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By Robert Hertzberg

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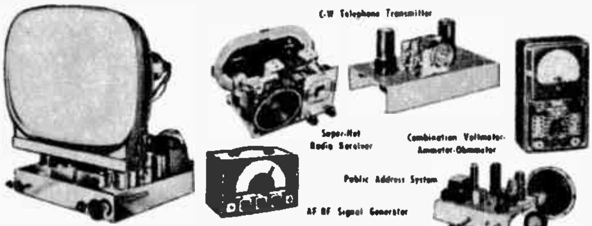

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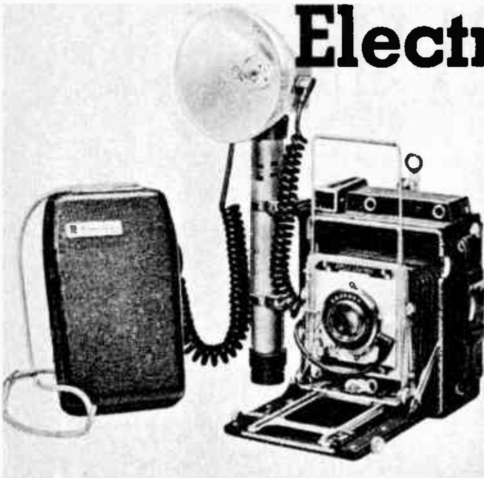

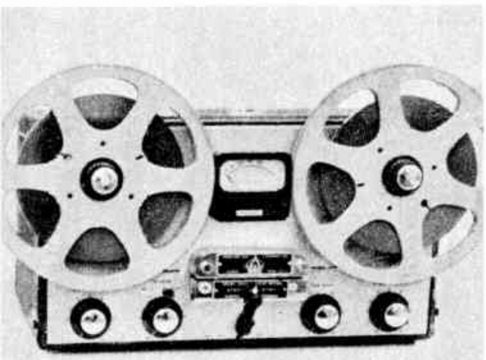

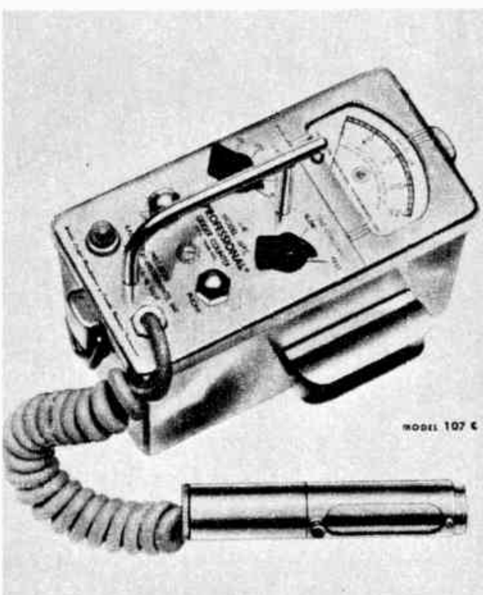

By Robert Hertzberg

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On the cover: Fairchild 240 control pre-amplifier, Heiland Strobonar Seven electronic flash unit, RCA "Judicial" Model 7TR3 tape recorder, Bell Telephone Company's experimental solar battery.

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INTRODUCTION

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Everybody will like to read about uranium hunting, remote-controlled boat models and garage doors, electronic flash photography, transistors, hi-fi sound, converting the sun's rays into electricity, and the new table-radio-size TV sets. Read, learn, and have fun at the same time . . . electronics is an absorbing and educational activity for everyone!

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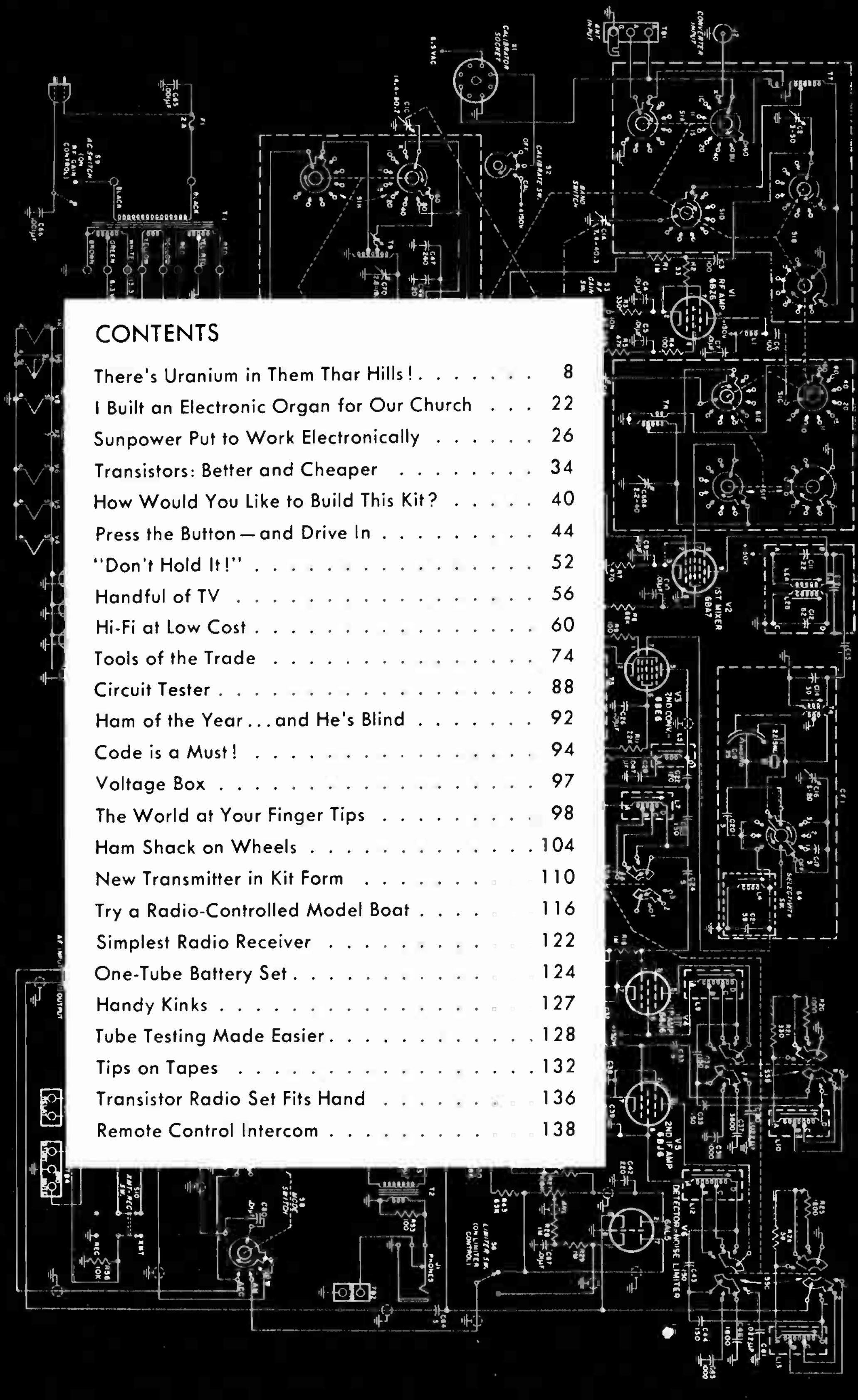

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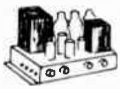

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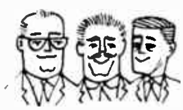

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Uranium
There's ~~Gold~~ in Them Thar Hills!

With the aid of simple electronic detectors, even an amateur prospector can find it and make millions.

A LITTLE MORE than a century ago, the discovery of gold in the Far West of the United States touched off the most frantic overland trek in history. Prospectors armed with pickaxes found gold, and many of them became wealthy overnight. Today, another rush is on, but the prospectors are armed with electronic devices. Their objective is not gold, but the magic fuel of the atomic age . . . uranium.

Thousands of people have already achieved success in this new and greatest treasure hunt of all time. Significantly, the richest hauls in recent years were made by rank amateurs who carried very simple equipment. Outstanding is the case of a former electrician and handy man who sold his "find" for a cool twelve million dollars!

The Atomic Energy Commission needs uranium, and encourages prospectors by offering heavy cash bonuses and high prices for the delivery of commercially useful ore from new finds. Several hundred thousand dollars each month is being paid out.

Uranium is widespread, and is being discovered in practically all parts of the country. However, the richest finds are in the mountainous areas of the West, which have long been known for the variety and ex-

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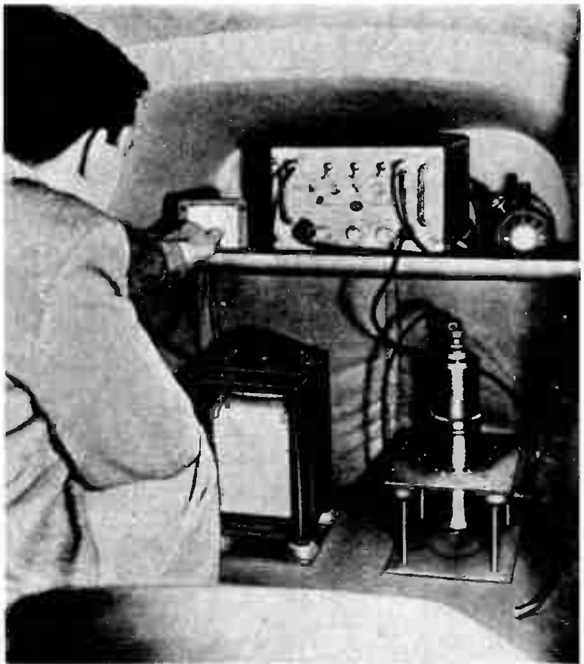
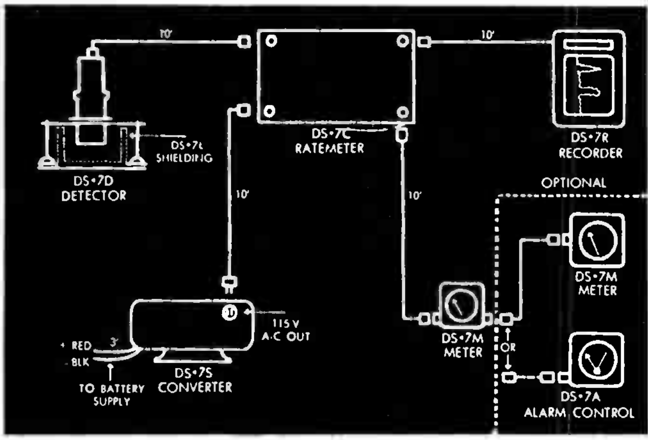
Opposite, armed with a radiation detector that costs $2,000, this prospector means business. Equipment is the Model 118B Royal "Scintillator," made by Precision Radiation Instruments, Inc., Los Angeles, Cal. It measures 13x17x5 inches.

Right, scintillation exploration by airplane is a popular method because a big area can be covered in a short time. Here is typical installation of the Model DS-7 Scintillation System, made by the Nuclear Instrument and Chemical Corporation, Chicago, Ill., in the baggage compartment of a Cessna 180 plane. Detector head, aimed downward through body of plane, is at lower right; next to it is recorder that makes a record of received radioactivity. On shelf are indicating meter (left), ratemeter, containing major electronic circuitry (center) and DC-to-AC converter. All of this is highly sensitive equipment.



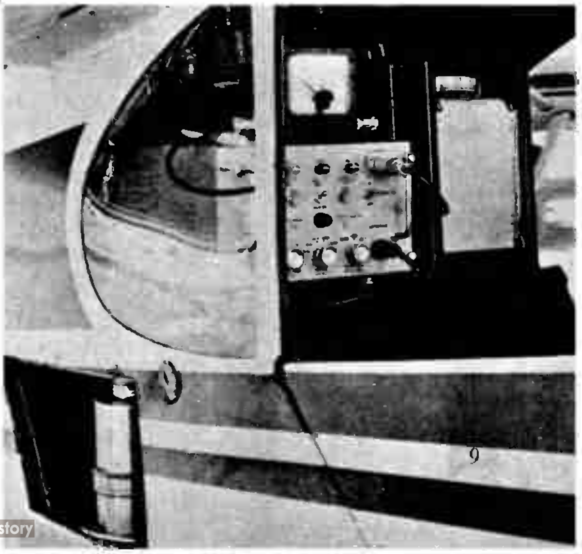
Below, this is a block diagram of the Chicago-Nuclear DS-7 Scintillation Exploration System.



Below, Nuclear-Chicago's Model DS-7 system in a Piper Super Cub. Note the detector head inside flap of baggage compartment. Some equipment is often installed in automobiles for ground searching. Complete system costs $3,912, and is so cabled that an untrained technician can install it in under 2 hours.

tent of their mineral deposits. As little as one-tenth of one percent of uranium in earth or rock is of commercial value. A concentration of ten percent makes the ore worth as much as $2,000 a ton.

The old prospectors had to dig and blast vast quantities of likely-looking rock and then examine it hopefully for tell-tale flecks of yellow. Their modern counterparts used various forms of electronic detectors, which not only indicate the presence of uranium ore but also measure its probable richness. These instruments are known as "Geiger counters" and "scintillation counters."



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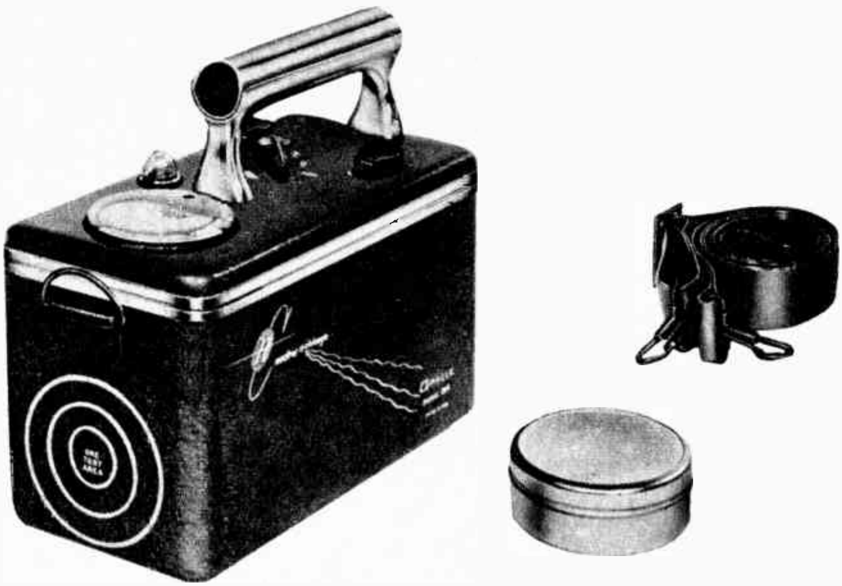

Completely self-contained, the "Oracle" is a portable uranium prospecting instrument measuring only 10x5x6 inches overall and weighing about 8 pounds. It uses 10 Geiger counter tubes and operates even if several fail. Costs $395 and is made by the Chicago Nuclear Instrument and Chemical Corporation.

Uranium ore is radioactive, and in its natural state it shoots off radiations called alpha particles, beta particles, and gamma rays. The first two have a relatively short range in air, but the gamma impulses are much stronger and can be detected by airborne equipment up to about 1000 feet above the ground.

The major difference between Geiger and scintillation counters is in their relative sensitivities. Carried at ground level, a Geiger counter can detect uranium deposits to a depth ranging from a few feet to several dozen feet. Under the same conditions, a scintillation counter is effective to depths of several hundred feet. Remember, these figures are only relative. A Geiger counter, although it is small, light and cheap, is still a very sensitive instrument, and it has been responsible for the finding of many rich deposits.

The detecting element in a Geiger counter is a gas-filled tube. In a scintillation counter it is a dense crystal of sodium iodide. The weak radioactive rays that enter the detecting elements are converted into electronic impulses and are amplified much in the same manner as radio-TV signals. The relative strength of the radioactivity is indicated visually by a neon flasher or a calibrated meter or aurally by a loudspeaker or earphone.

Practice and experience are needed for the correct interpretation of the "counts" of radioactive rays picked up by an instrument. The "radium" dial of a wrist watch is enough to make some counters go crazy!

To a man with a practical electronics background, most radiation counters are easy to understand and use. There is a wide range of factory-made units, from a pocket-size Geiger counter costing less than thirty dollars to an elaborate vehicular system costing about four thousand. Counters lend themselves admirably to do-it-yourself construction, and there are many excellent kits on the market. A basic Geiger counter kit can be bought for as little as sixteen dollars. Essentially electronic in nature, counters of various kinds are sold by radio parts distributors. In some parts of the West, they are often seen in drug, hardware, electrical, auto supply and outdoor supply stores.

A collection of representative radiation instruments is pictured and described on these pages.

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Radiation Counter Kit

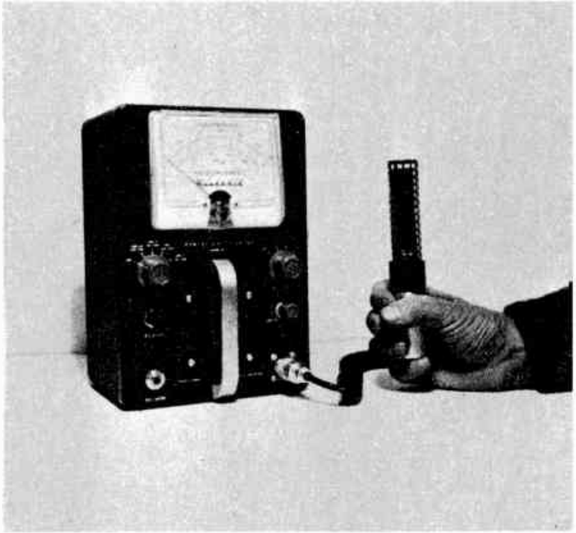
The Heath Company, of Benton Harbor. Mich., well known for its numerous electronic kits, announced a new radiation counter in knock-down form just as this book was being prepared. Greatly resembling a common vacuum-tube voltmeter and just as easy to assemble and wire, this is a very sensitive unit intended for the serious prospector. Because of the widespread interest in the subject, we are presenting here the complete schematic diagram and a detailed description of its functioning.

A prewired power supply delivering the required high voltage, coupled with a four-tube amplifying and pulse shaping circuit, gives extremely high sensitivity. A 4½-in. meter, calibrated in counts per minute. gives full scale readings from 100 cpm to 60,000 cpm. The meter is also calibrated in milliroentgens per hour (mR/hr) from .02 mR/hr to 10 mR/hr full scale.

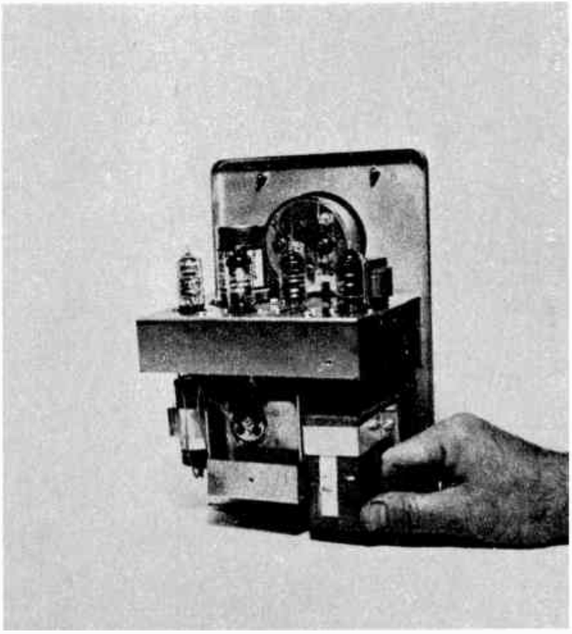
The circuit has been so designed to operate with the Heathkit Geiger Counter Probe Model GC-1, which uses a bismuth counter tube. A calibrated, completely safe radiation source is provided with each model RC-1 for spot calibration in the field.

Study the schematic diagrams seen on page 12 in connection with the following theory of operation. Negative pulses generated in the probe are impressed across the input grid resistor through the .01 mfd. blocking capacitor and are amplified and inverted by V1, appearing across the 68.000 ohm plate load resistor. V2 further amplifies and reinverts the signal pulses and injects them into the grid of V3. The two stages of amplification have been designed to have a sensitivity of approximately .1 volt and to limit at an input of .25 volt. This insures a pulse of the proper amplitude for triggering V3, even though the input pulses may vary considerably in height.

V3 and V4 together constitute a monostable multivibrator, sometimes called a "one-shot," since it makes one complete cycle for each pulse (trigger). Operation is as follows: The two tubes have a common cathode resistor of 15,000 ohms serving as one leg of the coupling impedance necessary for oscillation and also serving as a source of cut-off bias for V4. The control grid of V3 is returned to a positive point on the voltage divider connected between B+ and ground, causing it to conduct. This conduction causes current flow



The Heathkit Radiation Counter has the probe on the right. Loudspeaker, giving out tone signals to indicate radioactivity, is under the carrying handle. Complete kit is available for about $80.



Inside of Heathkit Radiation Counter looks like that of vacuum tube voltmeter or a small radio. Its batteries are held in clamps at the bottom.

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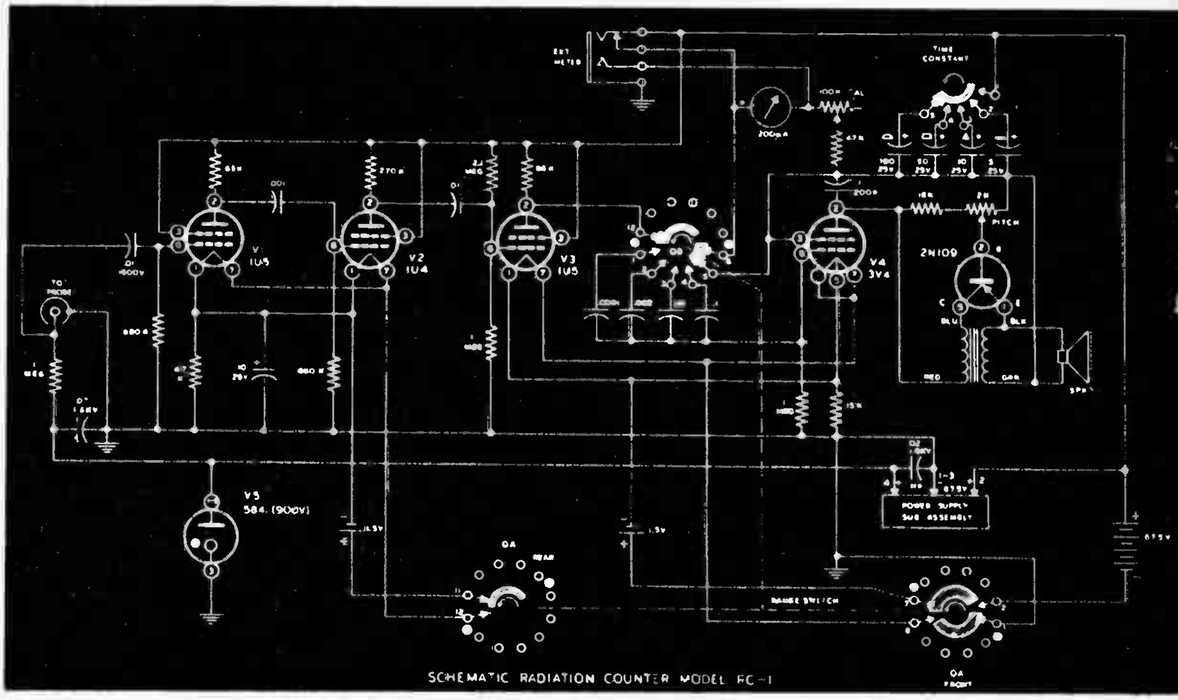
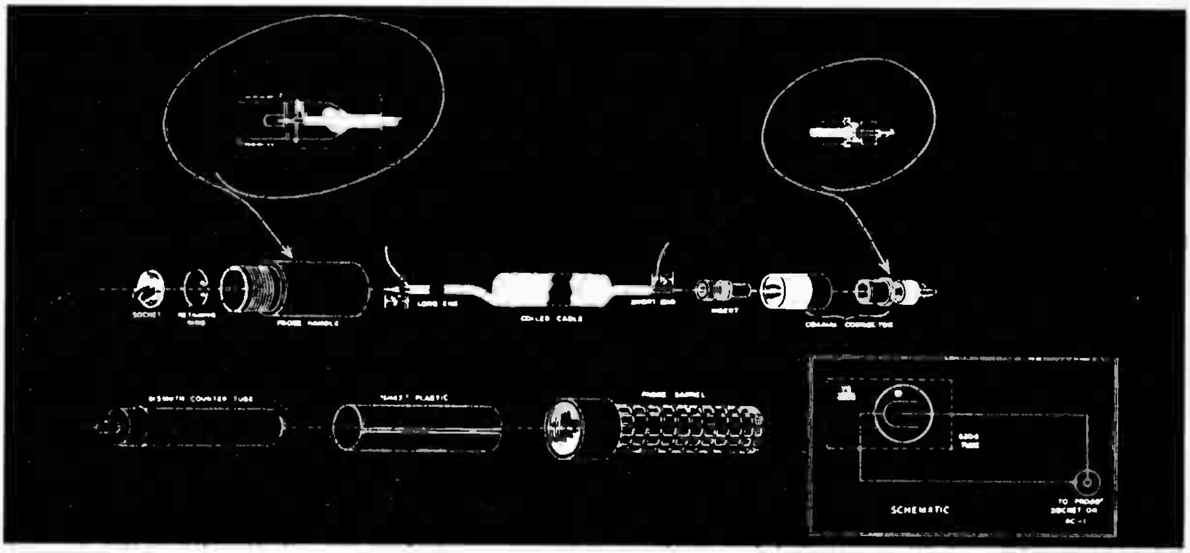


Complete schematic diagram of Heathkit Radiation Counter. The device marked 2N109 is a transistor.



