTRONICS, copy must be in our New York Office by March 10th. Address orders to C. D. Wilson, Manager, Classified Advertising, ELEMENTARY ELECTRONICS, 505 Park Ave., New York, N. Y. 10022.

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Unitize!

Continued from page 86

supply subassembly on the chassis is shown in Fig. 4.

(Remember to drill a lot of small holes in the cover of the box to give ventilation—

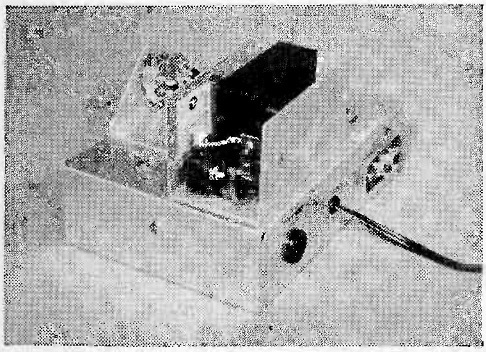

Fig. 4. Power supply (with cover removed) mounted on main chassis. Don't sacrifice ventilation for complete shielding. Heat buildup will break down components or at least change characteristics and values.

some selenium rectifiers will break down when their temperature passes 90°F. Silicon rectifiers will withstand much higher temperatures without breaking down and it is best to use this type wherever there is any doubt about keeping the temperature down below the rated level—Editor.)

This is the way to "unitize" only one project but these ideas can be applied to almost all other electronic construction projects like transmitters, stereo/hi-fi and other receivers. In fact just about anything you, as an electronics experimenter, want to build can be done more easily by making subassemblies instead of trying to mount everything on a single chassis.

The best part, the bonus, of "unitized" construction is that you can cannibalize discarded projects for complete subassemblies—the power supply, the audio amplifier—and use them without moving individual components from one chassis to another—preventing individual components from being damaged, leads broken and you know the subassembly works; it's been debugged the first time you put it together—or it will work about 90 per cent of the time.

Unitize your next project and have a whole new field of construction convenience unfold before you. You'll be surprised how a bit of planning, thinking in advance, will help you to make your next home-brew project look like a professional job and without many of the usual flustrations, frayed nerves and burned fingers. ■

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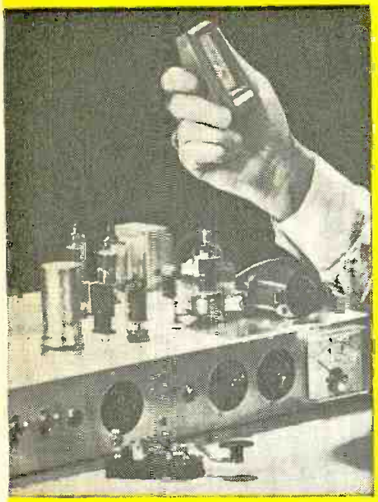

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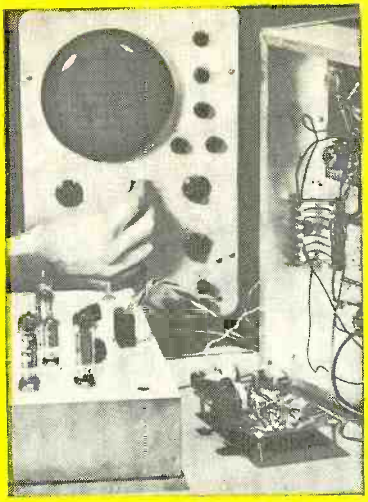
This is just one of seven training kits programmed into NRI's Complete Communications course. You get actual practice in building your own crystal-controlled, phone/code transmitter and putting it on the air. You experiment with modulation, "clamping" circuits, key filters, other aspects of commercial transmitter operation. Can be put on the air simply by attaching an antenna and complies with FCC regulations. As with all NRI training kits, you get the most modern features and parts.



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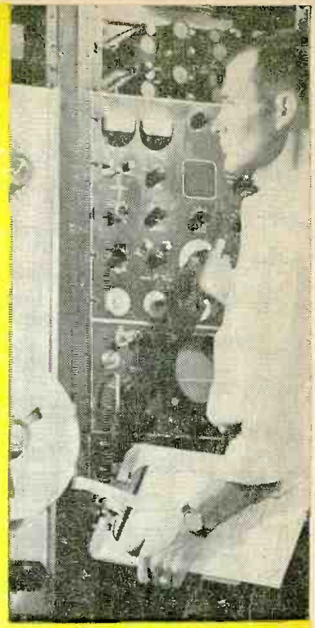

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[see page 31]

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