Assembly details of "probe" used with Heathkit Radiation Counter. The actual wiring is simple as the 6306 counter tube has only two connections.

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through the common cathode resistor and the voltage drop across it is sufficient to cut V4 off, since the grid of V4 is returned to ground. This enables the use of a tube with comparatively large emission capabilities as V4 without increasing the B battery drain, since V4 is not allowed to draw current except during the short operating cycle following each input trigger. The RANGE switch connects various precision capacitors between the plate of V3 and the grid of V4 and, in conjunction with the common cathode resistor, provides the necessary cross-coupling to enable multivibrator operation. The capacitors switched between the two tubes determine the period of time the multivibrator will remain in its unstable state. This in turn determines the average current flowing through the meter. The meter is calibrated in both COUNTS PER MINUTE and MILLIROENTGENS PER HOUR. The use of precision capacitors to determine the range and therefore the current for full scale meter deflection enables the use of a single calibration control. Calibration made at one point will hold to within 10% at all points. The calibration control also enables the instrument to be calibrated even when the B battery is quite weak. The over-all circuit including the power supply sub-assembly has been designed to operate correctly until the B battery voltage has dropped to 50 volts and/or the filament batteries have dropped to 1 volt or less. This has been done to enable longest battery life commensurate with reliable operation and to preclude the necessity for carrying an excessive number of spare batteries in the field.

An interesting departure from the usual method for aural monitoring has been incorporated in this instrument. A transistor oscillator, using an output transformer as the oscillatory inductance, derives its operating voltage from the voltage drop across a by-passed portion of the plate load resistance for V4, voltage being present only during unstable state immediately following the input trigger pulse. A small loudspeaker is connected directly across the output transformer and reproduces the audio tone generated by the transistor oscillator. This tone may be varied by adjustment of the 2000 ohm PITCH control to that most pleasing to the operator. Since it is an audio tone and not a click, it can be recognized in even the noisiest locations and is invaluable when prospecting in a moving vehicle or aircraft.

Two filament batteries (ordinary flashlight cells) and a 67½ volt B battery (such as is used in most portable radios) supply all operating voltages for the instrument The power supply sub-assembly derives its operating voltage from the 67½ volt B battery. Its output voltage is sufficiently high (greater than 1200 volts) so that it may be regulated at 900 volts for use with the Geiger counter probe.

The meter has a 200 microampere movement for greatest sensitivity combined with ruggedness. When the instrument is turned OFF, the RANGE switch puts a short across the meter for added protection. A TIME CONSTANT circuit has been incorporated to give added flexibility to the counter, allowing a meter time constant of ½ second to 10 seconds. The ½ second position of the TIME CONSTANT switch is used when moving over the ground rapidly and the 10 second position is used when checking ore samples for most accuracy.

The heart of the "probe," which the prospector passes over earth and rock in his search for "hot" ore, is a type 6306 thyrode counter tube. This is a gas diode (two-element tube) designed to produce an electrical impulse when it is penetrated by ionizing particles from radioactive material.

The ions and electrons produced within the tube by the ionizing particles are accelerated by the electrode potential and produce other ions. In this manner, the discharge spreads throughout the tube. The electrons are collected rapidly and account for the rise time of the pulse. The heavy ions of the quench gas form a sheath around the anode (where the field strength is strongest) and move outward toward the cathode, sweeping the field clear of electrons and thus quenching the discharge.

Counter tubes are classified according to the type of radiation which they are designed to measure, as indicated by their wall thickness and material. The 6306 tube is designed for accurate gamma counting in this instrument. The aluminum shell, although only 0.11 mm thick, is very strong and the tube will operate satisfactorily when accidentally dented.

World Radio History

PRI Uranium Detectors

One of the most popular and best known lines of Geiger and scintillation counters is made by Precision Radiation Instruments, Inc., of Los Angeles. This starts with a pocket-size unit costing only $29.95 and advances progressively to a super-deluxe job costing $4,995. As might be expected, the sensitivity, accuracy and other features vary pretty directly with price. However, it must be emphasized again that "greenhorn" geologists have struck it rich with light, inexpensive equipment.

Various of the PRI instruments are pictured and described here to give you an idea as to the design and appearance of uranium detectors. They are all built for rugged field service in the hands of non-technical people. Any would-be prospector can learn to use one in a couple of hours.

Model 16C "Lucky Strike" has three means of indicating radioactivity: neon flasher, earphones and meter. It is of the Geiger counter type. The calibrated meter enables prospector to estimate the quality and quantity of ore. It is priced at $99.50.

Model 107C "Professional" Geiger counter has a separate directional probe. The meter can be interpreted to read the percentage of uranium in radioactive ore, right in the field. Batteries are standard radio items which are obtainable everywhere. Size is 3⅝x4⅝x7¾ inches. Its price is $149.50.

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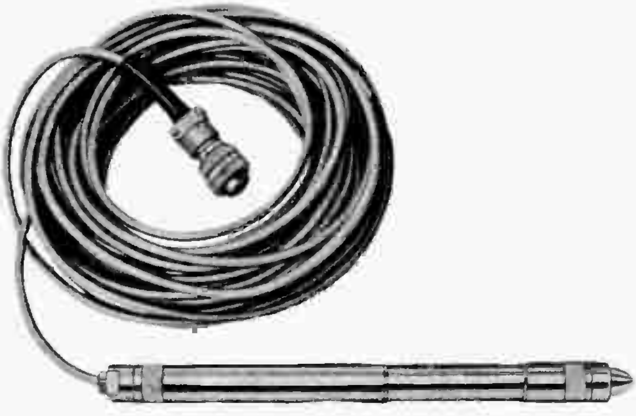
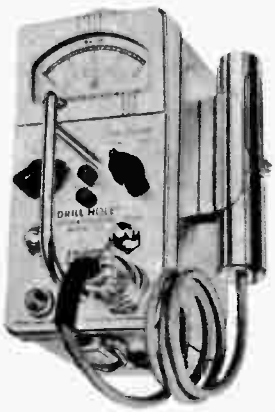
The Model 108 "Snooper" is a basic Geiger counter, taking about as much pocket space as three packs of cigarettes. Produces a loud series of clicks in earphones (not shown) in the presence of radioactive material, the number of clicks increasing as the material becomes closer. Works on one flashlight battery and one 22½-volt hearing aid type B battery. Size is 1½x3x5 inches. Price, $29.95.

The Model 117B Special "Scintillator" has sixty times the sensitivity of a Geiger counter. The detecting element is a thick thallium-activated sodium iodide crystal, hermetically sealed and optically coupled to a photomultiplier tube, within the case of the instrument. There are only two controls. Size is 4½x7¼x7 inches. Its weight is 6¾ pounds. It is priced at $299.50.

The Model 121 "Drill Hole" Geiger counter is a versatile unit designed for general uranium prospecting, Civil Defense radiation checking, laboratory purposes and especially for sub-surface exploration in drill holes. The drill hole probe, only ⅞ inch in diameter, is supplied with a 50-foot connecting cable, and additional lengths up to 1,000 feet are available. This flexible probe opens up interesting possibilities in searching for uranium in crevasses, over the edges of cliffs, etc. Price, $249.50.





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Left, Model 111 Standard "Scintillator" is designed for the prospector who prefers a "gun" type scintillator. It is 100 times more sensitive to gamma rays than a Geiger counter and is suitable for surveys from an airplane or moving vehicle, as well as for manual use in the field. Probe size is 3¾x13½ inches. Battery box measures 5⅝x4⅝x3 inches. Weight is 7½ lbs., and the price is $399.50. More advanced versions are Models 11B and 111C, costing $495 and $695.

Right, Model 115B Super "Scintillator" is an advanced instrument for both laboratory and field applications. It is not only a high-quality scintillator, but does double duty as an ultra-sensitive Geiger counter. Its size is 5x11x14½ inches; weight is 16 lbs. Priced at $595. There is also a Model 115C, using a larger detecting element, at $795. Of similar appearance is the Model 118C "Royal Scintillator" which costs $4,495.

Bitter weather doesn't stop determined uranium seekers. These two, observing a good reading on the meter of PRI Model 111C Scintillator, are about to blast out snowy, frozen earth.

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Geiger Counter Circuits

Geiger counter circuits offer the electronic technician an intensely interesting field of experimentation. Through the courtesy of "The Aerovox Research Worker" (Aerovox Corporation, New Bedford, Mass.), we are able to present here eight different hook-ups that were tested by the engineering department of that firm.

The counter tubes used in the circuits shown are Victoreen Types 1B85 and 1B86. Tubes having equivalent electrical characteristics also may be employed. The 1B85 requires a d-c operating voltage of 900 v. Its threshold voltage is 800 v, and its minimum plateau length 200 volts. Its life is 10^8 counts. The 1B86 requires a d-c operating voltage of only 300 v. Its threshold voltage is 280 v, and its minimum plateau length 60 volts. Its life is 5 x 10^7 counts. The counter tube may be operated in a probe on the end of a shielded cable, or it may be installed inside the instrument case, with a suitable opening, holes, or louvers for entry of radiant energy.

Basically, the differences between Geiger counter circuitry result from (1) the method of obtaining the high voltage for the counter tube, (2) whether amplification is employed, and (3) whether indications are aural, visual, or both.

Circuit 1. This is the simplest possible arrangement. Here, a 1B86 counter tube is connected in series with a miniature 300-volt battery (similar to Burgess U200 or RCA VS093), headphones, and a 1-megohm current-limiting resistor. A single pole switch allows the circuit to be disabled when not in use.

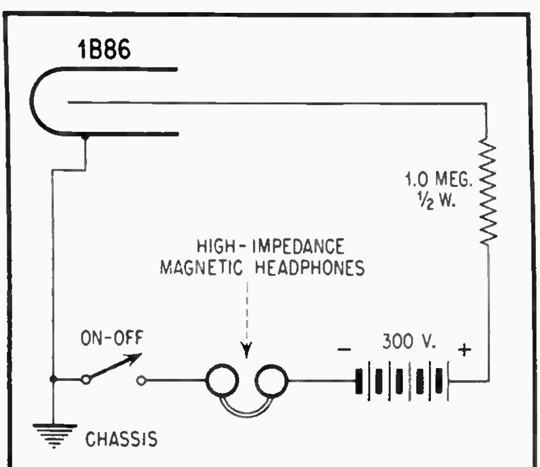
Each ionizing particle penetrating the counter tube causes a pulse of current to flow through the circuit, and this produces a click in the headphones. In order to complete the circuit, the headphones must be of the magnetic type and must have high impedance. A stepdown matching transformer would be required for low-impedance headphones. Crystal-type headphones, although possessing remarkably high impedance, are unsatisfactory in this circuit because they provide no continuity for dc.

The 1B86 is a glass-wall gamma ray tube. Its diameter is 0.4 inch and its over-all length, including its 1⅛-inch tinned leads, is 4¾ inches. For more compact assembly or smaller-sized probes, the 1B88 counter tube may be substituted. The latter also has a diameter of 0.4 inch, but its over-all length (including 1⅛-in. tinned leads) is only 2¾ inches.

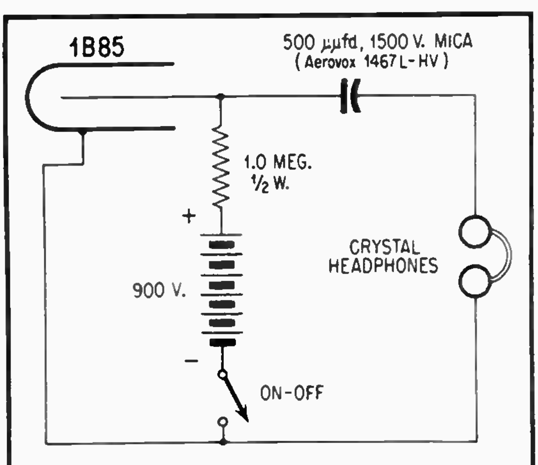
The 300-volt Type U200 battery measures 2$\frac{11}{16}$ x 2$\frac{7}{32}$ x 3$\frac{29}{32}$ in.

Circuit 2. The sensitivity of the simple, battery-operated counter may be improved by employing a general-purpose beta-gamma counter tube, such as Type 1B85, with a 900-volt d-c supply. The high voltage is obtained from three miniature 300-volt batteries (such as specified for single use in Circuit 1) connected in series. Circuit 2 shows this arrangement.

Because the 900-volt potential consti-



CIRCUIT 1



CIRCUIT 2

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tutes a serious shock hazard, we do not recommend connecting the headphones in series with the other elements in the way this was done in Circuit 1. Instead, high-impedance headphones are capacitance-coupled to the circuit through a 500-mmfd 1500-volt mica capacitor. Crystal-type headphones can be used to advantage.

The 1B85 is an aluminum wall tube having an A1-82 coaxial base. Its diameter is 51/64 inch, and its over-all length, including the coaxial base, is 4¼ inches.

Because of the higher d-c voltage employed in Circuit 2, particular care must be exercised during construction of the instrument to insulate the various parts of the assembly. To prevent leakage, use only high-grade non-hygroscopic insulating materials and keep all circuit points separated as widely as possible.

Circuit 3. In this arrangement, a pentode amplifier has been added to the rudimentary circuit (Circuit 1) to increase sensitivity and to provide louder clicks. Pulses from the 1B86 counter tube are transmitted to the grid of the 1U5 amplifier through coupling capacitor C_1.

The midget 300-volt battery, B_1, supplies both the counter tube and the plate and screen of the amplifier. The second battery, B_2, is a 1½-volt Size-D flashlight cell. The ON-OFF switch is connected to open both battery circuits simultaneously when in its OFF position.

Maximum efficiency will be obtained with high-impedance headphones. Crystal-type phones are recommended.

The shorter Type 1B88 counter tube also may be employed in this circuit.

Circuit 4. This is a variation of Circuit 3. Here, the plate and screen of the 1U5 tube have been disconnected from the important 300-volt battery and are supplied by the separate, midget 67½-volt battery, B_3. In all other respects, Circuit 4 is identical to Circuit 3.

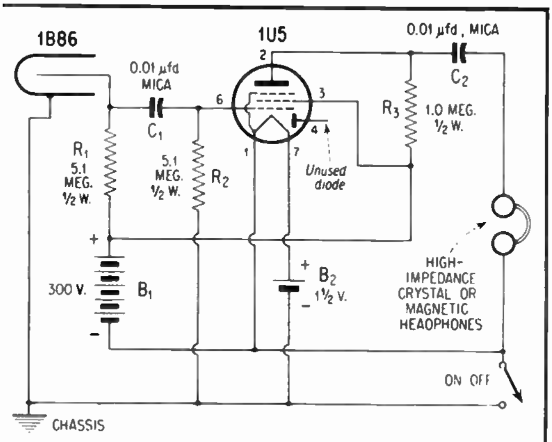
This circuit change is important when the instrument is to be used regularly over protracted periods. Under such circumstances, removal of the tube drain from the 300-volt battery and the consequent longer life of this battery sufficiently offset the additional cost, complication, and weight of the additional battery, B_3, to warrant the modification.

The switch interrupts all three battery circuits when thrown to its OFF position. It is shown in this position in the diagram directly below.

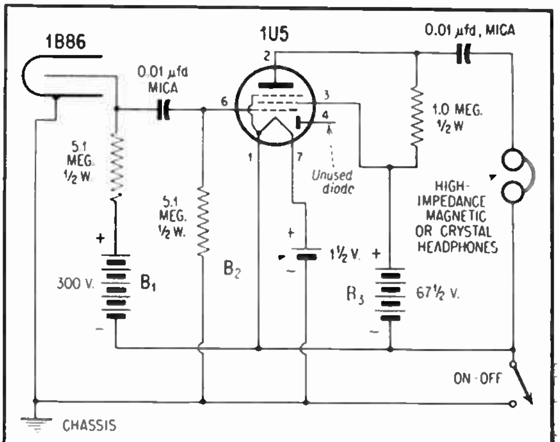
Circuit 5. This is an interesting 300-volt Geiger counter which is powered from a single 1½-volt Size-D flashlight cell. The high d-c voltage required for operation of the 1B86 counter tube is obtained by charging a capacitor through a high-turns-ratio stepup transformer.

The transformer may be any small universal replacement-type output unit, such as Merit A2900. Terminals A and B represent the *entire* primary winding of this transformer. (Do not use the center tap.) Terminals C and D are two of the low-impedance connector lugs selected from the transformer connection chart for a turns ratio between CD and AB of 300 to 1, or higher.

The single pole, double throw pushbutton switch normally rests in position a. This



CIRCUIT 3



CIRCUIT 4

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connects the headphones (plugged into the insulated phone jack) to the low-impedance winding of the transformer. When the switch is depressed and released momentarily, making a quick make-and-break connection in position b, a high-voltage pulse is induced across the high-turns winding, AB. This pulse fires the 1B86 tube and charges the 0.1-microfarad capacitor. Several repeated operations of the pushbutton switch will charge this capacitor fully. With the switch resting in position a, the capacitor cannot discharge through the circuit because of the insulating property of the 1B86 when it is not fired. The capacitor accordingly retains its charge and serves as a 900-volt source. When the counter tube is penetrated by a radioactive ionizing particle, however, it fires and induces a voltage across winding CD, and this produces a click in the headphones.

The length of time the capacitor will hold its charge depends upon the leakage characteristics of the capacitor and how well the circuit is protected from ambient humidity. This will vary from 5 to 30 minutes in most cases. As the charge leaks away, because of either leakage or rapid counting, the capacitor may be re-charged readily by quickly pulsing the pushbutton switch several times.

Because of the nature of this circuit, very small size may be attained in the completed instrument. An added advantage is the fact that the headphones, being inductively coupled, are not included directly in the high-voltage circuit and any possibility, ground, or short circuit consequently is removed.

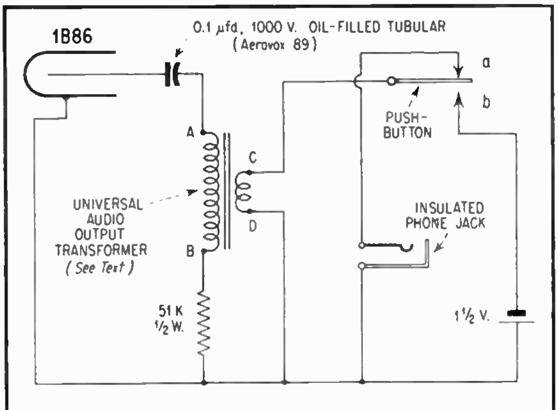
Circuit 6. The high potential of 900 volts is obtained in this circuit also by pushbutton-pulsing a 1½-volt cell through a backward-connected universal output transformer to charge a capacitor. Here, however, terminals 1 and 2 of the transformer are the lugs (selected from the transformer connections chart) which supply the *lowest* impedance. This permits the highest stepup ratio. The *entire* primary winding of the transformer is represented by 3 and 4. (Do not use the center tap.)

A small needle-type spark gap is connected between the 1B85 tube and the high-voltage winding of the transformer. A discharge takes place across this gap when the pushbutton (S_1) is depressed and released, and the capacitor is charged. Several successive, rapid pulsings of the pushbutton will charge the capacitor fully.

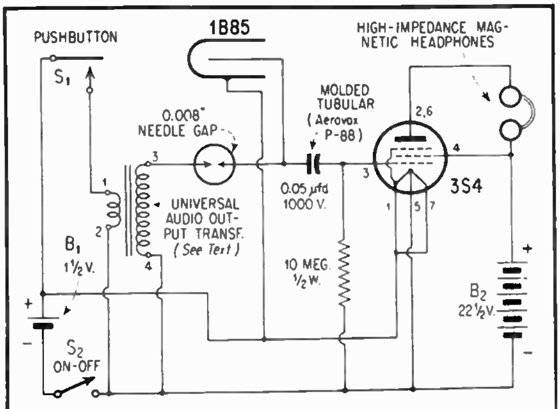
As the 1B85 tube fires under the influence of penetrating radioactive particles, the resulting pulses are presented to the grid of the 3S4 amplifier tube, and the amplified pulses are delivered to the headphones.

The 1½-volt battery, B_1, supplies both the transformer and the 3S4 filament. The 22½-volt battery, B_2, supplies only the plate and screen of the 3S4. For light-duty application, B_1 may be a single Size-D flashlight cell and B_2 a hearing aid battery. For more exacting work, B_1 should be made up of two or more Size-D cells connected in parallel, and B_2 should be a midget 22½-volt radio-type B-battery.

As in Circuit 5, the length of time that the capacitor will remain charged will depend upon ambient humidity and capacitor



CIRCUIT 5



CIRCUIT 6

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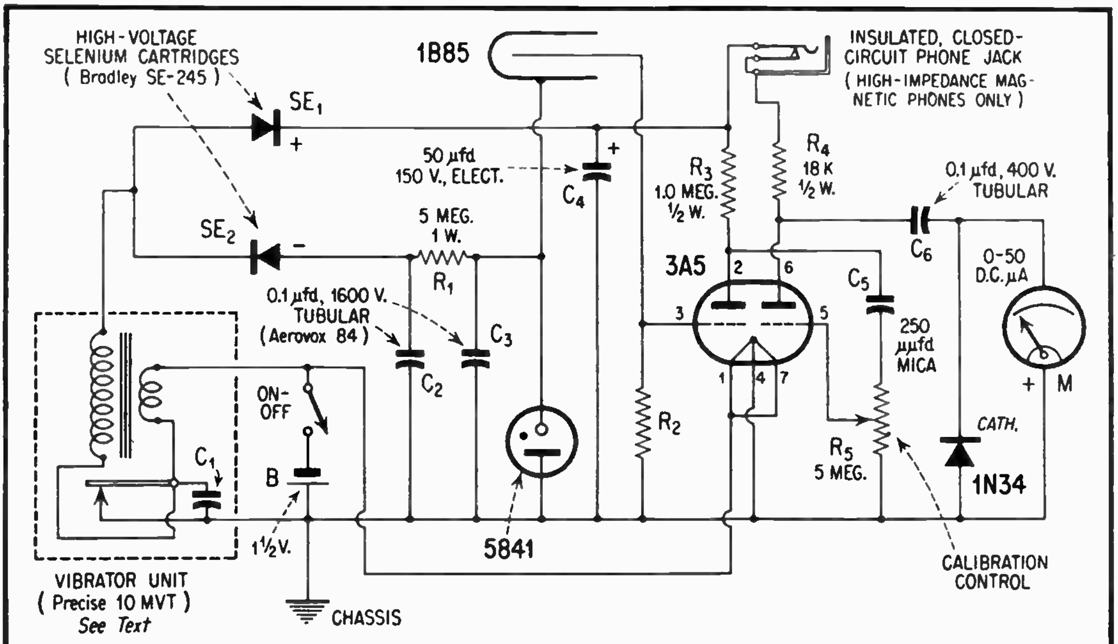

CIRCUIT 7

leakage and usually will be between 5 and 30 minutes. An occasional succession of rapid pulsings of the pushbutton switch, S_1, will restore the charge.

Circuit 7. This Geiger counter has a self-contained, miniature, vibrator-type power supply operated from a single 1½-volt Size-D flashlight cell. The vibrator unit supplies the 1B85 counter tube and the 3A5 dual-triode amplifier tube. Meter readings, as well as headphone signals, are obtained with this circuit.

The miniature vibrator unit is a Model 10MVT, a product of Precise Measurements Co., Brooklyn, N. Y. It consists of a vibrator integral with a high-voltage transformer. The spark-suppressing capacitor, C_1, is self-contained.

The high-voltage a-c output of the transformer is rectified by two sub-miniature high-voltage selenium cartridges. One of these, SE_1, is poled to supply positive output for the 3A5 tube. The other, SE_2, is poled for negative output for the 1B85. The 50-microfarad, 150-volt electrolytic capacitor, C_4, filters the 3A5 voltage, and its normal leakage holds this voltage to approximately 80 volts at 200 microamperes. The Victoreen Type 5841 regulator tube holds the counter tube voltage to a constant 900-volt level. Capacitors C_2 and C_3 and resistor R_1 form the high-voltage filter.

The 3A5 tube provides a 2-stage RC-coupled amplifier. The output triode is capacitance-coupled, through C_6, to a rectifier-type voltmeter comprised by the 1N34 diode and the 0-50 d-c microammeter, M.

The meter deflection is proportional to the number of pulses per unit time arriving from the counter tube. Its scale may be calibrated at various settings of potentiometer R_5 (which might also be a step-type attenuator), with the aid of a series of calibrated radioactive samples held close to the 1B85 tube. Magnetic-type headphones inserted into the phone jack will provide aural indications. Since this jack is of the closed-circuit type, it will restore the plate circuit of the second triode automatically when the headphone plug is extracted.

Circuit 8. This circuit employs a 3A5 dual triode in a cathode-coupled one-shot multivibrator circuit. The multivibrator is triggered by pulses from the 1B85 counter tube. Each pulse switches the multivibrator on and off, causing a single pulse to be delivered to the metering circuit. Capacitors C_6, C_7, and C_8, switched into the circuit, after the pulse duration and repeti-

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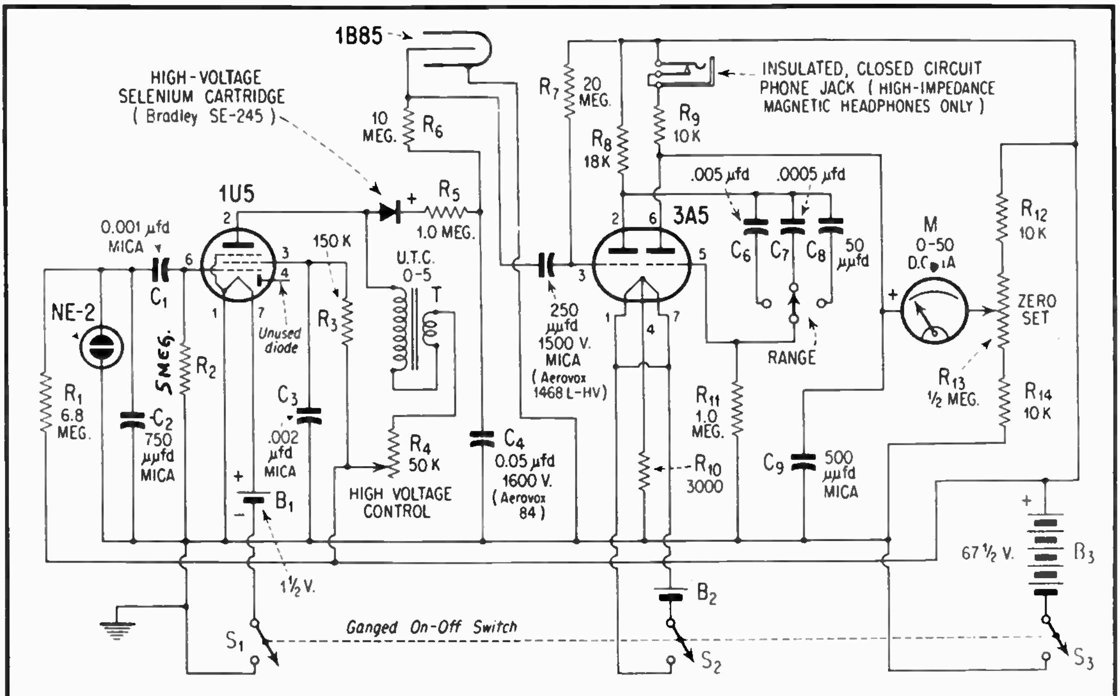
tion rate of the multivibrator and thus change the meter range. The microammeter thus is provided with several "total count" ranges. The microammeter scale accordingly may be calibrated in counts per unit time, milliroentgens per hour, or similar units. For this purpose, a series of calibrated radioactive samples may be employed.

Like a v-t voltmeter, the meter is set initially to zero in the absence of any input signal, by adjustment of potentiometer R_{13}. An aural indication is obtainable from magnetic-type headphones plugged into the closed-circuit jack.

The 900-volt potential for the counter tube is developed by a special power supply based upon a neon-bulb relaxation oscillator. Operated from the same 67½-volt battery, B_3, that furnishes the 3A5 plate voltage, the relaxation oscillator consists of resistor R_1, capacitor C_2, and the NE-2 neon bulb. The sawtooth voltage developed by this oscillator is applied to the grid of the 1U5 tube. A choke coil, consisting of a miniature "Ouncer" transformer, T, with its primary and secondary connected together in series-aiding, is connected in series with the 1U5 plate. The rapid fall of current through this choke, due to the decay ("flyback") of the sawtooth wave, induces a high voltage across the choke. This high voltage then is rectified by the high-voltage selenium cartridge, filtered by R_5 and C_4, and applied to the 1B85 tube. The high-voltage dc may be set exactly to the required level of 900 volts (preferably with the aid of an electrostatic voltmeter) by adjustment of potentiometer R_4.

A separate 1½-volt cell, B_2 is required for the 3A5 filament, since the cathode-coupled circuit in which this tube is used requires that the filament "float" 3000 ohms above ground. B_1 and B_2 are Size-D flashlight cells. B_3 is a radio-type 67½-volt B-battery. •



CIRCUIT 8

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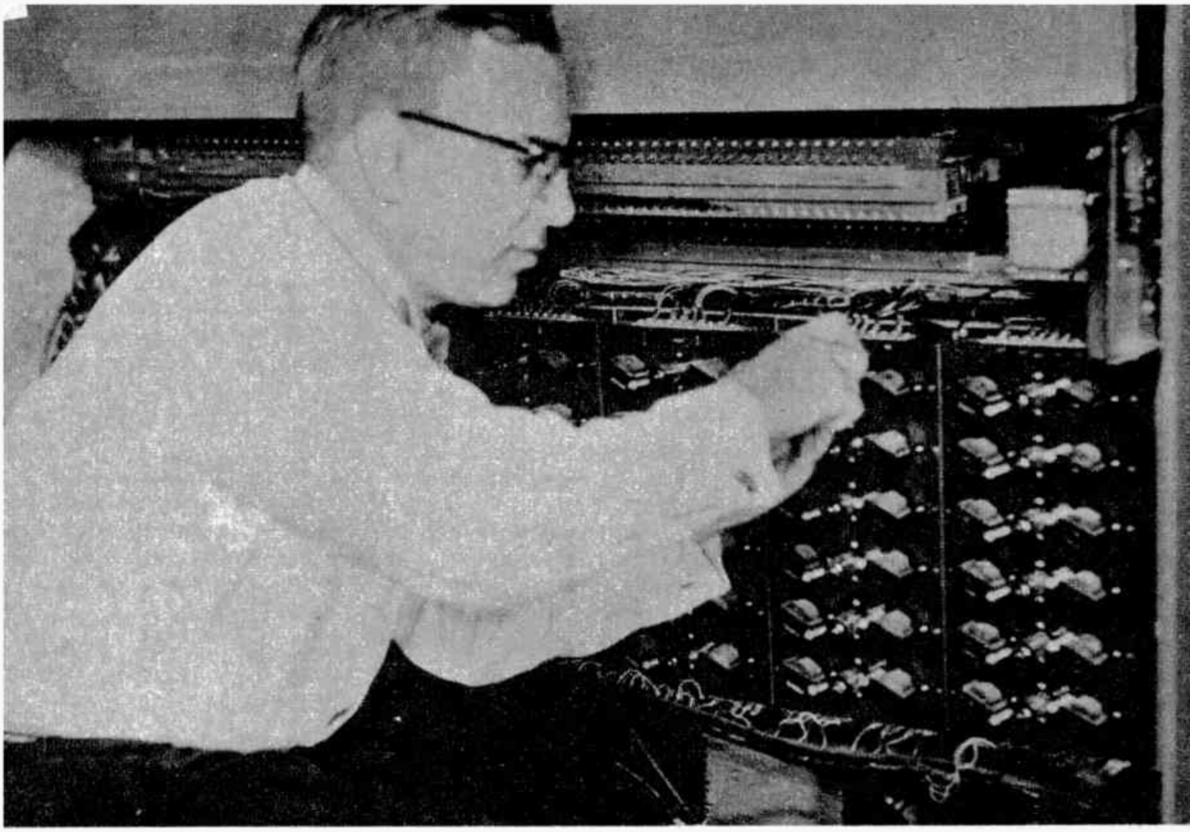

Author Earl Percy makes final adjustments on tone generators of the church organ he assembled himself.

I Built an Electronic Organ for Our Church

By Earl Percy

as told to Robert L. Eby

IT ALL STARTED with a casual remark someone made to me at my office (I am a chemist by profession), that the build-it-yourself fad had really mushroomed. I asked what he meant and was informed that even an electronic organ could be purchased in kit form.*

This aroused my curiosity, as our church (the Rosemead California Ward L.D.S. Church, Los Angeles) was under construction and the members had been considering organs. The hitch so far in the selection had been that the full-sized two-manual models which we wanted were far above our budget. I investigated the organ kit and had a bill of materials drawn up for an installation to meet our requirements. Our organ committee went over the plans, heard some completed installations, and confirmed my opinion that this was the answer to our financial and musical problems.

The assembly at first seemed like a monstrous undertaking, but after trying my hand at a couple of the component units I discovered that the work was not only relatively simple but also lots of fun. Eventually, my problem wasn't to get help but to weed out the many applicants who

* This is the "Artisan" instrument, sold by Electronic Organ Arts, Inc., 4878 Eagle Rock Boulevard, Los Angeles 41, Cal.

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had heard of the project and wanted to lend a hand. The way it turned out, I became so engrossed in the job that I ended up doing most of it myself.

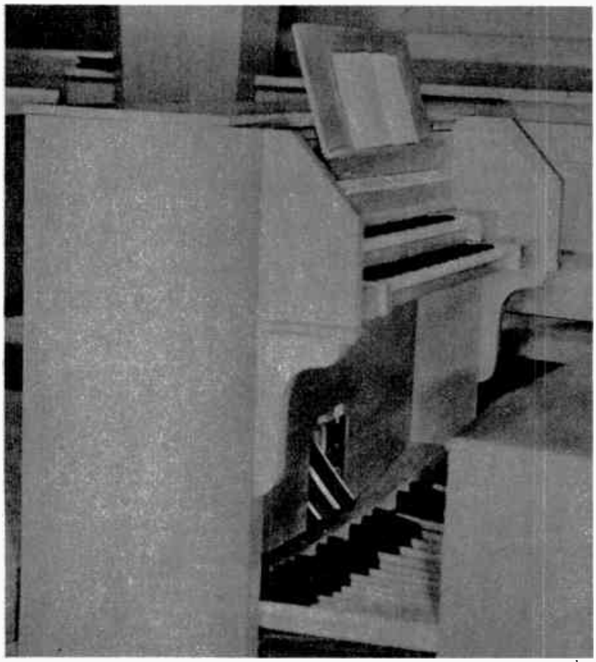
I did the kit assembly on a workbench in a small den in my house. I wired one tone generator kit at a time until I accumulated about a dozen of them. By this time I also had a power supply and an amplifier rigged up, and I began testing the generators, or "notes," as they are called in organ parlance. Surprisingly enough, better than 90% of them worked right away, although this was my first attempt at electronic assembly.

As kits were purchased, they were wired, tested and set aside for future installation in the console. I found that the wiring was simplified by having a workbench of ample height to eliminate stooping, along with a good source of illumination. With the complete and detailed instruction manuals supplied by the manufacturer, no previous electronic experience was required, although on several occasions I called on him for advice.

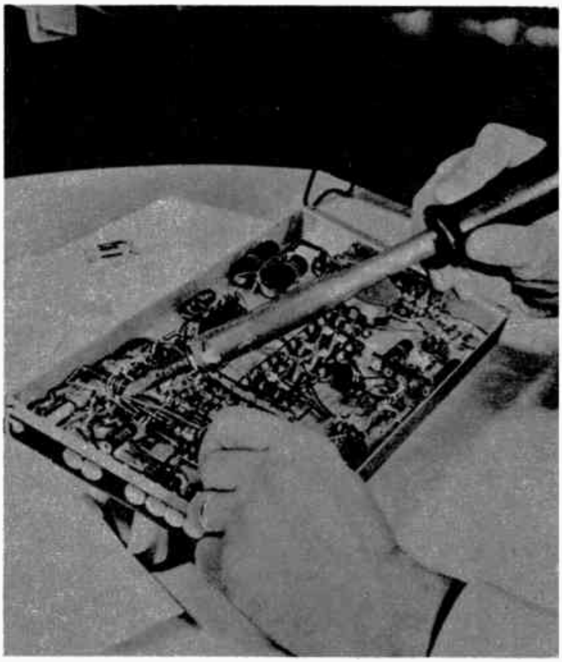
The second stage of the work started the day the console arrived. This was placed in the den at 90° to the wall for easy access to both front and rear. With the manufacturer's suggested layout, I proceeded to mount all the chassis in the console shell. Since no keyboards or pedalboard had arrived, there was plenty of working space for attaching each chassis. This portion of the work was entirely different from the previous in that it involved drilling, sawing and fitting. The particular console we selected was one of the first of its type to come from the factory and required some hand-fitting of the power supplies so they wouldn't interfere with the stop board or cover.

I felt like a monkey, crawling under, over and around the console, night after night. When I assemble another organ (as I certainly hope to for myself) I will set the console up on low horses to eliminate the stooping. After a few bumps on the head and a blister or two from screwdriving, I completed mounting all the chassis.

The organ now began to take on a most imposing appearance. Friends and neighbors, some whom we hadn't seen for a long time, started dropping in, using the organ project as an excuse. So great was the interest that I considered charging admission!



The complete organ, built from a kit, as it appears in the author's church. Assembly is a nut-and-bolt job, and there is much soldering to do.



The individual chassis of the church organ are very much like the amplifiers and pre-amplifiers which are used in high-fidelity sound installations.

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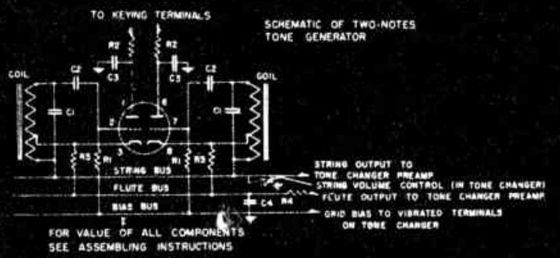
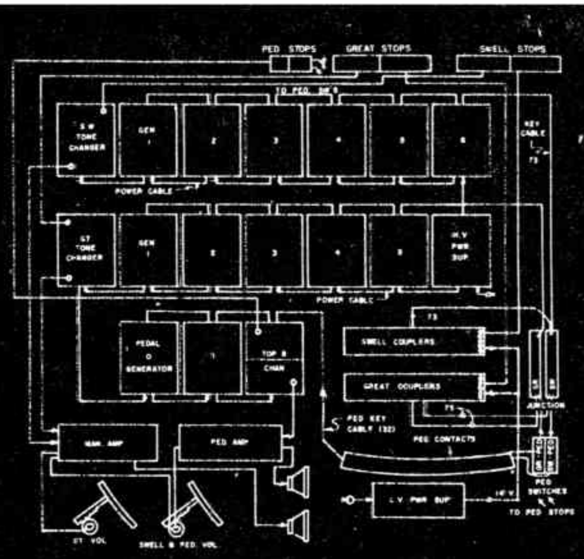


Above is the schematic diagram of an individual tone generator of the electronic organ. Single 12AU7 tube functions as a dual audio oscillator and produces two notes of different frequency.



At right is a block diagram of a typical Artisan electronic organ installation. Various musical tones are created in tone generator, which are merely audio oscillators, amplified by powerful amplifiers, projected by a bank of loudspeakers.

Some were quite enthusiastic and complimentary, but many were skeptical, saying they'd bet a turkey dinner that no music would come out of that array of gadgetry.

Then came the next stage of the work, wiring and installing the manuals and pedals. By this time I had acquired a certain technique in handling a soldering iron. Having successfully completed hundreds of joints in the various chassis, I thought I knew how to solder. However, the procedure in wiring the key and pedal contacts required an entirely new approach. First of all, I had to forget my big 100-watt iron. I obtained a little 35-watt model, much like a large pencil, and after a little practice found the right combination of heat and solder to make the wiring quite easy.

With a keyboard upside down in front of me, the junction board to my left, and a spool of No. 28 wire within arm's reach, I felt very much like a weaver operating a loom. One at a time, each wire was pulled through improvised guides to the proper contact, wrapped one turn, soldered and cut. Gradually the cable grew until it contained 73 wires. I knew then that this manual was completed, and I moved on to the other.

Since the pedal contacts were installed inside the console, they had to be wired while I was on my knees. With the help of some pillows, I managed to get this cable installed with only a slight burn, when I picked up the iron without looking.

With the cables finished and connected to their proper terminals, I stood back and studied my handiwork. I knew the time must come when I would turn on the power. What manner of noise, smoke or fire would issue forth? Would I be the laughing stock of the neighborhood? Would the church music committee turn down my efforts? I had a lot of time at stake—no use wasting any more—so on went the power.

Strangely enough, no noise—no smoke—no fire—in fact, nothing. Somehow I had reversed the wiring on the two paralleled power supplies and had blown both fuses. With this error rectified, the tubes started to glow throughout the entire console. After a warm-up period, I depressed some stop tablets with one hand and held some keys with the other. The sounds that came forth could hardly be called music, but they were music to my ears. The fact that most of the keys and stops played at all meant that the perfected product was not now far away.

Tuning or "voicing" the organ was a most interesting and educational part of the project. I learned how to use tuning forks to lay the temperament; how to tune other octaves to this master set; how to adjust the relative volume of the flute and string divisions; and most interesting of all, how to regulate the tone of individual stops. The Artisan organ is so designed that the builder can adjust almost any voice to his own tastes. Whether he prefers popular, classical or a mixture of both, he can get the desired tone quality and vibrato with adjustments supplied with the kits. Since this organ was to go into a church auditorium, it followed that the voicing should be on the church-organ side. Some of this adjusting was done while the organ was at my house, but the final voicing was done after the console was installed in the church.

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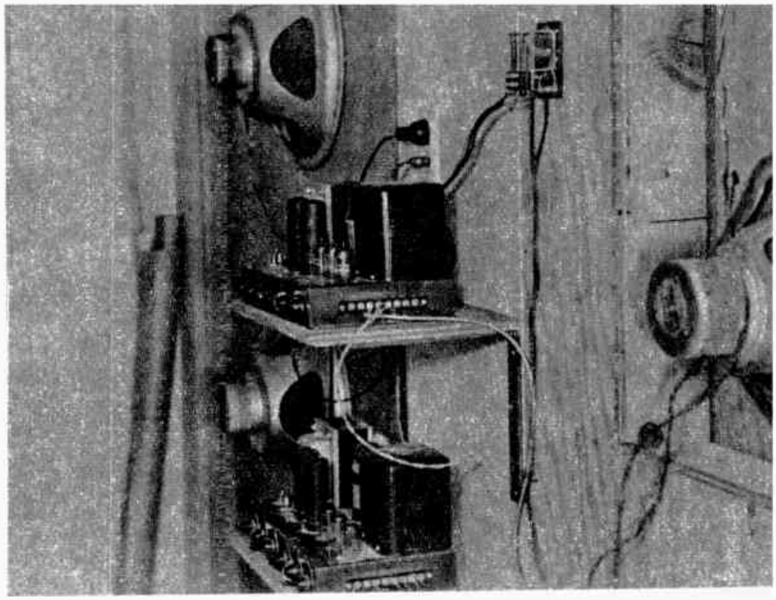

This is a view of main power amplifiers and some of loudspeakers of electronic organ.

On the day I moved the console, I got the help of the neighbors and with a rental trailer managed to transport everything to the choir loft. Cables had already been installed between the console location and the organ chambers where the loudspeaker system would be. The plywood baffles had already been installed by carpenters, so my task was to cut a hole for each speaker and mount the amplifiers and speakers in their correct positions.

Following a block diagram included in the kits, I attached the various audio and power lines. This phase of the work was complicated by the presence of dozens of curious church members who either simply wanted to watch my every move or who suddenly became experts and insisted on giving free advice. Strangely enough, those who had the most to say had never had any previous experience installing an electronic organ. Then there were those who were most helpful in assisting in the dozens of little steps involved in such a project. With these willing helpers the installation was completed, ready for the final step of voicing.

With the console volume control pedals "wide open" I gradually increased the amplifier gain until the sound level in the church was ample for the loudest organ passages. I also adjusted the various tone balancing controls in the console and at the amplifiers so the low tones were well balanced with the high notes. Although this phase of the finishing was entirely new to me, I found that by placing most of the controls in a neutral position the tonal balance was quite satisfactory. This regulating took us several Sundays, as adjustments made with the room empty were found to require changes when the room filled with people.

There were, of course, the usual number of "bugs" to be removed, as would be expected in a complex electronic device of this type. A few dead notes were found to be caused by poorly soldered connections or a key contact not properly spaced. Most of the problems encountered could be traced to my inexperience. I don't believe I will repeat the mistakes when I build another organ, for my own family.

How much time did the project take? I didn't keep an accurate record, but I would say about 90 days at an average of two hours per day. I could probably do better on a second organ. Certainly, a person with some previous experience in kit construction can beat my time. I wasn't out to set a record; I wanted to be sure of my work.

In the way of tools employed, this involved the usual hand tools found in any hobby shop: good soldering irons, long-nose pliers, wire cutters and screwdrivers.

It is certainly of interest to consider the financial savings involved. The organ I assembled for the church was of average size and cost just over $2,000, in kit form. It contains 165 independent oscillators, nineteen speaking stops and fourteen couplers, and compares favorably with factory-built instruments ranging in price from $4,000 to $7,000. This financial saving was not the only factor which led to our selection. The fact that the console and bench were available in a wood to match the rest of the church's furniture was a consideration. •

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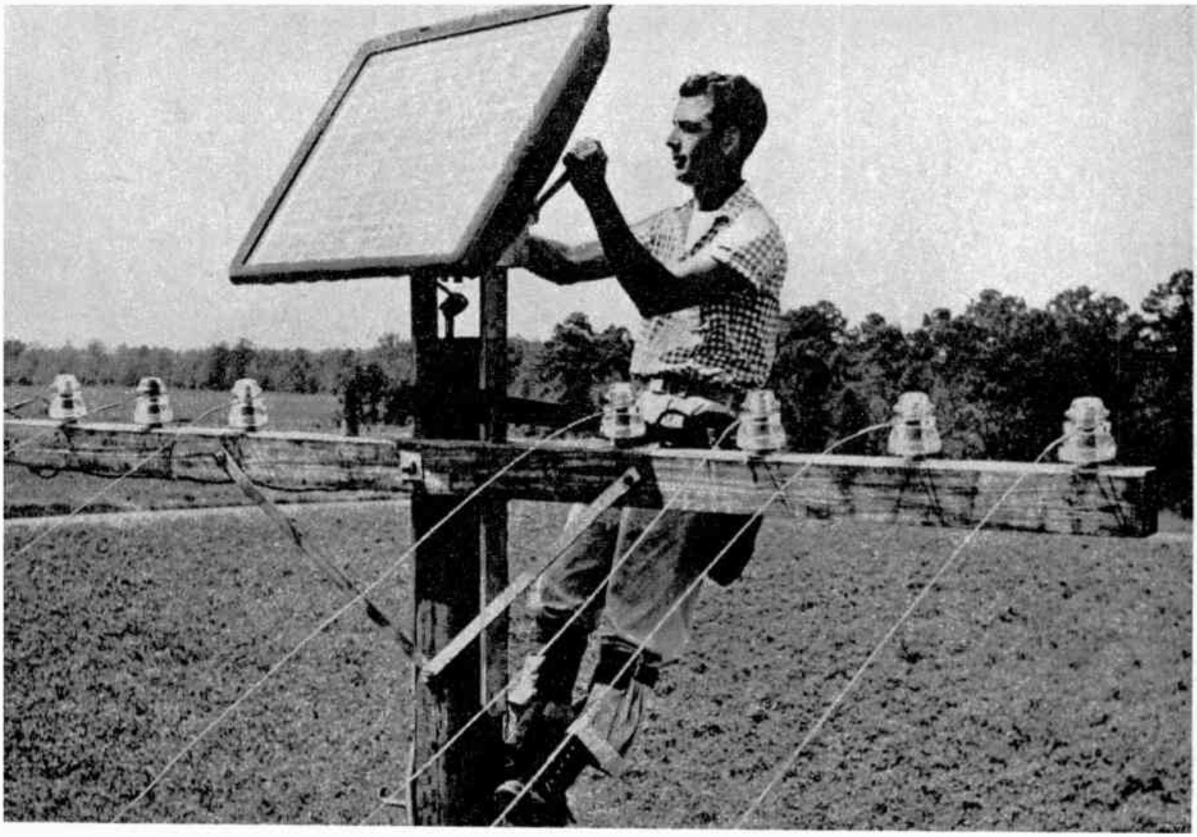

Actual installation of Bell solar battery atop telephone pole near Americus, Georgia. It is being adjusted to best catch sun's rays. The grid of wires, hazily seen along top edge, is lightning discharger.

And Now...

Sunpower Put to Work Electronically

Already in use experimentally, a new silicon battery converts solar radiation into electricity with unparalleled efficiency.

THE SUN is the ultimate source of all the power which man has at his disposal. The conversion of solar radiation directly into electrical power by some cheap and efficient means has been sought for several decades. Many different methods have been tried for the purpose, but none of these can compete pricewise with conventional fossil fuel or hydroelectric power plants. Until recently the efficiency figures were very discouraging. Within the past two years, however, a major improvement in efficiency by one particular method has been achieved, thus reviving interest in this important field of research.

The three most successful devices for converting solar radiation directly into electrical power, listed in the historical order of their inception, are the thermopile, the photogalvanic cell and the barrier layer photovoltaic cell.

The thermopile is an outgrowth of the pioneer investigations of T. J. Seebeck beginning in 1823. He found that an emf* is developed in a circuit containing two separate conducting materials when the junctions are held at different temperatures. In a solar energy converter it is therefore the heat generated by the radiation that produces the electrical output. A modern design of thermopile has been made to operate at an overall efficiency of about 1 percent in converting solar radiation into electrical power. This value is plotted in Figure 1 together with the efficiencies ob-

* "electromotive force," or voltage

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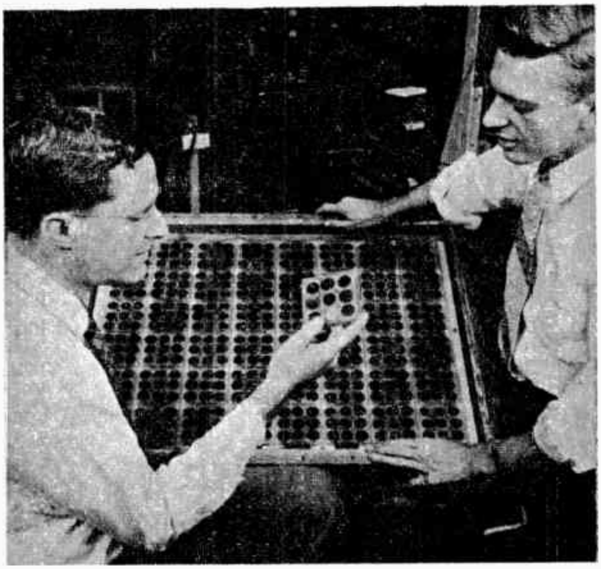
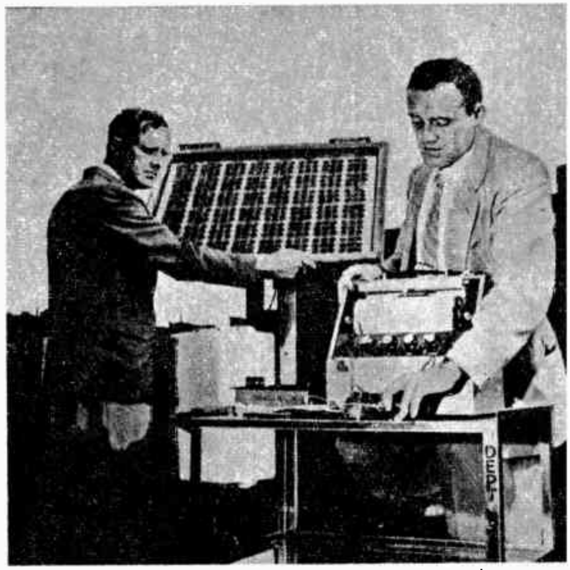
At left below, a solar battery for experimental use on a rural telephone line is assembled at the Bell Telephone Laboratories, where it was invented. The device uses wafer-thin discs of silicon, about the size of quarters, 9 to a unit. A yard square, the battery contains 432 cells. Scientists, at right, take advantage of a hot day to measure output. As you will see in Fig. 7, current is strongest at noon.





tained from the other converters (page 28).

The photogalvanic cell was first described in 1839 by A. E. Becquerel in a paper entitled "On Electric Effects Under the Influence of Solar Radiation." This device consists of two electrodes immersed in an electrolyte and produces an emf when light falls on only one of the two electrodes. The highest efficiency obtained from this type of cell is somewhat less than 1 percent.

The barrier layer photovoltaic cell is a true solid state device and was first developed around 1876 using selenium as the light-sensitive material. Selenium photocells are widely used in present day industry for such diverse purposes as photographic exposure meters, photo switches and photoelectric eyes. They have an overall conversion efficiency of about 0.6 percent when operated in direct sunlight.

The three devices mentioned above summarize the situation as of 1953. The thermopile ranked highest with a conversion efficiency of about 1 percent. In 1954, D. M. Chapin, C. S. Fuller, and G. L. Pearson of the Bell Telephone Laboratories announced that they had succeeded in raising the efficiency of the photovoltaic cell to 6 percent through the use of silicon prepared in a special manner. Since that time further improvements have been accomplished, and the efficiency has been raised to 11 percent. This is an order of magnitude higher than the best previous devices and makes the use of this type of solar energy converter a distinct practical possibility. For example, the solar energy falling on a square meter of the earth's surface at Phoenix, Arizona, on a clear day, is about 1,000 watts, and a silicon photovoltaic cell of this area would have an electrical output of about 110 watts.

Editor's Note: The material on pages 26 through 31 is excerpted from a paper entitled "The Silicon Solar Battery", presented by Gerald L. Pearson, of the Bell Telephone Laboratories, Inc., at a recent meeting of the American Association for the Advancement of Science.

Principles and Construction of Silicon Solar Cells

The heart of the new silicon solar cell is the p-n junction formed near the front surface of a plate of silicon, one of the most common chemical elements on the face of

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Popular application of older type "solar battery" is represented by photographer's exposure meter. A light-sensitive cell generates minute current which registers on microammeter. Scale of latter is calibrated in lens openings and shutter speeds.

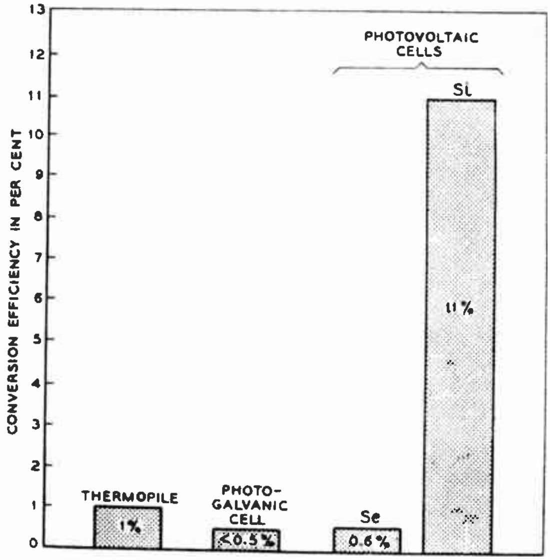

Fig. 1. Relative efficiencies of various devices for converting sun's rays to electrical energy.

the earth. Figure 2 indicates the fundamental principles of a p-n junction.

Electric conduction in silicon can take place by negative charges (electrons) or positive charges (missing electrons which we call holes). We label these two types of conductors n-type and p-type respectively. If in a single crystal of silicon one part is p-type and another part n-type, the location at which the two parts meet is called a p-n junction. Silicon, which appears in the fourth column of the periodic table, is a near insulator at room temperature when it is chemically pure. If a small amount of some element from the fifth column, such as phosphorus or arsenic, is added to it as an impurity, an n-type semiconductor with electron conduction is obtained. If, on the other hand, a small amount of some element from the third column, such as boron or gallium, is added to it as an impurity, a p-type semiconductor with hole conduction is obtained. So much for the definition of n- and p-type silicon.

In the construction of silicon solar cells, the raw materials are silicon and arsenic. The silicon is in crystalline form and is extremely pure. Only a very small amount of arsenic is required, the ratio being about 1 part of arsenic per million parts of silicon. These two raw materials are melted together, and a large single crystal ingot of arsenic-doped silicon is pulled in the second step. The ingot is n-type because of the arsenic impurity. In step 3 the crystal is cut into thin wafers with a diamond cutting wheel, the final dimensions being about 2½ inches in length, ½ inch in width, and 1/25 inch in thickness.

In the fourth step, which is the most important of all, a thin layer of p-type silicon is formed over the entire surface of the n-type wafer, thus providing a p-n junction just where it is wanted. This is accomplished by placing the wafer in a quartz tube containing vapors of boron compounds. The assembly is then heated between 1000 and 1200°C for a specified time in an electric furnace. During this treatment, boron atoms are deposited on the silicon surface and diffuse inside to make the thin p-type skin. The thickness of this skin can be regulated through control of the heating cycle, and experience shows that good solar batteries are obtained when the p-n junction is about 1/10,000 of an inch below the surface. After cooling, the p-layer is removed from the back surface and lead wires are connected to the p-layer on the front surface and the back of the slab, which is now n-type. The silicon p-n junction photovoltaic device is now completed and can be made to deliver electrical power by merely illuminating its front surface.

Figure 4 has been prepared to answer the question: "How does a solar battery work?" Now, light consists of individual

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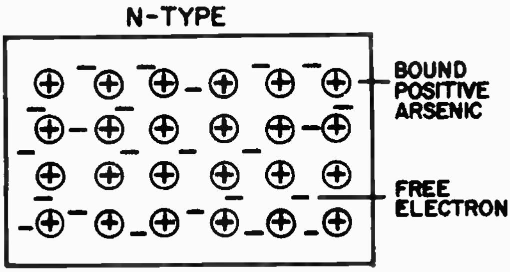
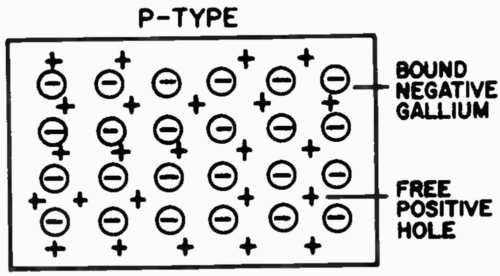
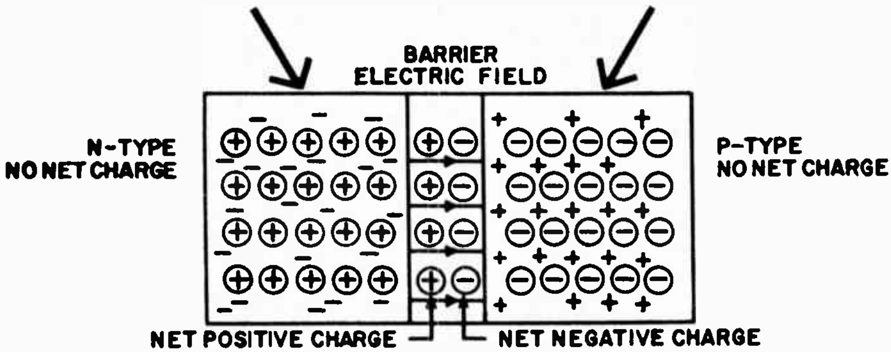
Fig. 2. Operating principles of the p-n junction.



N-type, or electron-rich silicon is made by adding minute traces of an element like arsenic to silicon. From each arsenic atom that is added, one electron (unit negative charge) detaches itself, thus becoming free to move, and leaves behind the arsenic atom with unit positive charge bound into the crystal structure. Thus, n-type silicon consists of silicon to which is added equal numbers of free electrons and bound positive charge, so that there is no net charge.

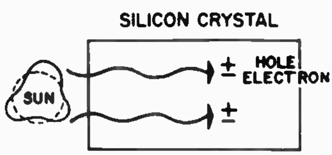


P-type, or hole-rich silicon is made by adding minute traces of an element like gallium to silicon. For each gallium atom that is added one hole (unit positive charge) detaches itself, thus becoming free to move, and leaves behind the gallium atom with unit negative charge bound into the crystal structure. Thus, p-type silicon consists of silicon to which is added equal numbers of free positive holes and bound negative charge, so that there is no net charge.

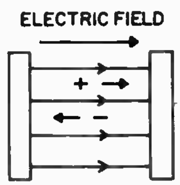


When p-type silicon and n-type silicon meet at a junction, the free holes and free electrons try to intermix like gases. However, the holes which enter the n-type material disappear and leave behind negatively charged gallium atoms, and the electrons which enter the p-type material disappear and leave behind positively charged arsenic atoms. These fixed charges constitute an electrical barrier, or field, which prevents the rest of the holes in the p-side and electrons in the n-side from intermixing.

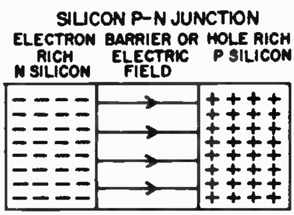
Fig. 3. How the Bell solar battery works.



Light is absorbed in a silicon crystal by liberating free-to-move negative charges, called electrons—and free-to-move positive charges, called holes.

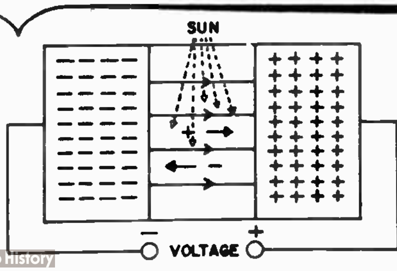


An electric field exerts a force on charged particles causing them to move if they are free. The force moves holes in one direction and electrons in the opposite direction.



In a thin barrier at the junction between an electron-rich n-region and a hole-rich p-region in a silicon crystal, a strong built-in electric field exists which keeps the electrons in the n side and holes in the p side.

When light is absorbed liberating electrons and holes in the barrier region at a p-n junction, the built-in electric field forces the holes into the p-side, making it positive, and the electrons into the n-side, making it negative. This displacement of the newly-freed charges causes a voltage to appear between the ends of the crystal, a voltage that is a source of electrical power. Thus light energy is converted into electrical energy.



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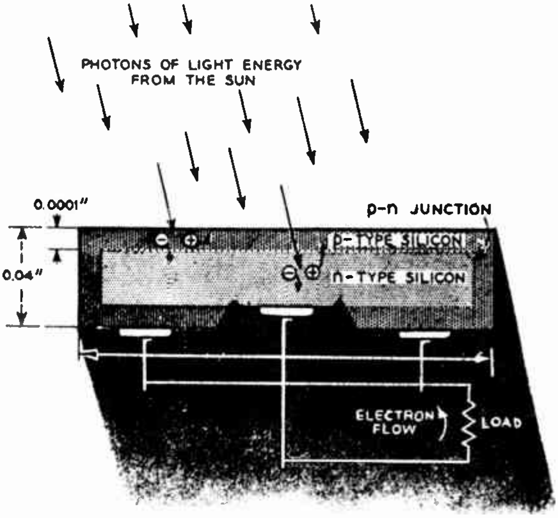

Fig. 4. Cross-sectional view of a silicon p-n junction solar cell, illustrating the creation of electron-hole pairs by photons of light energy.

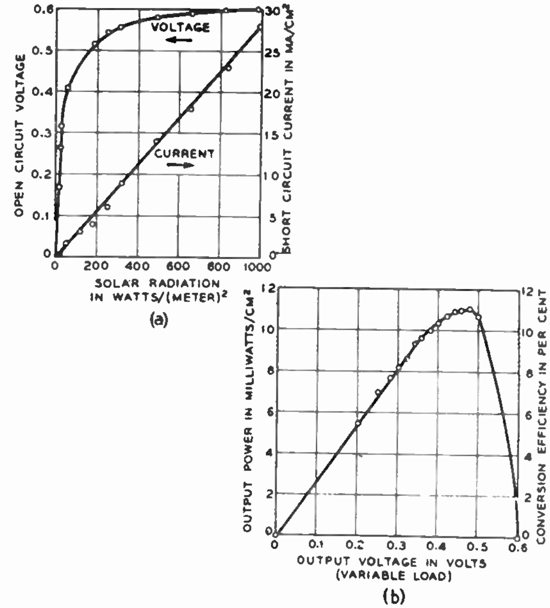

Fig. 5. Electrical characteristics of a silicon p-n cell at an operating temperature of 17° C.

corpuscles of energy called photons, and the amount of energy in a photon is inversely proportional to its wavelength. When light is absorbed in a silicon crystal, those photons having sufficient energy liberate a free-to-move negative charge and a free-to-move positive charge or, in technical terms, they expend their energy in creating a hole-electron pair. In a solid ingot of silicon where no electric field is present, these hole-electron pairs recombine in a matter of few microseconds before they can be made to do any useful work. If, however, an electric field is applied to the ingot, a force is exerted on the charged carriers and the free ones move. This force moves holes in one direction and electrons in the opposite directions. Once separated, the charged carriers can be made to do useful work.

In a p-n junction such as described above, there is a permanent built-in electric field. This is indicated in the upper right-hand portion of Figure 3. At the junction between the electron-rich n-region and the hole-rich p-region there is a strong built-in electric field which keeps the electrons on the n-side and the holes on the p-side. When light is absorbed in this region, as shown in the lower part of the figure, electron-hole pairs are produced, and the built-in electric field forces the holes to the p-side and the electrons to the n-side. This displacement of the newly-freed charges causes a voltage difference between the ends of the crystal, the p-region being plus and the n-region minus. In full sunlight each cell in a solar battery produces an open circuit voltage of about 0.6 volt. When a load is connected to the terminals, this potential difference causes an electric current to flow, and thus light energy is converted into electrical energy.

Figure 4 is a cross-section view of a silicon p-n junction solar cell. The center part is n-type and the outside p-type skin forms a p-n junction about 1/10,000 of an inch below the surface. Photons of light energy from the sun produce hole-electron pairs near the junction. The holes are collected at the surface and the electrons drift to the center. When a load is connected at the terminals, an electron current flows in the direction shown by the arrow.

Photoelectric Characteristics of Silicon Cells

Figure 5 gives the electrical characteristics of a silicon solar cell as fabricated by D. F. Ciccolella and measured by E. J. Stansbury. These data were taken when the solar radiation was 1000 watts/(meter)^2 and the ambient temperature was 17 degrees centigrade. It can be seen that the short circuit current is directly proportional to light intensity and that in full sunlight amounts to 28 ma/cm^2.* The open circuit voltage rises sharply under weak light and saturates at about 0.6 volts for radiation between 200 and 1000 watts/(meter)^2. This characteristic is particularly advantageous when solar cells are used as trickle chargers of storage bat-

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teries. Figure 5B gives the variation in power output from a solar cell irradiated by full sunlight as its load is varied from short circuit to open circuit. The maximum power output is about 11 milliwatts/cm[2] at an output voltage of 0.45 volt. Under these operating conditions the efficiency is 11 percent. That is, the electrical power dissipated in the load is 11 percent of the total radiant energy subtended by the cross section of the cell. The output power as well as the output current is, of course, proportional to the irradiated surface area, whereas the output voltage can be increased by connecting cells in series just as in an ordinary chemical storage battery.

The spectral relationships in the silicon solar cell are more easily understood by referring to Figure 6. Wavelength in microns is plotted horizontally and the insert indicates the visible part of the spectrum as well as the ultraviolet and the near infra-red regions. Curve A represents the distribution of solar energy among the various wavelengths relative to an arbitrary maximum of 1.0 and was taken from published meteorological data. Curve B shows the relative number of photons in solar radiation and was derived from Curve A simply by multiplying by the wavelength. Curve C is the measured short-circuit response curve of a typical silicon solar cell.

Applications of Silicon Solar Batteries

The first experimental application of the silicon solar battery is its use as a primary power source in connection with a rural telephone system. The general arrangement of this project, which was engineered by the power development group at the Bell Telephone Laboratories for a trial at Americus, Georgia, is shown in the accompanying photos (p. 26-7). An array of silicon cells, 432 in all and capable of furnishing 9 watts of electrical power in bright sunlight, is mounted at the top of a pole. This primary source of power serves as a trickle charger for a 22-volt nickel-cadmium storage battery (mounted near the base of the pole) which in turn powers an all-transistor carrier amplifier. The electrical energy derived from the sun during daylight hours should be sufficient to keep the storage battery charged for continuous operation of the amplifier no matter how inclement the weather.

Figure 7 is a plot of the charging current from such a solar battery on August 21, 1955, while mounted on the roof of the Bell Telephone Laboratories building at 463 West Street, New York City. This indicates a peak charging current of about 0.35 ampere into the 22-volt storage battery at noon-time. Charging current continued from 6 AM to 6 PM, and the total accumulated charge during the day was 2.4 ampere-hours.

A word of caution. Although the silicon solar battery is more efficient than the best previous device for converting solar energy directly into electricity and although I have described some promising communication applications, it should be realized that this new power source is still an experimental device.

* Milliamperes per square centimeter

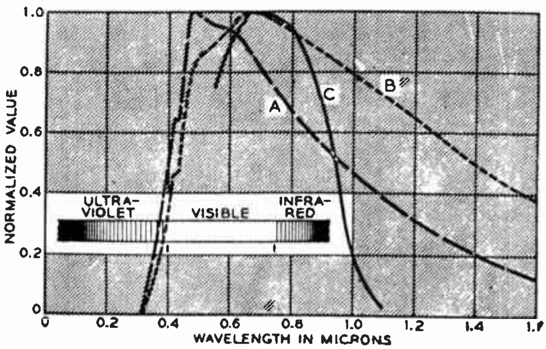

Fig. 6 (diagram directly above). A—solar energy distribution; B—solar photon distribution; C—short-circuit response, of the silicon solar cell.

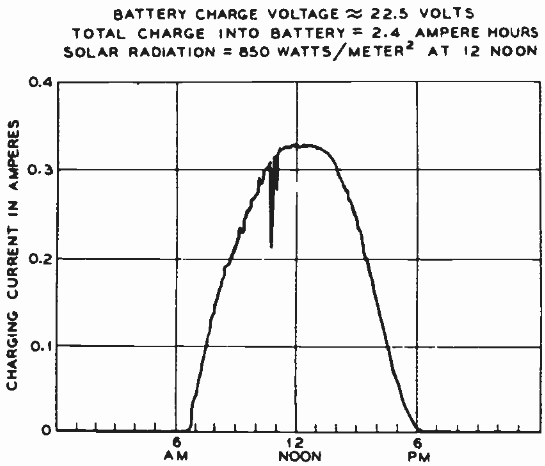

Fig. 7 (at right). How the current from a solar battery varies with time of day. As expected, it is highest at noon, when the sun is strongest.

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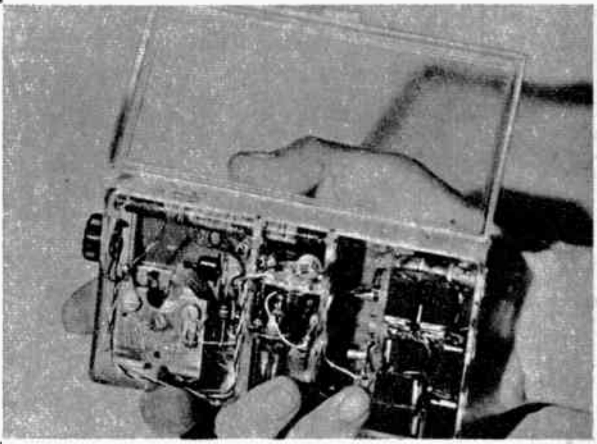
This one has its place in the sun, and in darkness, too! Edward Keonjian, General Electric engineer, demonstrates it—an experimental sun-powered broadcast receiver. Tuning knob is on front surface; volume control on end.

The GE experimental solar-powered receiver is a conventional transistorized superheterodyne. A midget storage battery is in center, 7 selenium "sun batteries" at right. Receiver works on only 1 milliampere at 1½ volts, which is supplied by solar batteries in daylight, by storage battery at night. The transparent plastic case enables light to energize the sun batteries at all times.



Care to make your own solar-powered equipment? "Sun Battery," used in the GE set, is available at radio parts stores: the type B2M, made by International Rectifier Corp. of El Segundo, Cal., is packaged as shown. Unit is about ½ by ¾ in. by ⅛ in. thick, and has small mounting brackets, pig-tail leads. Depending on use, output varies from about 60 microamps to 2 milliamps. Nearly any number can be connected in series or series-parallel combinations. Uses: light measurement, headlight dimming, garage door openers, etc. Price: about $1.50.

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Admiral portable receiver, in attractive case, left of photo, works on its own batteries or on separate "Sun Power Pak." Latter is sold as an optional accessory.

Solar-Powered Radio Receivers

A pocket-size solar-powered radio receiver, weighing only ten ounces and capable of working more than eight months in total darkness without recharging, has been developed by the Advanced Circuits Sub-Section of the General Electric Electronics Laboratory at Syracuse, N. Y. This is a purely experimental unit and is not being considered for production, at least not yet, because of the relatively high cost of the required solar batteries.

The G-E solar receiver will operate continuously in daylight and will run 500 hours in darkness without recharging. If used at the rate of two hours a day, which is considered normal usage for a portable radio, it would work for a minimum of 250 days in absolute blackout.

Long operation in total darkness is made possible by the use of a miniature storage battery which is contained in a transparent plastic case along with four transistors, seven solar cells and other components. The case is 5½ inches wide, 1¼ inches thick and 3 inches high.

The present size makes it convenient for the user to place the receiver in a suit pocket and to hear programs with a miniature ear-plug. The size could be cut in half, G-E said, by substituting sub-miniature components now in existence which were unavailable when developmental work was being conducted.

The Company said the primary benefit of solar power over other power sources, as demonstrated in the new equipment, is that there is no necessity for battery replacement. Transparency of the case permits battery-charging by simple exposure of the unit to the sun's rays.

Under normal daylight conditions, light rays strike the selenium cells which convert solar energy to electrical current. The electrical energy travels directly to transistors in the daytime, powering the receiver. Simultaneously, the miniature storage battery builds up a supply of energy to be employed when sun-power is lacking.

Artificial light, such as a lamp containing a 100-watt bulb, may be used instead of sunlight. Smaller artificial sources, such as matchlight or candlelight, do not provide the necessary light power.

The Admiral Corporation, of Chicago, has announced a commercial sun-powered portable. Actually, this is a regular six-transistor receiver, normally energized by six standard flashlight batteries. The "Sun Power Pak," which contains 32 silicon cells, is available as an optional accessory, and when it is plugged in the dry batteries are cut out of the circuit and allowed to rest. Indoors, the light from a 100-watt lamp is sufficient to activate the cells.

The receiver itself has the nominal list price of $59.95. But here's the catch: the Sun Power Pak is priced at $185! So that you won't think this is a typographical error, the figure is repeated: one hundred and eighty-five dollars. Obviously, Admiral doesn't expect to sell many of these, but at least the firm is showing that it is abreast of technical developments! •

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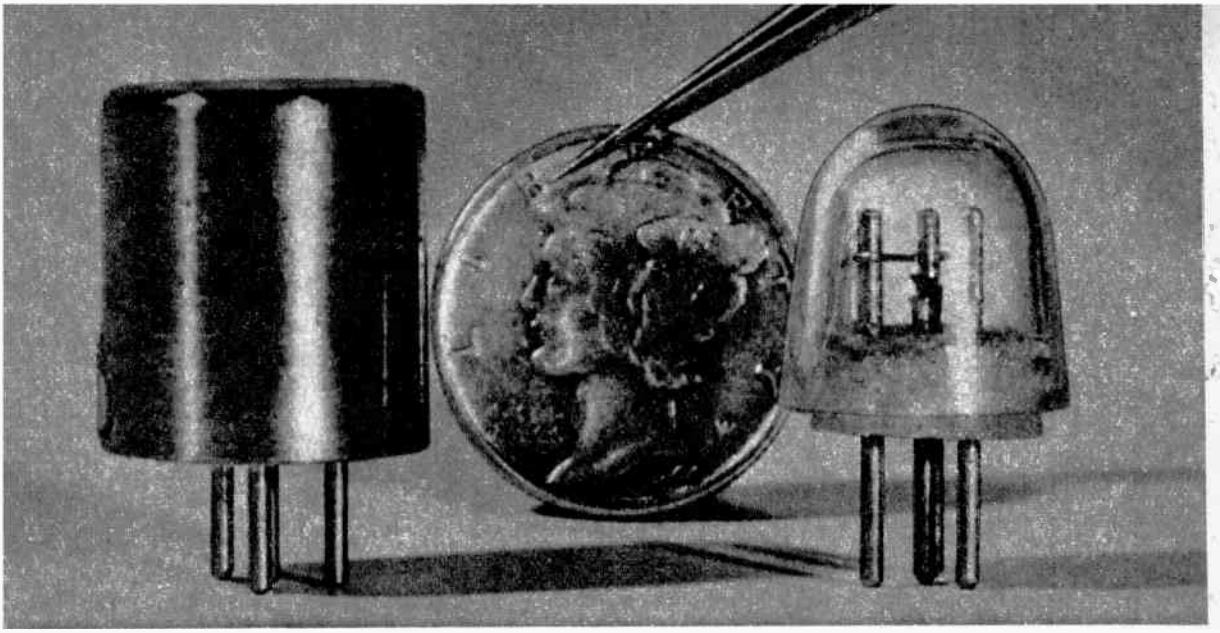

These are laboratory models of silicon (left, with brass cap) and new germanium (right, in glass) transistors announced by the Bell Telephone Laboratories. The dime in center gives size comparison.

Transistors:

Better and Cheaper

WITH THEIR RELIABILITY increasing and their prices dropping, transistors are finding more and more applications in a wide range of electronic equipment. Because of their small size and very modest battery requirements, they are especially popular for use in pocket-size radio receivers, hand-carried "portables," hearing aids, etc. Some models of transistorized auto sets have been made, but these are not yet "commercial" because manufacturers are afraid of what will happen to the heat-sensitive transitors in a closed car left parked in the sun on a summer day. The feature of transistors that makes them especially desirable for car use is their ability to work directly off a 12-volt storage battery, without requiring a vibrator-type high-voltage supply. This is important, inasmuch as fully 95% of all car-radio repairs involves faulty vibrators.

New High-Frequency Transistor

From the Bell Telephone Laboratories, where the transistor originated, came news recently of new fabricating techniques for an entirely new kind of transistor. These techniques will have far-reaching effects on the manufacture and use of the tiny amplifier, particularly in the telephone and television fields and in other jobs, too. What is unusual about the new Bell transistor is its effectiveness as an amplifier at the very high frequencies employed for communication and TV purposes.

Key to the new fabricating techniques is the development of controls over microscopic chemical layers. The heart of the new transistor is a layer 50 *millionths* of an inch thick. The new techniques involve the adaptation of the chemical process of "diffusion" used in treating silicon for the Bell Solar Battery, first device to convert sunlight into substantial amounts of electricity. Diffusion is a process by which minute amounts of impurities are introduced in controlled amounts into a material.

The transistor consists of a three-layer chemical "sandwich." The center layer is known as the "base." The other two are the "emitter" and "collector" layers. The narrower the base layer can be made, the higher the frequency at which it will operate. Diffusion provides a high degree

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C. A. Lee, Bell Telephone physicist, peers into vacuum oven and adjusts gauge to determine the temperature in diffusion chamber where the new germanium transistor is made. Tiny impurities give the material unique electronic properties.

A Bell Laboratories technician performs one of the operations in making new germanium transistor. Here electrical contacts are made to germanium by vaporizing a metal onto the surface of the material. Later on, wire leads are attached.

of control of such microscopic dimensions.

Because of its very high frequency characteristics, the new transistor appears to be ideally suited for application in guided missiles and electronic "brains."

Color television sets offer a possibility for the new transistor, too. Although vacuum tubes are now doing this job, the new transistor is much smaller, requires less power, and does not heat up like a tube. It is expected to have a longer life than a vacuum tube.

C. A Lee, of Bell Laboratories, is chiefly responsible for perfecting the techniques with germanium. C. S. Fuller and M. Tanenbaum have applied the diffusion technique in making the new transistor from silicon. William Shockley and George C. Dacey were instrumental in directing work that led to the development.

Transistor performance has been measured in two principal ways. One criterion has been the number of oscillations or self-generated electrical pulses per second. A second criterion, considered by Bell scientists to be more significant, is the number of voice or communication channels that can be amplified. In this latter category, they report that the new transistor is unequaled.

Experimental units of the device made at Bell's Murray Hill, N. J., laboratories have amplified by 100 to 1 currents across a 20,000,000 cycle (20 megacycle) wide band. Either the amplification or the number of communication channels can be made three times that of any other transistor. The number of communication channels or pathways varies with the degree of amplification.

In considering the practical application of transistors, engineers are concerned with what they call the "frequency cut-off." This is the frequency point up to which there is straight, full amplification of a signal and after which the signal is amplified with steadily diminishing strength.

Currently available transistors have a frequency cut-off of 1-10 megacycles, and several recently announced transistors have had a frequency cut-off between 100 and 200 megacycles. Thus far, the new transistors have been found to reach a cut-off between 500 and 600 megacycles.

In making the new transistor, an impurity must be introduced only once into the growing crystal. The fully grown crystal receives two other doses of impurity in the easily controlled diffusion process, which is more precise than the older "double-doping" and alloy processes. Both of these processes require control, at very high temperatures, of the boundary between liquid and solid germanium or silicon, in order to determine the dimensions of the base layer. •

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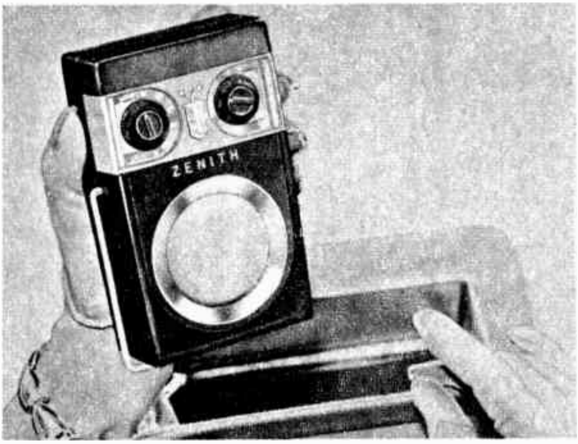
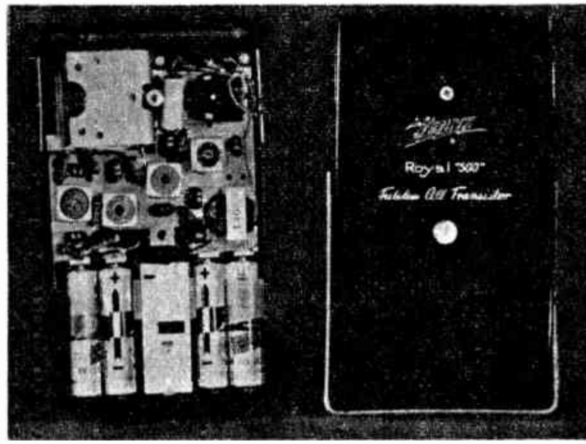
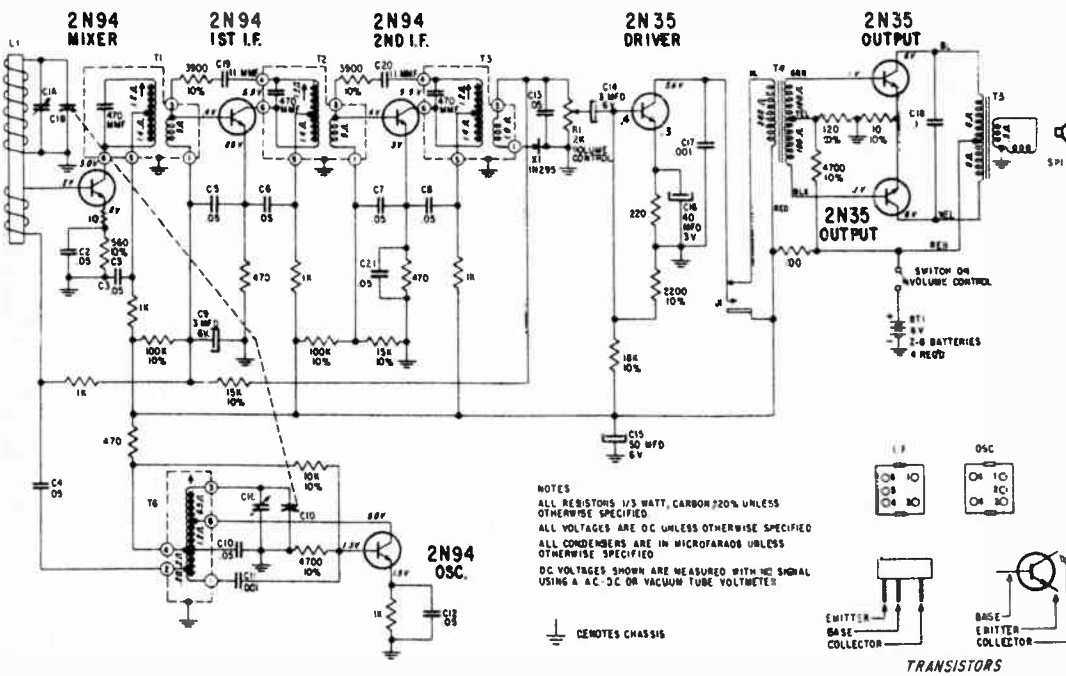




Not much larger than a king-size package of cigarettes, the new Zenith Royal 500 pocket radio (above left) owes its compactness to its all-transistor circuit. Loudspeaker is represented by round plate at bottom. For "private" listening, a hearing-aid type earphone can be plugged in. When the back plate of the Royal 500 is removed (above right) the four penlight batteries can be seen at bottom. They provide all needed energy. The miniature set uses seven transistors and needs no tubes at all.

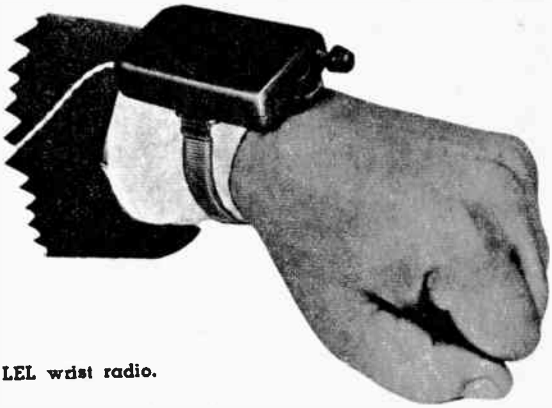


Here is complete schematic diagram of Zenith all-transistor portable. Earphone plugs into jack J1, between the 2N35 transistor and audio transformer T4. The output stage uses two 2N35's in push-pull.

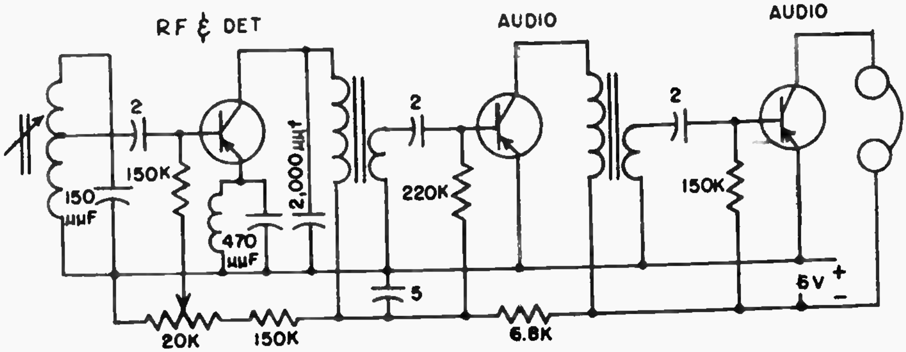
World Radio History

MORE TRANSISTOR DEVELOPMENTS

Shades of Dick Tracy! This factory-made wrist radio weighs only 2½ ounces. It has a three-resistor circuit, built-in aerial, hearing-aid earphone. Yields good reception up to 25 miles from stations, over greater distances with "outside" aerial from 6 inches to 3 feet long. Its dimensions: 2¾x1¾x34 inches. LEL, Copiague, Long Island.



Schematic diagram of the LEL wrist radio.



New CBS all-transistor home radio (below right) can be played anywhere in house or outside without plugging into electrical outlet. It contains six transistors and a battery pack good for about 1,500 hours of normal listening. Slide-rule dial on top of case can be tuned from either side. The 9-inch oval loudspeaker provides excellent tone quality. Stand is an accessory; receiver is portable. For the benefit of electronic experimenters and hobbyists, Sylvania offers a kit (below right) containing two transistors, a crystal diode, 48-page book of instructions. Available from radio parts jobbers.

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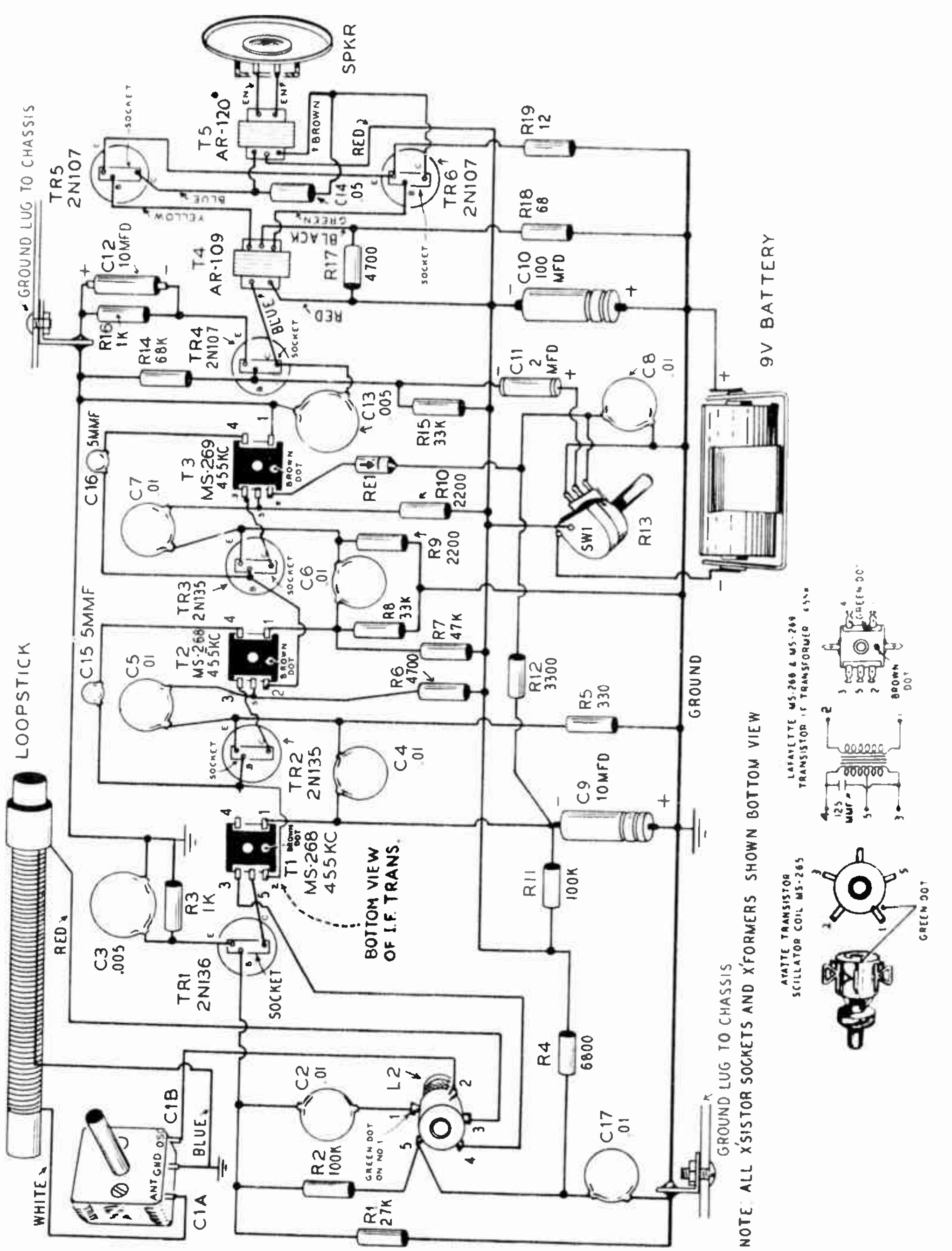
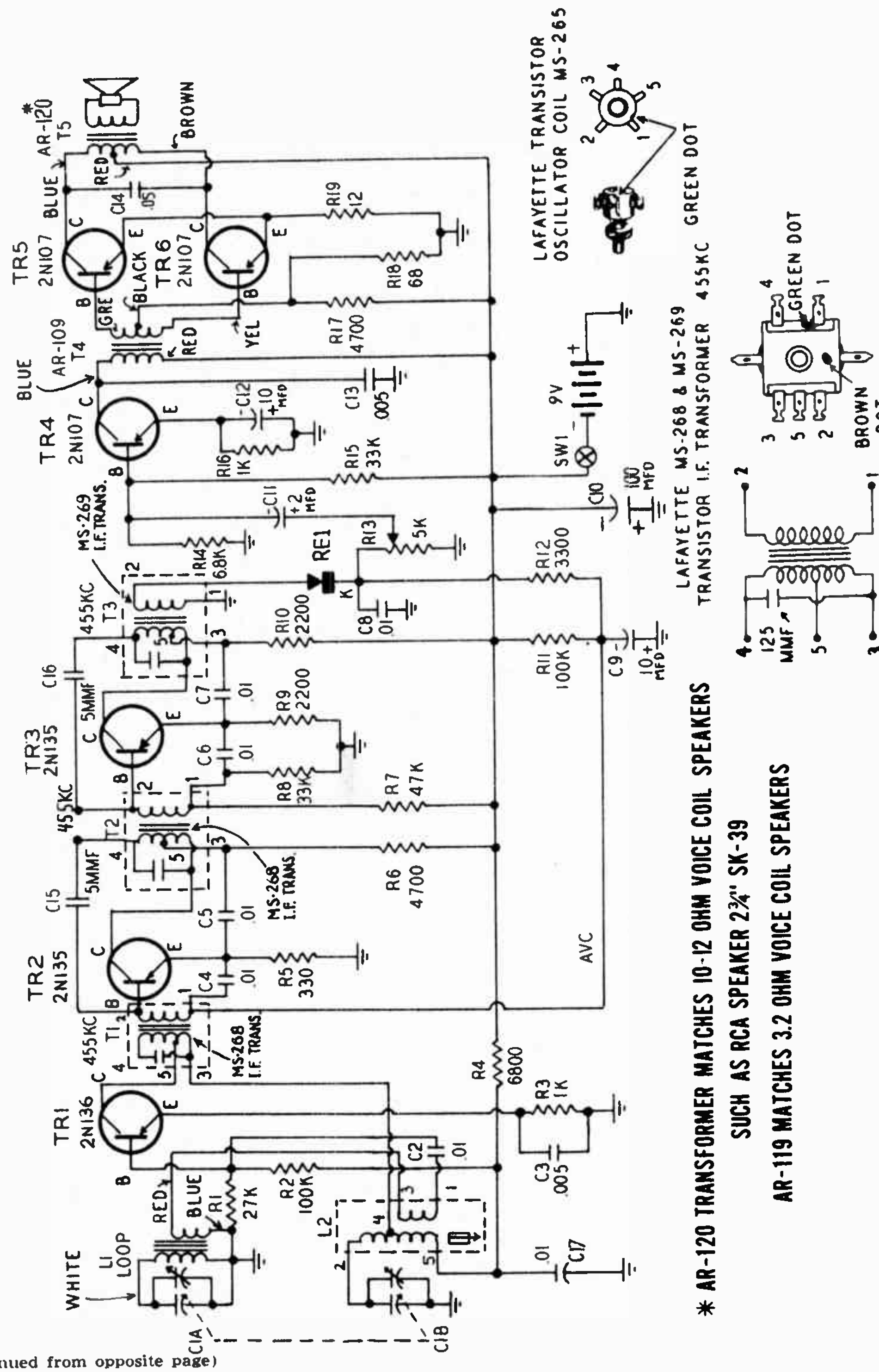
When using the New ULTRA-MINIATURE POLY-VARI-CON Variable Condenser, use Matching Loop Antenna MS-272: When using Variable Condenser MS-261, use Matching Loop Antenna MS-264: Oscillator MS-265 can be used with either condenser:



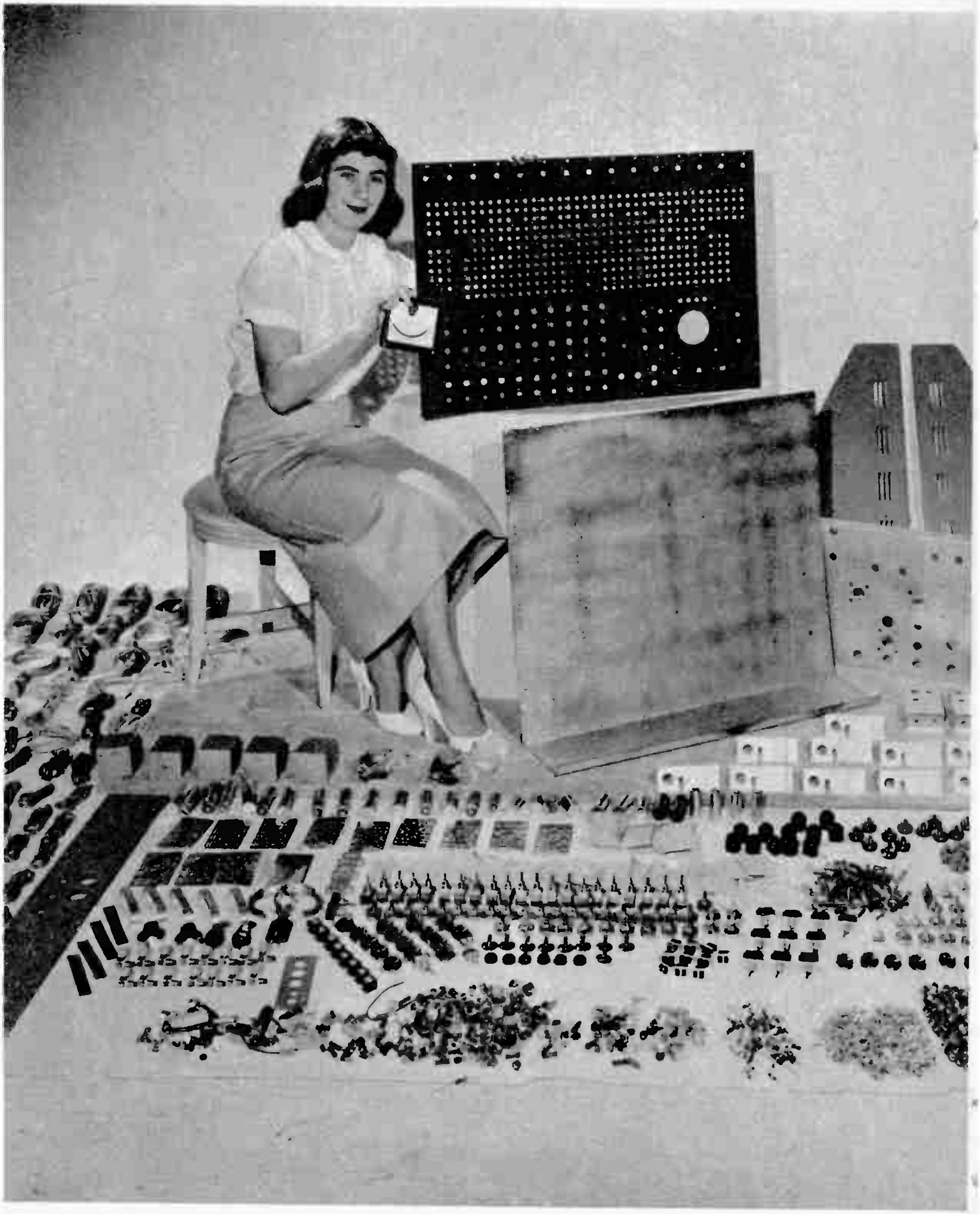
Have you been looking for circuit dope on a powerful transistor receiver that really pulls in the stations? Here's a six-transistor job using standard parts, many of which you'll probably find in your junk box. Diagram on this page is in picture form; on facing page is equivalent schematic diagram. No physical layout is given. Best idea is to make up the receiver first in "breadboard" form on a light

(continued on opposite page)

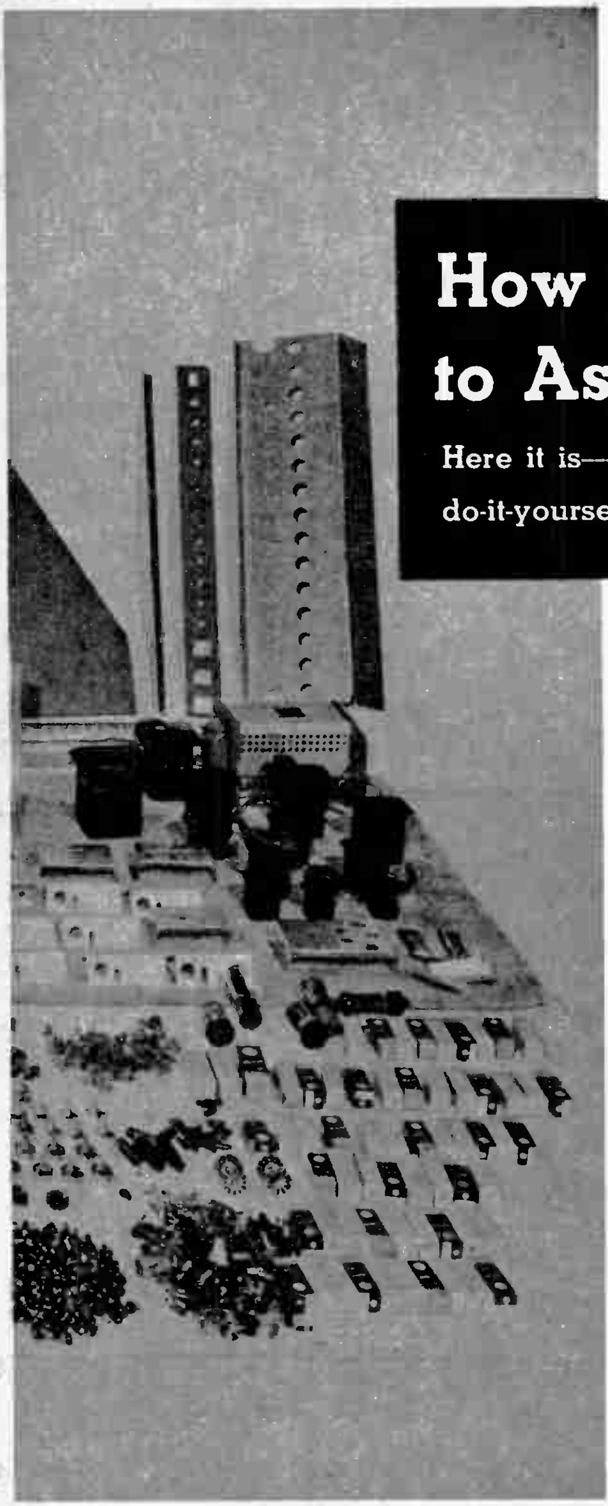


(continued from opposite page)

aluminum chassis. Get in working order, learn how to handle various small parts and then rebuild it into any convenient container. C1A-C1B is dual 365 mmfd. miniature variable tuning capacitor. L2, oscillator coil. Transistors are numbered TR1, TR2, etc. RE1 is type 1N64 crystal diode. TR is driver transformer. T5 output transformer. Parts available from Lafayette Radio, New York 13, N. Y.



World Radio History



How Would You Like to Assemble THIS Kit?

Here it is—the biggest and most challenging do-it-yourself project yet—the electronic brain!

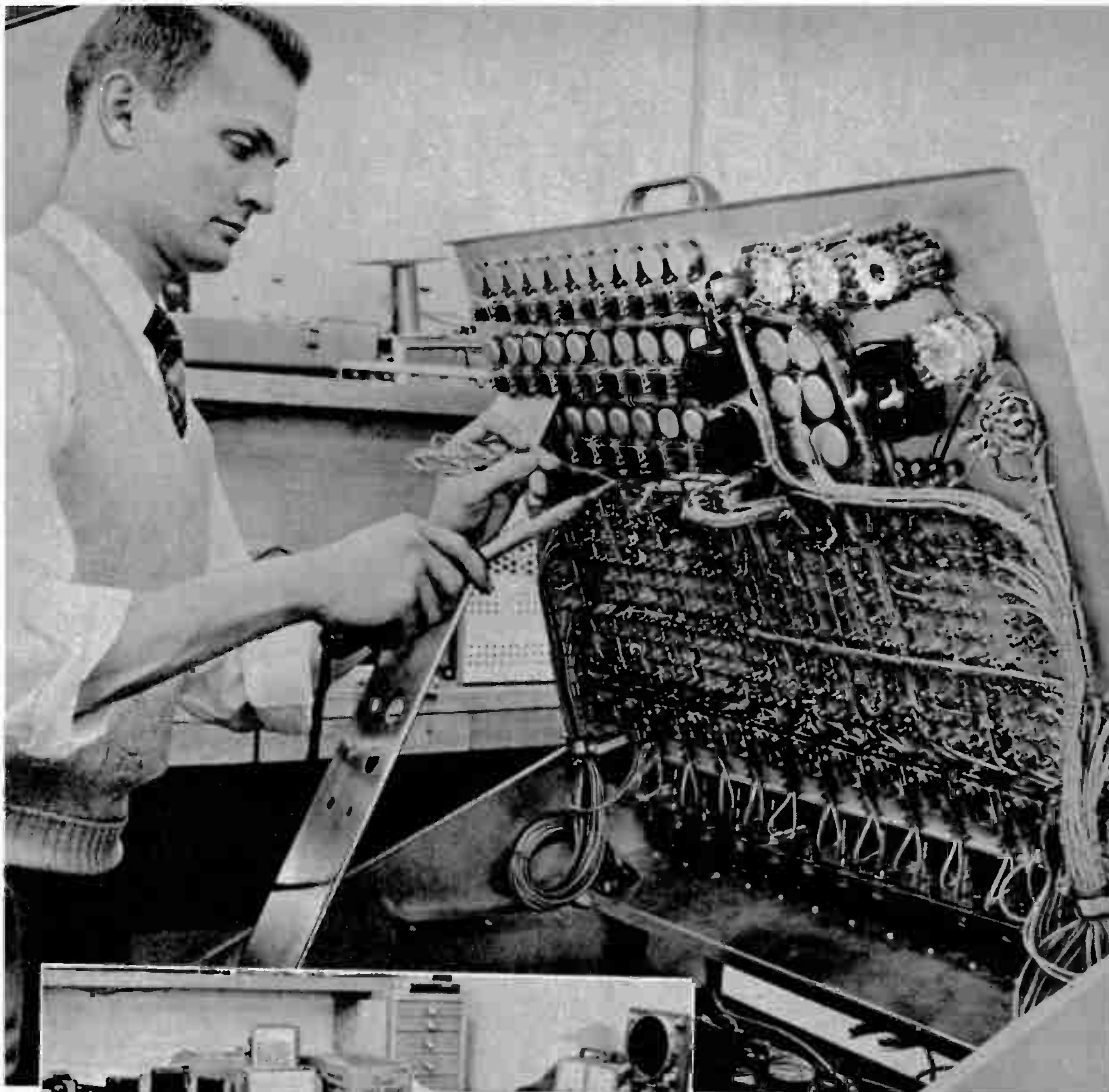
YOU ALMOST NEED an electronic brain to add up the myriad resistors, capacitors, transformers, tubes, switches, relays, plugs and miscellaneous hardware that comprise the kit pictured here . . . certainly the largest and most ambitious do-it-yourself project ever offered. And if you assembled and wired all these parts, an electronic brain is exactly what you would have as the finished result! Specifically, this is the Heath Electronic Analog Computer, a not-so-junior version of the huge, room-filling machines which in minutes solve mathematical problems that would take weeks or months if tackled with a pencil.

Under development for more than a year, the computer is a practical, economical tool for engineers and teachers who don't need and can't afford the big, extremely expensive factory-made devices. Actually, the kit isn't nearly as complicated a job as it appears at first glance. Many of the units are identical multiples, and individually they're quite simple. For example, there are fifteen separate amplifiers that respond to elements of equations fed into them in the form of small voltages. They make an imposing row along the top of the cabinet, but each contains only three tubes and a handful of small resistors and capacitors. The Heath people say that about 200 man-hours are needed for the entire undertaking.

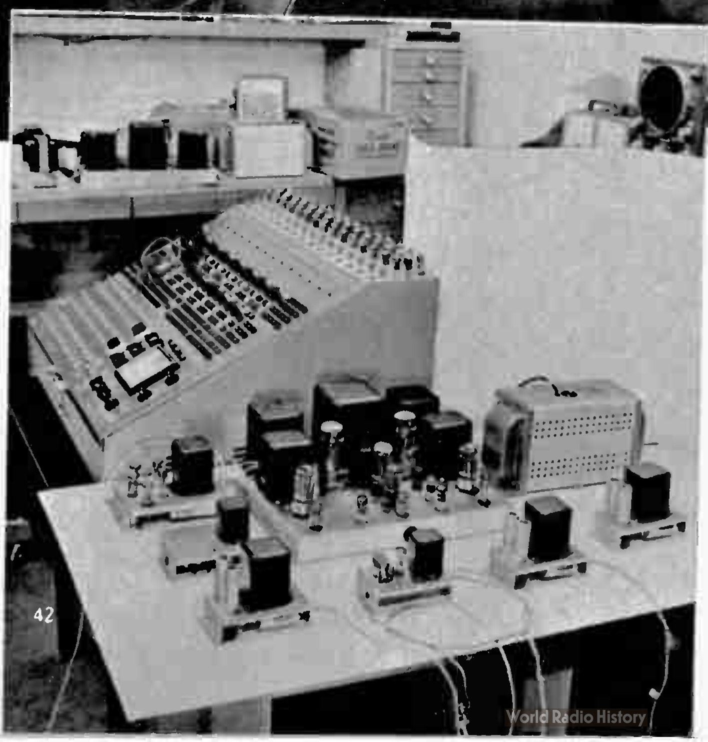
Like all the well-known Heathkits, the

Staggering, isn't it? But all these parts go together quite easily to make up the Heath Electronic Analog Computer. Job takes approximately 200 hours.

World Radio History



Carl Heald, project engineer on the development of the analog computer kit, puts a few finishing touches to the wiring of a laboratory model. Hinged main panel is easier to work on than the chassis of many radio sets.



On the table are some units that are normally stored inside the angled cabinet. Large center unit is the amplifier power supply; to its right, a constant-voltage transformer that smooths out power line fluctuations. Smaller chassis are oscillators and power supplies.

World Radio History

computer is furnished complete to the last lock washer. The various chassis members are formed, punched and engraved, and assembly is strictly a screwdriver and wrench job. The wiring, however, is formidable, and takes time and patience. A few small mistakes are likely to throw the system out of gear. If you presented such a problem to an incorrectly-assembled computer as, "How much is two times three?", the answer might come out "Five."

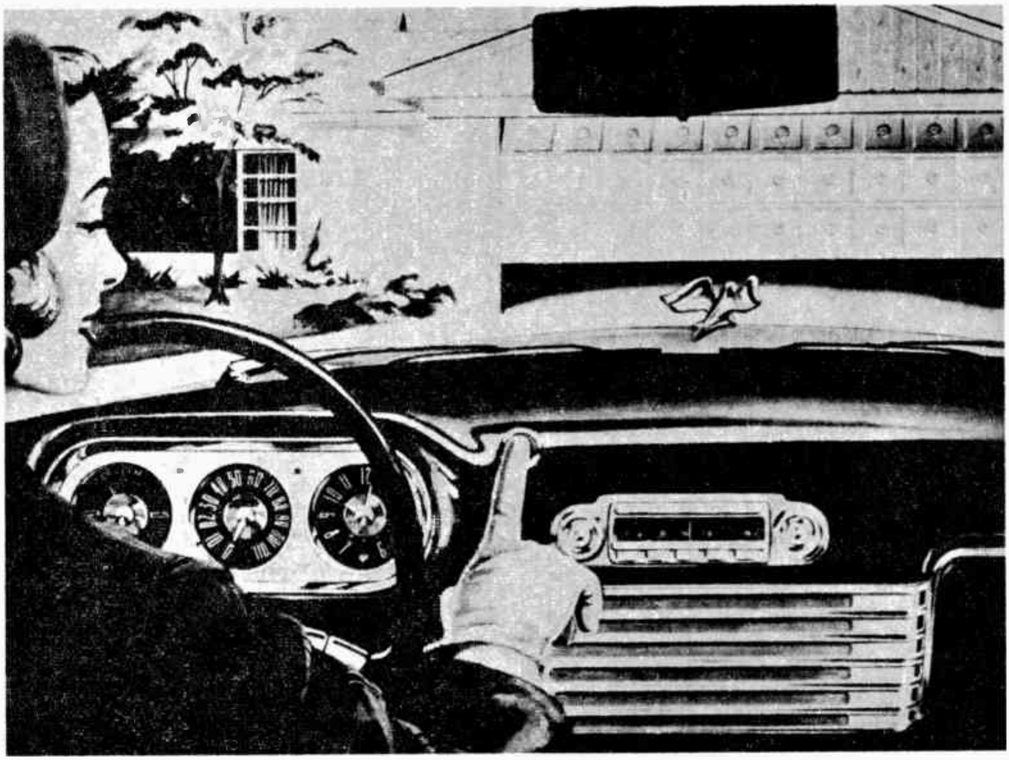
Depending on how many amplifiers and incidental units are required, the cost of the kit runs between $475 and $945.

The photographs on these pages were made especially for this book by John Deetjen, of St. Joseph, Mich. •

The angled cabinet has been designed to make the entire front face of the computer simple to operate, as demonstrated here by Chalmer Jones, assistant to the president of the Heath Company.

Close-up of control panel shows interconnecting plugs and jacks at top. The voltage adjustments, which represent elements of equations, may be seen at the bottom.

World Radio History



Press the Button—and Drive In

With this remote radio-control installation, you can open and close the door of the garage from the driver's seat of your car.

AN UNEXPECTED STORM has blown up, and the rains beat noisily against your windshield. You have no umbrella or raincoat in the car. As you near the house, you dream:

"Oh, to press a button on the dashboard, watch the garage door roll up by itself, and pull inside safe and dry!"

Dream no longer, chum. An enterprising electronics manufacturer has brought out a practical radio-controlled garage door opener in packaged form for easy installation by anyone possessing a rudimentary knowledge of electricity. It consists of three units: 1) A compact transmitter, for installation in the car; 2) A receiver, for installation in the garage; 3) A motor drive, for the door itself. Both the transmitter and the receiver are factory-assembled and wired. The only real mechanical work involved is the mounting of the motor mechanism.

Made by the Perma-Power Company, of Chicago, the door opener is sold through regular radio supply outlets, including the large mail order firms. It isn't as expensive as you might think: about $140 for the whole package.

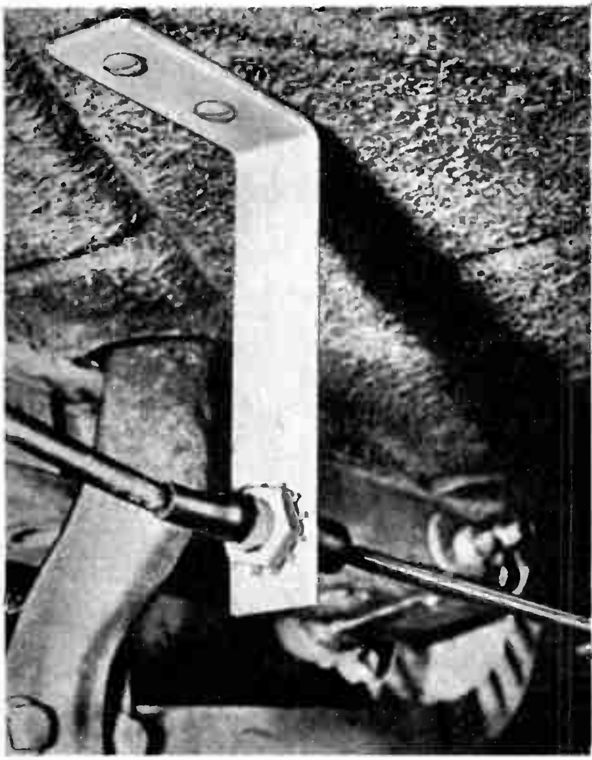
The radio transmitter works on a frequency of 27.255 megacycles, authorized by the Federal Communications Commission. This is one of the so-called "Citizen's Bands," and is also used for radio-controlled model airplanes and boats. An FCC license for the transmitter is required, but you get it merely by applying for it. Because it has to cover only a short distance —the length of a driveway—the transmitter in the car is of very low power, and is rated at less than a quarter of a watt.

World Radio History

Left. Easy does it! As you enter driveway, merely press the radio transmitter button and your garage door magically rolls up. Backing out, you can close it as easily.

The car transmitter unit mounts readily on the firewall. Heavy wire (right of photo) is the antenna lead. Thinner ones (left of photo) are to battery and control button.

Below. The transmitting antenna is a short rod concealed on the underside of the car. L-shaped bracket is attached to gravel pan.



The receiver contains a sensitivity control, by means of which it can be adjusted to respond to the signals from the car's transmitter within a limited range of perhaps 75 or 100 feet. This provision eliminates the possibility of the door opening and closing wildly under the influence of signals from model-control transmitters. The latter often can be "heard" miles away.

To guard further against interference, particularly from other garage-door openers, the Perma-Power transmitter incorporates tone modulation, on any of ten different frequencies, as follows:

Channel 1	—	600 cycles
Channel 2	—	750 cycles
Channel 3	—	950 cycles
Channel 4	—	1200 cycles
Channel 5	—	1500 cycles
Channel 6	—	1900 cycles
Channel 7	—	2400 cycles
Channel 8	—	3000 cycles
Channel 9	—	3750 cycles
Channel 10	—	4700 cycles

A receiver containing channel selector 3, for instance, will respond only to a transmitter containing the same numbered selector, and to no other.

(*Continued on page 50*)

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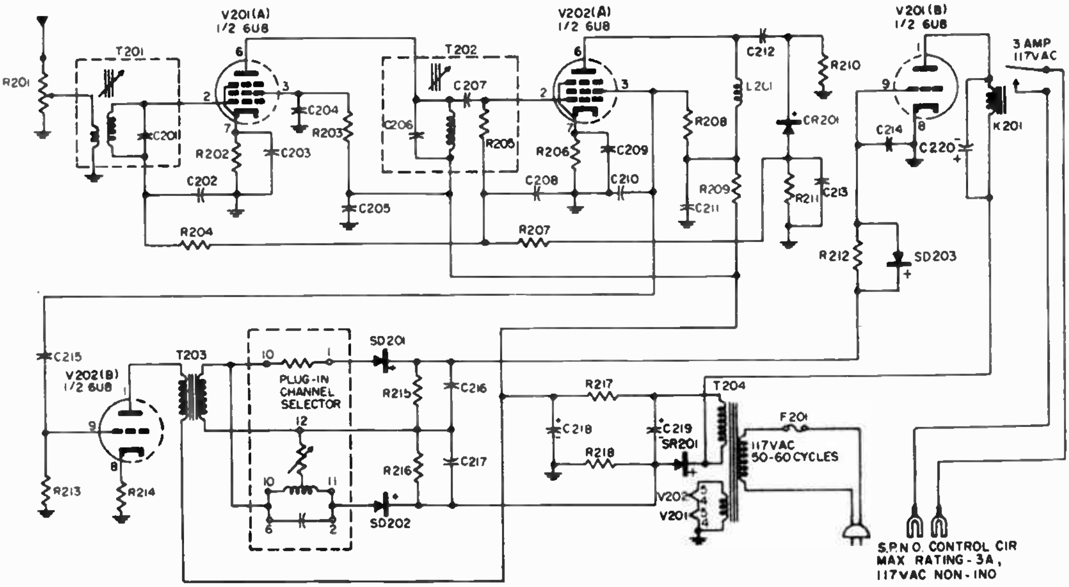
MODEL RC-101 RECEIVER (CHASSIS FROM SERIAL 03500)



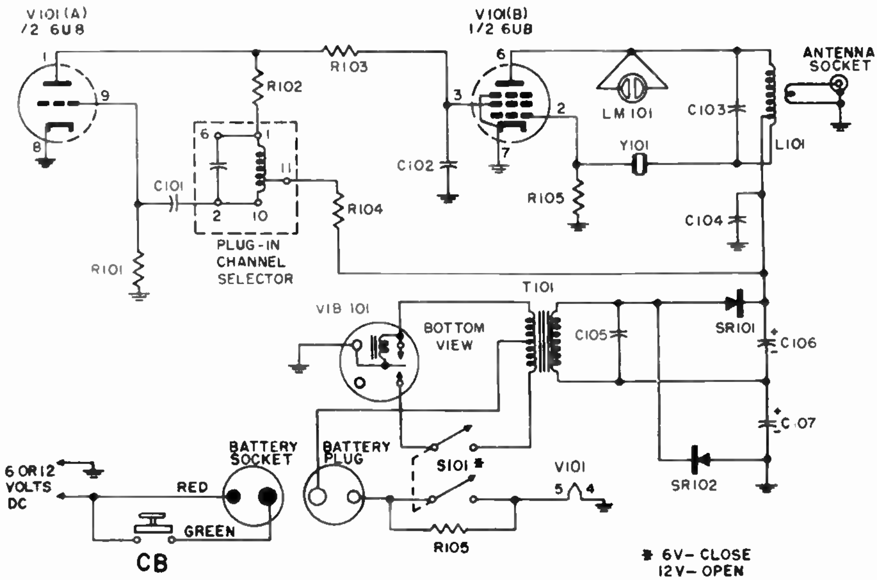
REPLACEMENT PARTS LIST

CIRCUIT SYMBOL	PART	PART NUMBER
R201	1000 OHM CARBON POT. LIN. TAPER	156AD2
R202, R214	68 OHM 1/2W ±20%	
R203, R208, R210	22,000 OHM 1/2W ±20%	
R204, R213, R215, R216	470,000 OHM 1/2W ±20%	
R205	47,000 OHM 1/2 ±20%	
R206	120 OHM 1/2W ±20%	
R207	4700 OHM 1/2W ±20%	
R209	1000 OHM 1/2W ±20%	
R211	220,000 OHM 1/2W ±20%	
R212	10 MEG OHM 1/2W ±20%	
R217	1000 OHM 2W ±20%	
R218	330 OHM 1/2W ±20%	
C201, C206	10 MMF ±10% 300V CERAMIC	
C202, C215, C216, C217	.01 MF GMV, 300V CERAMIC	
C203, C205, C209, C211	1500 MMF GMV, 300V CERAMIC	
C204, C207, C208, C210, C212, C213	220 MMF ±20% 300V CERAMIC	
C214	.5 MFD 200VDC ±20% PAPER	
C218, C219, C220	20 MFD 150 WVDC ELECTROLYTIC	30AD2
CHANNEL SELECTOR	PLUG-IN ASSEMBLY—FACTORY ADJUSTED	1AD6R*
CR201	1N64 GERMANIUM DIODE	
SD201, SD202, SD203	1S1 SELENIUM DIODE	1S1
SR201	SELENIUM RECTIFIER 130V AC 30MA DC	159AD1
L201	PEAKING COIL	40AD1
T201	ANTENNA TRANSFORMER	1AD1
T202	RF TRANSFORMER	1AD2
T203	INTERSTAGE TRANSFORMER 1:3	204AD3
T204	POWER TRANSFORMER	204AD1
F201	FUSE 1/4 AMP 3AG	
K201	RELAY 6-7MA DC 3500 OHMS	160AD1

*(Specify Channel)

World Radio History

MODEL RC-101 TRANSMITTER
(CHASSIS FROM SERIAL 04100)



REPLACEMENT PARTS LIST

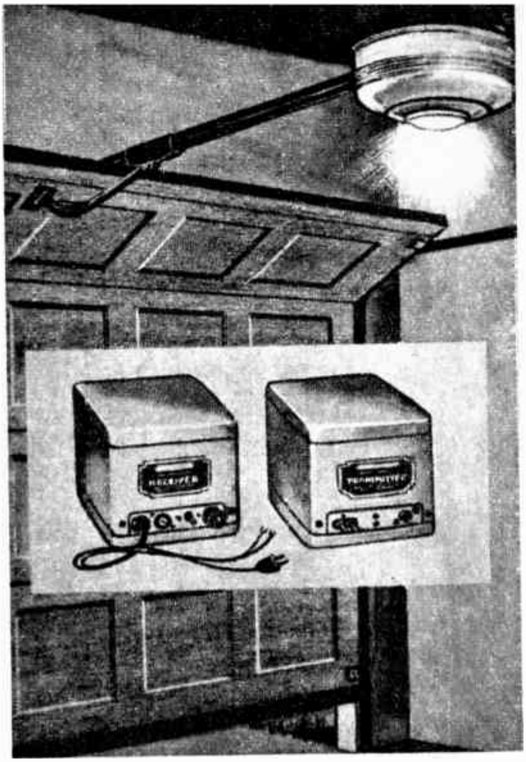
CIRCUIT SYMBOL	PART	PART NUMBER
R101, R105	47,000 OHM 1/2W ±20%	
R102	68 OHM 1/2W ±20%	
R103	22,000 OHM 1/2W ±20%	
R104	4,700 OHM 1/2W ±20%	
R105	13.5 OHM 4W WIRE WOUND	
C101	.01 MFD GMV, 300V CERAMIC	
C102, C104	1500 MMFGMV, 300V CERAMIC	
C103	10 MMF ±10% 300V CERAMIC	
C105	.05 MFD ±20% 600V PAPER	
C106, C107	20 MFD 150 WVDC ELECTROLYTIC	30AD2
L101	TANK COIL ASSEMBLY (INCLUDES C103)	1AD3
LM101	NE-2 NEON INDICATOR LAMP	
CHANNEL SELECTOR	PLUG-IN ASSEMBLY FACTORY ADJUSTED	1AD7-T*
T101	VIBRATOR TRANSFORMER	204AD2
Y101	CRYSTAL 27.255 MC	33AD1
S101	DPST SLIDE SWITCH	
SR101, SR102	SELENIUM RECTIFIER 130VAC 30 MADC	159AD1
VIB101	VIBRATOR 4 PRONG INTERRUPTOR 115 CY	J2SP

*(Specify Channel)

Left, above. Schematic diagram of the Perma-Power receiver unit of garage-door opener. Two dual-purpose 6U8 tubes are used. Unit R201, extreme top left, is sensitivity control which limits the range of equipment to very short distance.

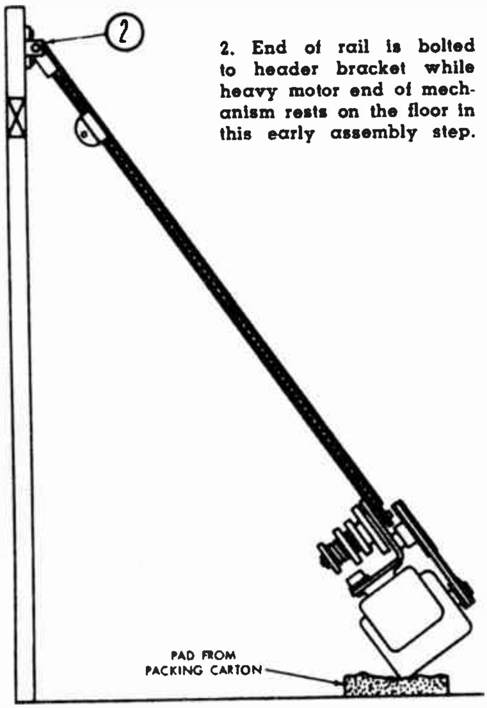
Directly above. The radio control transmitter is simpler than the receiver. One 6U8 tube, having double function, is used. Switch S101 is closed for 6-volt cars, opened for 12-volt cars. Pressing control button CB puts transmitter on air.

World Radio History



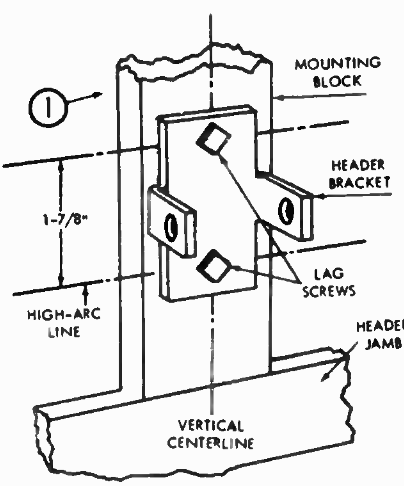
Round housing, mounted on ceiling of the garage, contains ¼-horsepower motor which raises and lowers door under control of transmitter in car. Light, part of housing, goes on and off with the door's movement. Transmitter and receiver, inset, are self-contained units, about 6 inches per side.

The drawings on these pages show some of the details of the garage installation. The motor is belt-coupled to a chain drive on the long horizontal rail. The chain carries a trolley which in turn is connected to the garage door itself by an L-shaped arm. The motor is equipped with a safety clutch, and the door stops in transit if it encounters any obstruction. Power to the motor also goes off.

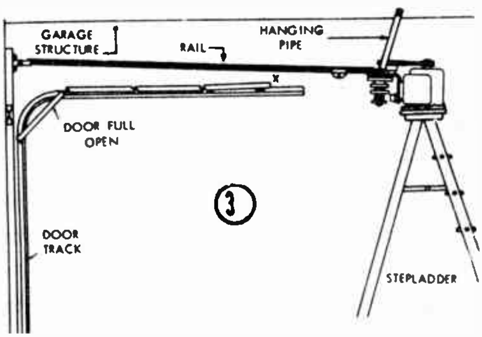


2. End of rail is bolted to header bracket while heavy motor end of mechanism rests on the floor in this early assembly step.

1. This header bracket supports the horizontal rail over the header jamb of the garage door.

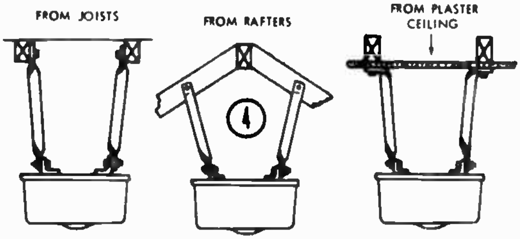


3. Motor end is raised, supported temporarily on ladder, while hanging pipe supports are installed.



World Radio History

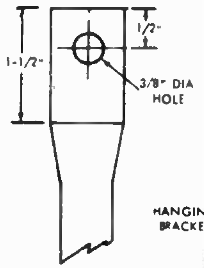
PIPE-HANGING INSTALLATIONS

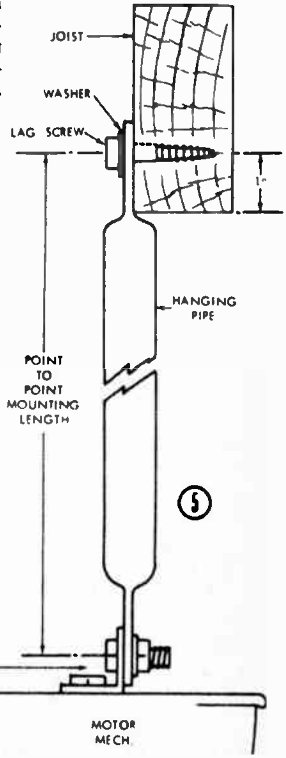


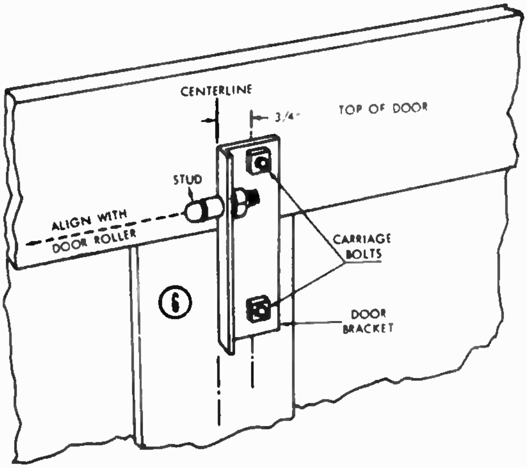
4. The method of installing pipe hangers for the motor depends on the construction of your garage.

5. Rigid motor hangers are made from ordinary 1-inch water pipe, with ends flattened and drilled for lag screws. Ceiling height determines the actual length.

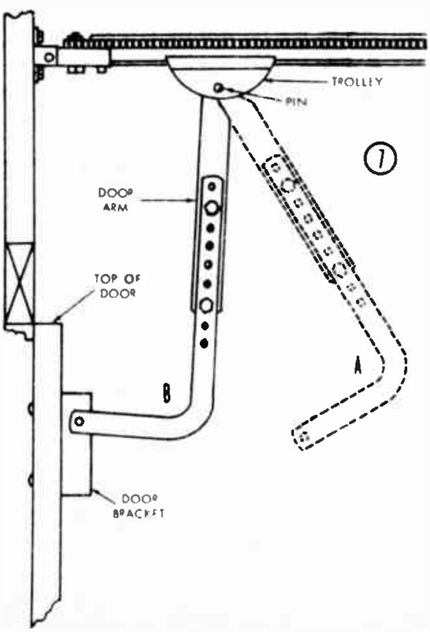
HANGING PIPE DETAIL



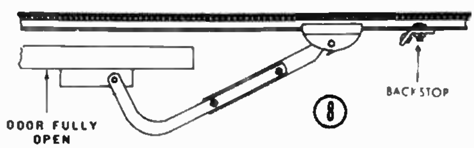




6. This bracket, which is bolted onto the top of the garage door, carries the end of the door arm. The latter is actuated by the motor drive.

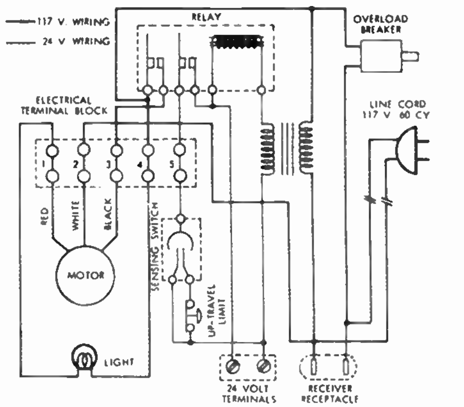


7. With door closed, trolley is near end of rail and door arm is vertical. Arm can be unhooked readily if manual operation of door is desired.



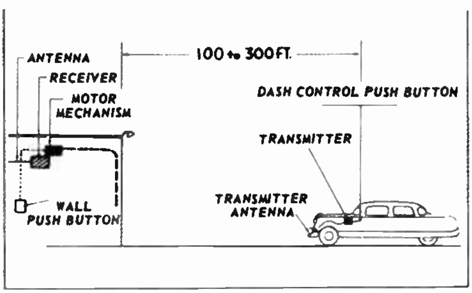
8. Position of door and trolley when the door is fully open. The backstop prevents over-running.

World Radio History



Here is wiring diagram of the motor head unit.

Effective range of radio-control rig is 100 to 300 feet—more than enough for any driveway.



(*Continued from page* 45)

Of course, it is entirely possible for two people living fairly close to each other to install transmitter-receiver combinations containing the same channel selectors, and if they do they're in for some fun. A little neighborly cooperation is then in order: *One* of them must change his channel. Anticipating this situation, the manufacturer has worked out a no-charge exchange arrangement for the selectors. No tuning adjustments are needed when selectors are changed; the units plug into the transmitter and receiver chassis just like ordinary tubes.

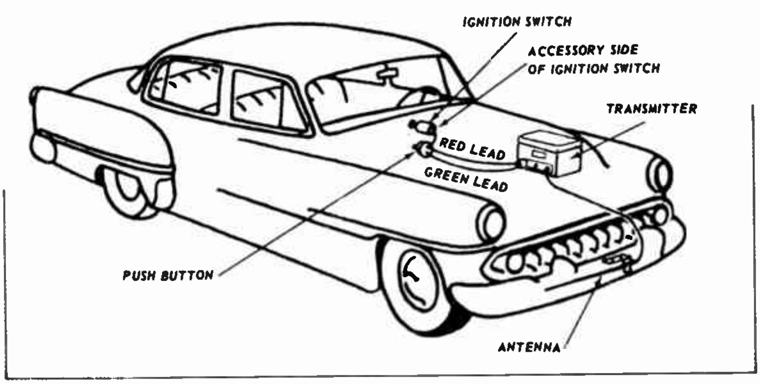
"How," you might ask, "does one learn who the other radio-control owners are?"

These garage-door openers are still such novelties that when one goes into operation it is sure to attract attention, and word will circulate. A very good source of information is the local mail carrier. He gets around and knows everybody in the community.

If there are two cars in a family, housed in the same garage, it is no trick at all to install duplicate transmitters and channel selectors in them.

The system provides complete convenience in either direction. If the car is in the garage, and the door of the latter is down, you open it merely by touching a push button mounted on the wall. You get into the car, start up, and back out. When you clear the garage proper, you press the dash control button once, and the door rolls down. Coming in with the garage closed, you press the transmitter button once when you're about halfway up the driveway. The door goes up and you can pull in without stopping. If it's a cold day and you're really lazy, you can remain in the car and

Transmitter installation diagram. Tube's filament is warm when car's ignition is on, but transmitter sends out signal only when push button is pressed.

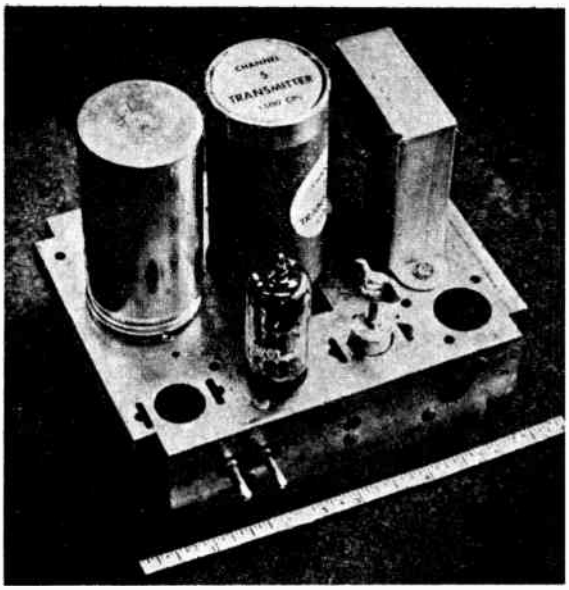


lower the door by pressing the dash button again. *Immediately turn off the ignition,* to keep the garage from filling with exhaust gas.

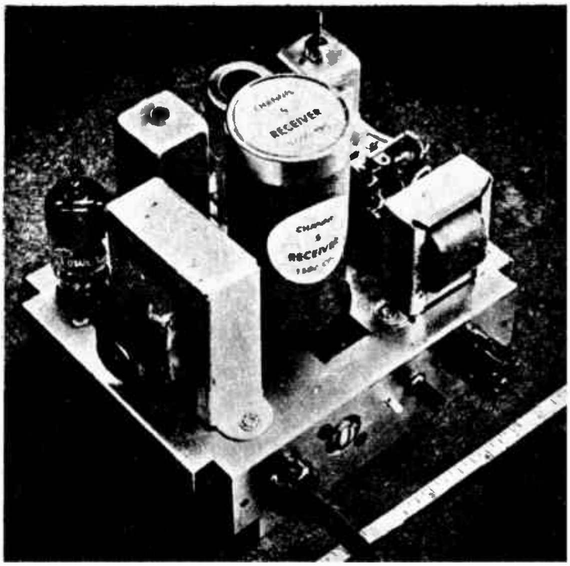
If the garage is part of the house and has a connecting door, it is convenient to have *two* manual switches, one near the connecting door and the other near the garage door. Thus, if you enter the garage from the house, you can tickle the switch button and the door will be up by the time you get into the car. If the door is already up and you walk in from the outside, you can close it by the other switch.

In the case of completely detached garages, it is usually necessary to supplement the radio control by an external switch mounted on the door jamb or on a post in the driveway. This switch merely parallels the control unit inside the garage, and enables other members of the family to open the door when the radio-equipped car is elsewhere. The external switch can, of course, be of the key-locking type. This control feature is needed because the motor-driven door locks securely when it reaches its fully closed position.

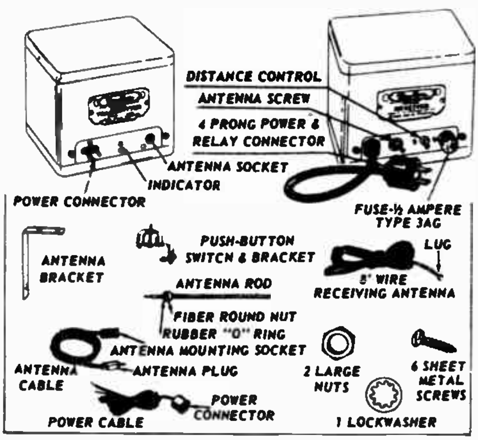
It might occur to you that this remote-control system requires that the receiver in the garage be kept running all the time the car is out being used. It does. There wouldn't be much point to the deal if you had to get out of the car, run in to turn on the receiver, and then go back to the car to push the radio button! However, the receiver contains only two tubes and consumes only a small amount of juice, which represents very cheap payment for the convenience the installation affords! Of course, there's nothing to prevent you from turning the receiver off at night after the family car is safely tucked in. •



Chassis view of transmitter. Only one tube is used, and operation is dependable. Round unit in center is channel selector which is replaceable.



Chassis view of the receiver which contains two tubes and is similar in appearance to transmitter.

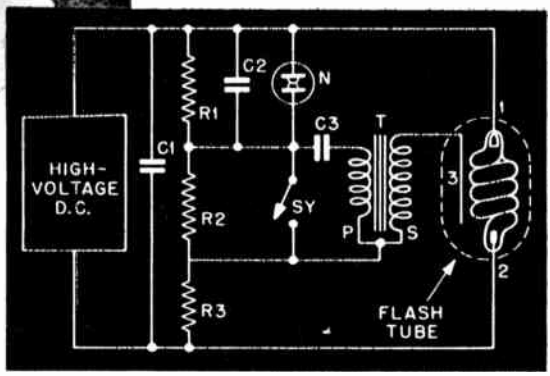


Left. These are the essential electronic parts of radio-control units of the garage door opener.

World Radio History

Here a typical small electronic repeating flash unit is shown mounted on a Leica camera. This is the Strobonar Seven, which derives its high voltage from but a single large dry battery.

Below is basic wiring diagram of electronic repeating flash units.



"Don't Hold It!"

Repeating electronic flash units "freeze" photographic motion. Here is the way that they work.

WHEN the foil-filled photographic flashbulb came into popular use some years ago, a standard joke concerned the store clerk who tested bulbs, before selling them to a customer, by putting them one at a time into a flash gun and pressing the control button.

"See," he would say, "it's OK."

The idea that a flashbulb could be fired *more* than once was considered just as funny. When Professor Harold E. Edgerton of the Massachusetts Institute of Technology actually produced a repeating flash tube, many people refused to take it seriously, and dismissed it as a gag of some sort. Far from it! "Electronic flash," as repeating flash systems are generally called, has been highly successful.

With the development of electronic flash, the traditional cry of the photographer, "Hold it!" is scarcely heard any more. The reason is found in the extremely short duration of the light: as high as 1/10,000 of a second, and as low, comparatively, as 1/1000. The illumination stabs on and off so quickly that subjects don't have a chance to blink or squint; it "freezes" very rapid action that would hopelessly blur pictures taken by other means. For shooting sports events, squirming babies, lively pets, etc., electronic flash is supreme.

An ordinary flashbulb contains a quantity of crumpled magnesium or aluminum foil, a short filament wire or fuse, and oxygen. When current from a battery passes through the filament, the latter ignites and in turn ignites the foil. In the presence of the oxygen, the foil flares up brightly and briefly and is consumed completely. The bulb is now worthless, except as a small-arms target. An electronic flash tube works on an entirely different principle. The glass bulb or envelope appears to be empty except for three wire connections. Actually, it is filled with a colorless gas called xenon. In some tubes the

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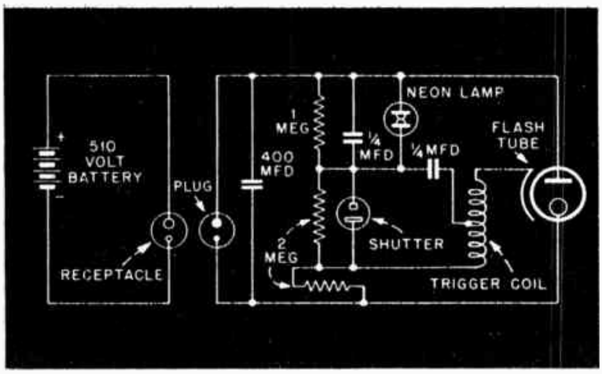
gas is confined to a small loop or spiral of glass tubing and the outer glass envelope is only a protecting shell; in others one end of the spiral is open and the whole glass envelope is filled with xenon.

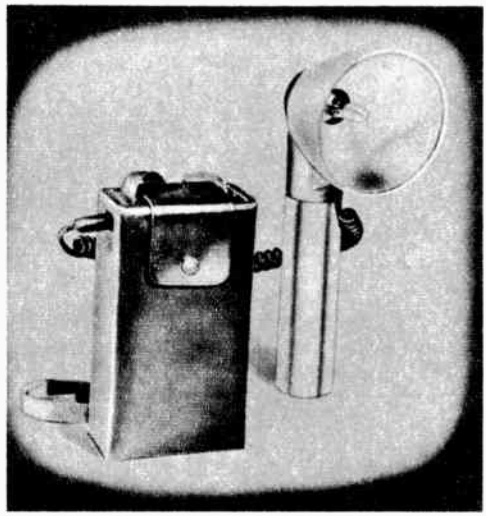
The basic operation is best described with the aid of Diagram 1.

We start on the left with a source of high voltage direct current, ranging from 300 volts for small tubes to 5000 or more for large studio sizes. Connected directly across this voltage source are the capacitor C1, which has a value usually of several hundred microfarads; a string of several small resistors, R1, R2, and R3, totalling perhaps five million ohms; and the electrodes 1 and 2 of the flash tube proper. The pressure in the tube is carefully adjusted during manufacture so that the resistance of the gas is just high enough to prevent the tube from flashing through immediately when the prescribed high voltage is applied.

The high voltage DC charges the capacitor C1. This action takes several seconds, depending on the size of C1, the internal resistance of the voltage source, and the resistance of any series resistors inserted between the DC source and C1 to prevent accidental short-circuiting of the former. The voltage across resistor R1 charges capacitor C2, which is of about ¼ microfarad. When this capacitor is fully charged it causes the small neon tube N to light up. This indicates that the main capacitor C1 is also fully charged.

The voltage across resistor R2 charges capacitor C3 (also about ¼ microfarad in size) through the relatively low resistance primary winding P of a small step-up





HEILAND STROBONAR SEVEN

A two-piece, light-weight electronic flash, the Heiland Strobonar Seven, top right, is good for use with miniature, or with standard press-type cameras, as shown, lower photo. Its coat-pocket-size leather case holds a special 510-volt Eveready dry battery made for repeating flash units. High voltage is carried by the coiled cord to the flash head, which contains flash tube proper in a reflector and capacitors, resistors, and trigger coil in the round body. Wiring diagram, directly above, is very simple. "Receptacle" is part of the battery case; "plug" is on end of flexible cord from flash unit. The trigger coil here is an auto-transformer, lower part acting as primary, entire winding as secondary. Made by Heiland Div., Minneapolis-Honeywell, Denver 22, Col.

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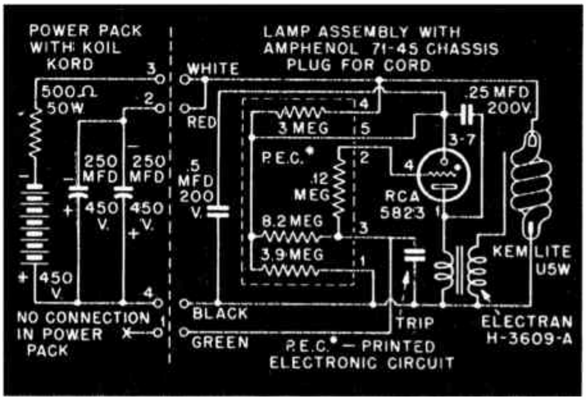
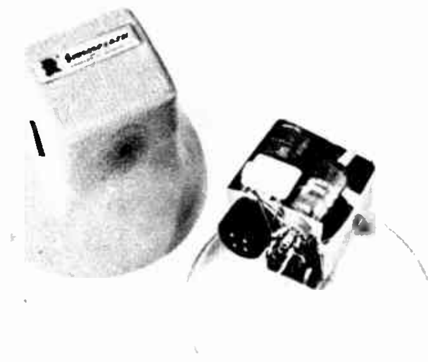


GRAFLEX STROBOFLASH

The Graflex Stroboflash uses a 450-volt battery pack combined with the main storage capacitors in the carrying case. "Gun" is shown, lower left, on a Speed Graphic. Protective cover, left of photo below, has been removed from the lamp assembly to show the few parts that are mounted behind reflector. Triggering action of the photo tube is aided by the thyratron tube, RCA type 5283 in wiring diagram. Made by Graflex, Inc., Rochester, N. Y



transformer T. This transformer is virtually identical with the small ignition coils widely used in model airplanes. The switch SY, representing the "synchronizer" contacts on the camera shutter, is open. The secondary winding S of the transformer connects to electrode 3 in the flash tube, placed somewhere along the gas-filled spiral between electrodes 1 and 2.

When a picture is taken, the switch SY closes. The charge of electrons stored in capacitor C3 is now discharged rapidly through the primary P. The momentary rush of current in this winding induces another momentary voltage in the secondary S. Because of the high step-up ratio of the primary-to-secondary windings, the secondary pulse may reach 10,000 or 15,000 volts for a very small fraction of a second. This high voltage, impressed on the flash tube between electrodes 3 and 2, causes the xenon gas in that vicinity to "ionize," or become conductive. With the entire tube already under the strain of the voltage between electrodes 1 and 2, the rest of the gas ionizes, too, and becomes conductive. The large charge of electrons in capacitor C1 then rushes through the tube and causes a miniature atomic explosion to take place. The major effect is the release of a very bright, white light which makes excellent photos.

The xenon gas doesn't burn up because it's not inflammable, the way oxygen is. Each electrical jolt it receives liberates only a tiny part of the total energy of its atoms, and this part appears as light. The latent energy is so large that the tube can be fired thousands of times before it finally uses itself up.

The expression "miniature atomic explosion" is no mere figure of speech. Some of the larger flash tubes go off with the sharp report of a rifle.

Since the capacitor C1 can be charged only to the voltage of the high-voltage source, you might ask, "Why use it at all? Even if it's removed, the flash tube is still connected to the high voltage."

If the voltage source is big enough, C1 *can* be eliminated. However, it is much more economical to use a small source and to let it build up a charge in C1 slowly; that is, in a few seconds instead of instantaneously. A water analogy is appropriate here.

If the water pressure in a house is low and the pipes are rusty, a faucet can deliver only a slow trickle. However, if you put a pail under it and wait patiently, the pail will fill up. It will be just as full after ten minutes under a slow tap as it would be after say five minutes under a fast one. Regardless of how long it took for the pail

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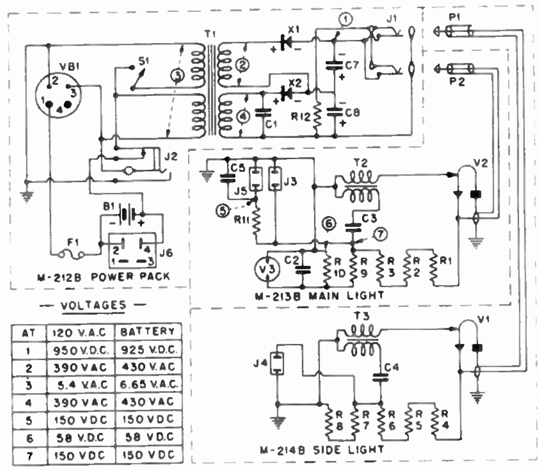
SYNCTRON CANDID MODEL 208B

The Synctron Model 208B contains a "Dynaseal" sealed storage battery which operates a vibrator power supply, with selenium rectifiers, in a voltage-doubling circuit. Accessories available include a battery charger and an AC power adapter. Two electronic flash tubes can be plugged in by means of the connectors, P1 and P2, upper right of wiring diagram. B1 is the sealed storage battery, VB1 the vibrator, T1 the step-up transformer, X1 and X2 the selenium rectifiers, and C7 and C8 the main storage capacitors. AC power adapter plugs into jack. J2. This model is made by Dormitzer Electric & Mfg., Cambridge, Mass.



AT	120 V.A.C	BATTERY
1	950 V.D.C.	925 V.D.C.
2	390 VAC	430 V.AC
3	5.4 V.A.C	6.65 V.A.C.
4	390 VAC	430 VAC
5	150 VDC	150 VDC
6	58 V.D.C	58 V.D.C
7	150 VDC	150 VDC

to fill, it can be emptied in an instant. In the electronic flash circuit, the capacitor is the pail and the small high-voltage source the water tap.

The capacitors, the resistors, the transformer, and the neon tube are all relatively small, light components. The big problem in making flash units small and light enough to be portable was and still is the voltage source. Two methods of producing high voltage at low values of current are now being used successfully. In the first, the primary source of energy is a small storage battery of three or more often two cells, developing a little more than six or four volts, respectively. This is hooked to a vibrator-power unit exactly like the ones used in automobile radio sets, except that it is smaller. The vibrator interrupts the DC from the battery, and enables a transformer to step it up in voltage. This increased voltage, which is now essentially a rough kind of AC, is turned back into DC by small selenium rectifiers, and the DC in turn charges the storage capacitor C1. The advantages of this type of voltage source are that the storage battery is reliable, easily recharged by means of a built-in or auxiliary charging unit, and has a long life.

The second method of obtaining high voltage is so obvious that it can easily be overlooked: a dry battery, just like an ordinary radio "B" battery but of higher voltage. Manufacturers have done a lot of work along this line, and are now producing flat, compact batteries rated between 300 and 600 volts. These are usually carried in a shoulder-slung case, connected to the flash tube assembly on the camera by a flexible cord. Like any dry battery, these special electronic flash units gradually become exhausted and eventually must be discarded and replaced. Their advantages are utter simplicity and compactness.

Some portable flash assemblies can be used interchangeably on self-contained batteries or the AC house line. The latter type of operation means that the user is tethered by the line cord and is somewhat restricted in his movements. There is virtually no limit to what can be done with fixed studio equipment, since weight and bulk are not important and the AC line can furnish any desired voltage through a simple transformer-rectifier set-up.

Several representative portable units are pictured here, along with a few wiring diagrams. The latter are kindergarten stuff for any radio man or electronics technician. There is constant progress in this field, and improved flash tubes and power units are being announced almost monthly. •

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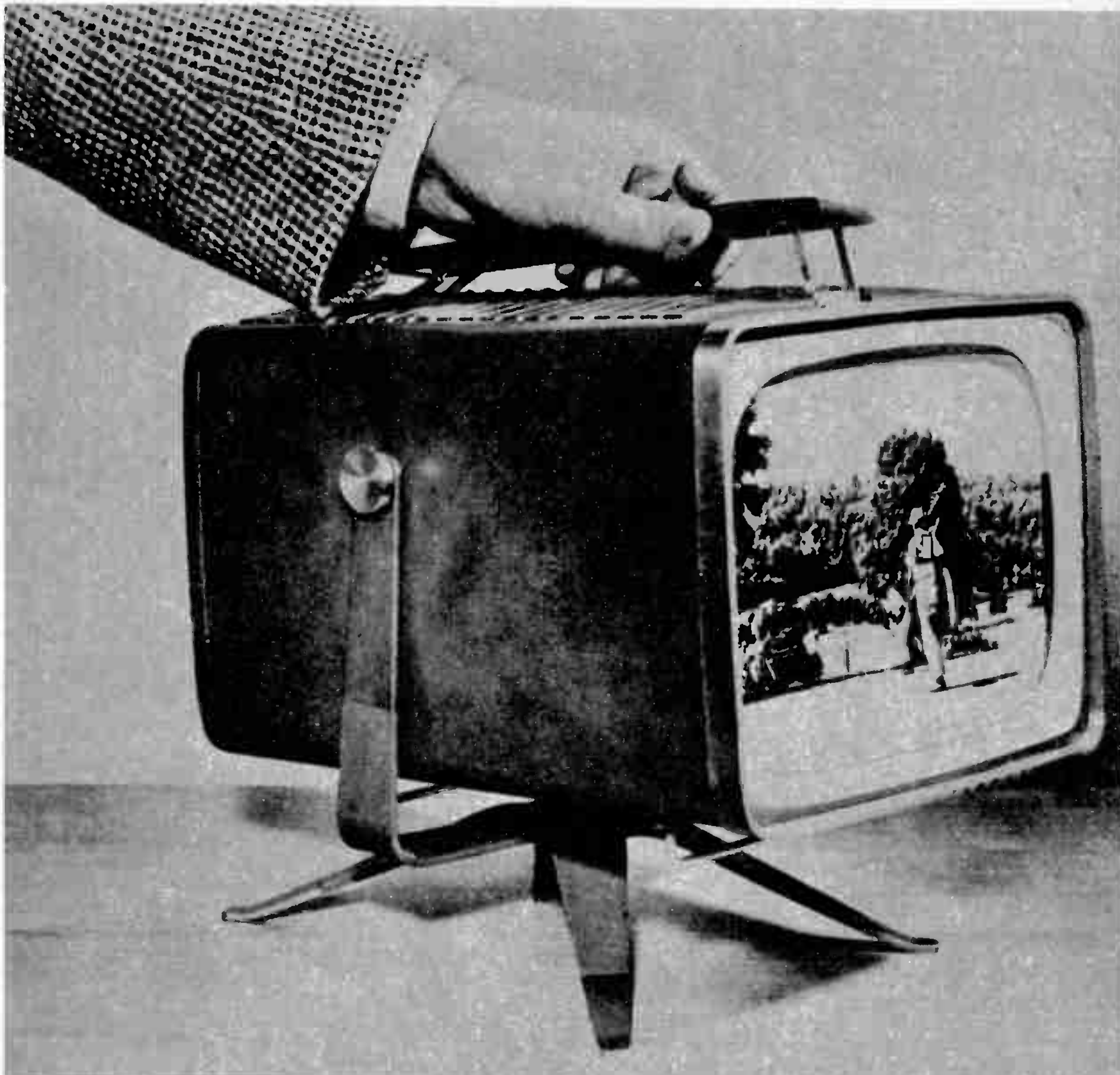

Handful of TV

These new receivers are hardly larger than a table model radio.

FOR A LONG TIME, television manufacturers were engaged in a frantic race to make sets larger and larger. Picture tubes grew from 10 inches to 12, 14, 16, 17, 19, 20, 21, 24 and 27 inches; there was even a short-lived monster of 36 inches. Now the trend is definitely in the other direction, and sets are becoming smaller, lighter, more compact.

Typical of this new line of development is the RCA "Personal" receiver. It measures only 10¼ inches high, 9¼ inches wide,

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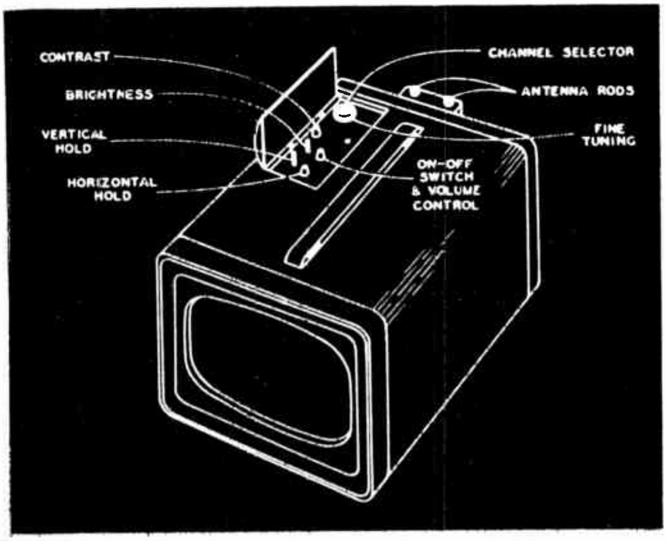
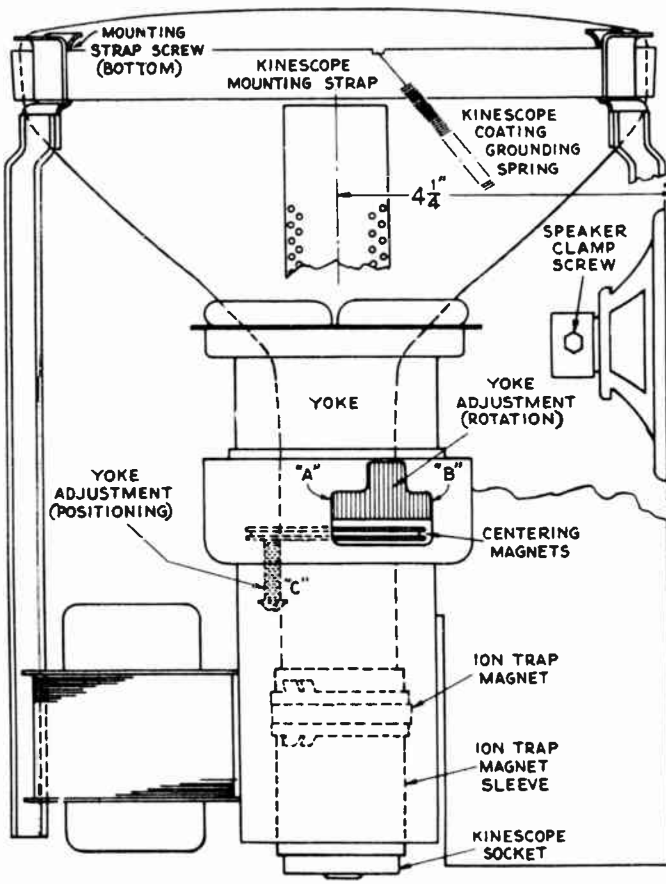


Tuning controls of "Personal" television receiver are under lid near the back of the cabinet.

Left. You can plug in this RCA "Personal" anywhere and watch television in privacy and comfort. Angle of cabinet is adjustable.



Skeleton top view of the set shows how loudspeaker is nested neatly against body of the picture tube.

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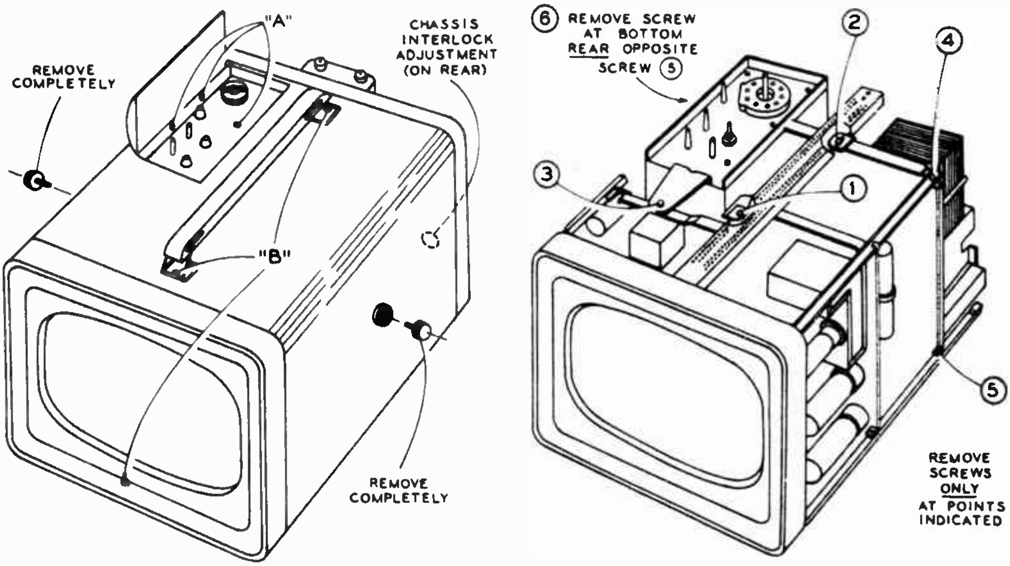


Though tight and compact, the receiver is easily opened when this sequence of operations is followed.

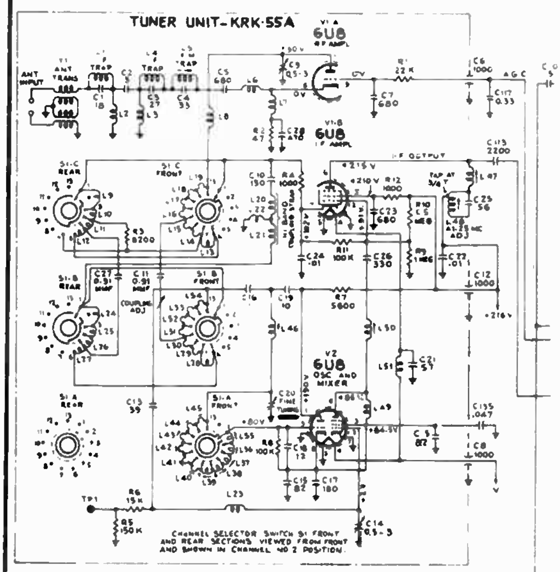
and 12⅞ inches deep, and weighs a trifle more than 22 pounds. It has a handle and can be picked up and carried short distances without causing any strained muscles. Strictly speaking though, it still isn't a real "portable" because it depends on the regular AC power line for its juice. It is a very nice little job, and will certainly prove popular both indoors and out.

The picture tube is described as having an 8½-inch outside *diagonal* measurement, with 36 square inches of viewing area. This means that the picture actually measures a trifle more than 5 by 7 inches. The chassis contains only ten tubes, plus the picture tube, four crystal diodes, a rectifier tube and a double selenium rectifier. Seven of the tubes have double functions. A built-in V-type antenna is provided, as is means for connecting an outside antenna.

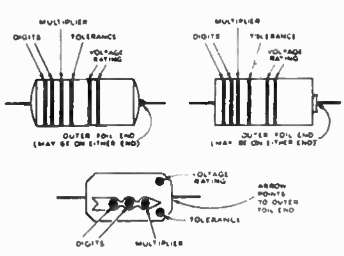
The set proper pivots on the arms of a spider-web table stand, and is readily adjusted for best viewing angle. The tuning controls are under a hinged panel on top.

The chassis is divided into two sections, which pull apart to make the components accessible for inspection and testing. There is no waste space here!

Inside views of this interesting new receiver, as well as the complete wiring diagram, are shown here as a matter of interest to electronic technicians. •



COLOR CODES MOULDED PAPER CAPACITORS



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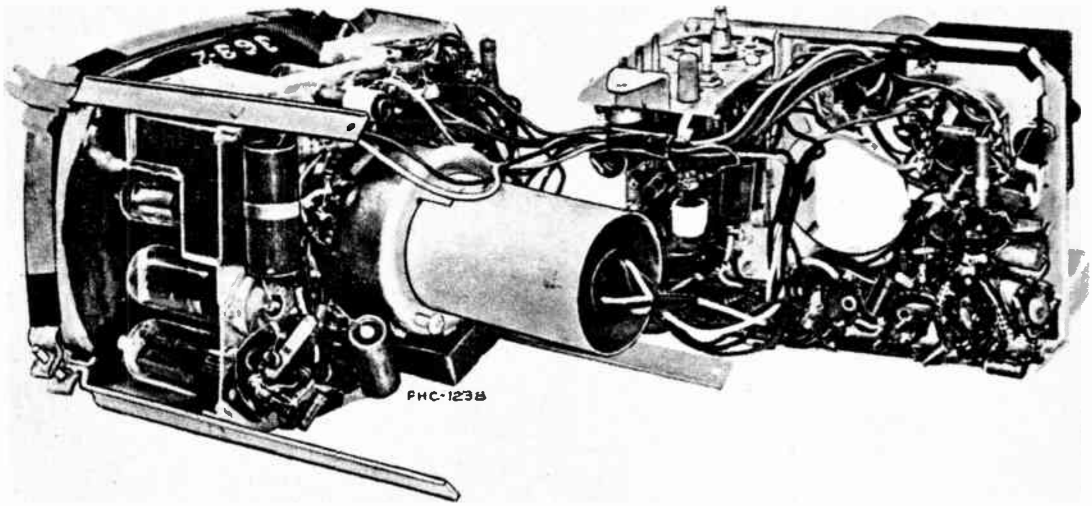
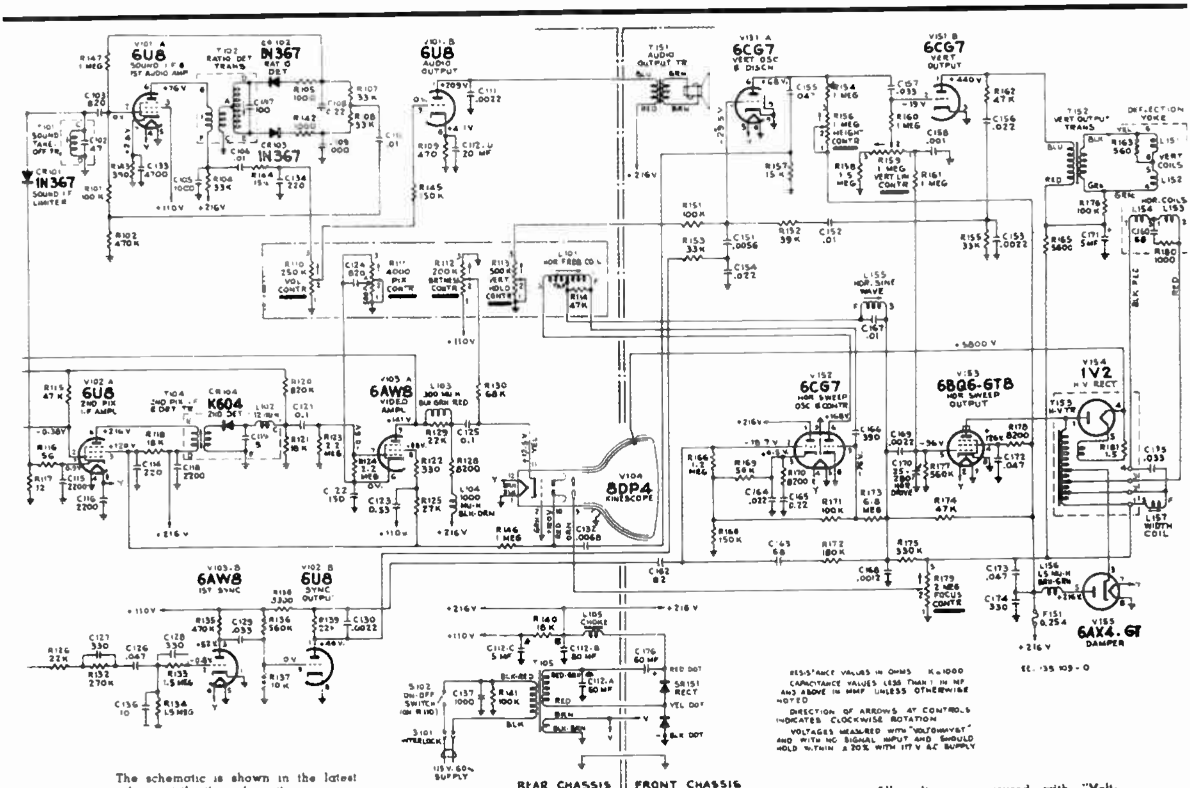


Removed from case, chassis separates into two sections. Section on right fits around neck of picture tube.



The schematic is shown in the latest condition at the time of printing

All resistance value in ohms. K = 1000

All voltages measured with "Volt-Ohmyst" and with no signal input. Voltages should hold within ±20% with 117 v. a-c supply.

All capacitance values less than 1 in MF and above 1 in MMF unless otherwise noted

Direction of arrows at controls indicates clockwise rotation

COMPLETE WIRING DIAGRAM OF THE RCA "PERSONAL" TELEVISION RECEIVER

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Hi-Fi at Low Cost

Do it yourself and save money at no sacrifice in the quality of your new high-fidelity system.

THE MERE EXPRESSION "high fidelity" has an expensive air to it. This is misleading. You can enjoy hi-fi sound at relatively low cost if you are willing to spend some time and effort assembling and wiring your own "system" from the numerous kits now on the market.

There is bound to be a saving between factory made and homemade equipment because labor cost is such an appreciable element in the former. The electronic industry is a long way from the "automation" we read about so much, and assembly and wiring are still pretty much manual processes.

Hi-fi units lend themselves particularly well to home assembly by non-technical persons because they are fairly simple in mechanical construction and require little or no circuit adjustment or alignment when

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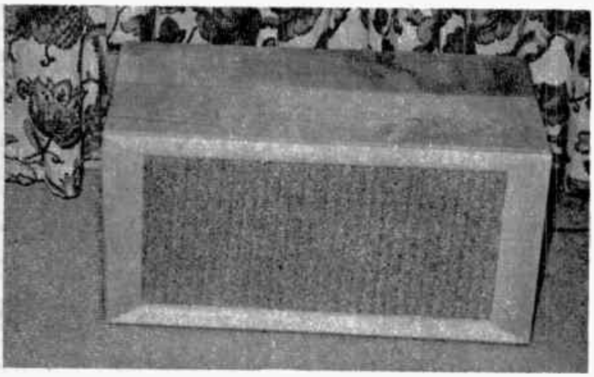
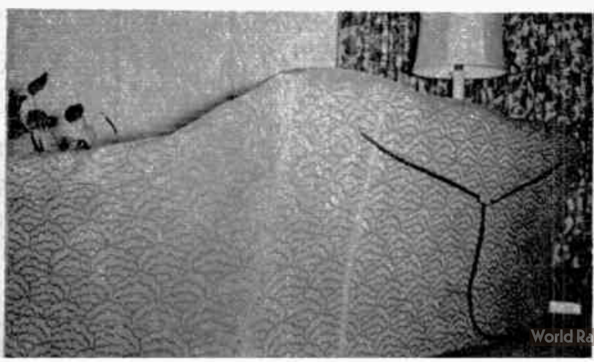
With FM tuner and pre-amplifier on end table next to sofa, as shown below, tuning in a program for hi-fi reproduction is easy and comfortable. Note the large amplifier on floor beneath the table.

This handsome, low box contains two loudspeakers, puts hi-fi sound where it is wanted in the room. It also provides an extra seat for the children.



FM tuner's aerial is 5 feet of twin-lead TV lead-in wire, safety-pinned to sofa. This is satisfactory in strong-signal areas, though usually a roof-mounted TV antenna is better for FM, since the FM band falls between TV channels 6 and 7.



completed. Well-planned kits, complete to the last washer and soldering lug, are available for AM and FM tuners, pre-amplifiers, power amplifiers, and loudspeaker systems. So far, no one has brought out high-quality record players or tape recorders in knocked-down form, probably because they do not offer much real saving. These machines are mechanical rather than electrical in nature, and do not contain the multi-stage circuits and numerous small components that make the wiring of tuners and amplifiers so costly. Still, the "do-it-yourself" movement is so strong that the appearance of player and recorder kits is inevitable.

A hi-fi "system" can be simple or complicated, but there must be no weak links in it. There is no sense, for example, in buying a good amplifier and a good loudspeaker, and then pinching pennies on a cartridge for the tone arm of the record player.

A basic system consists of the following: 1) A signal source. This can be a record player or a radio tuner, or both. A tape recorder is an interesting and useful supplementary unit. The sound end of a television receiver can also be piped in. 2) A pre-amplifier for strengthening the weak input signals. This usually incorporates tone controls, a selector switch for cutting in various signals, and adjustments for different types of phonograph records. 3) A power amplifier, for building the signal up to loudspeaker level. 4) A loudspeaker system. The word "system" is used because the actual sound reproducer is not merely the single small speaker found in radio and television receivers, but as a minimum is a combination of two speakers and frequently more. The enclosure or box for the speakers is very important, and its design and construction strongly affect the quality of reproduction. Audiophiles, as hi-fi nuts like to call themselves, have been known to get into fist fights over the merits of this enclosure over that one.

The pre-amplifier is sometimes combined with the power amplifier on one large chassis. More usually, it is a separate, small unit, kept near the record player and the tuner.

Hi-fi to most people means superior reproduction of classical music on long-playing ("LP") records. The radio tuner is often considered incidental or unnecessary, especially in areas served only by AM broadcasting stations. This is a mistake, because the quality of transmission from many of these stations is very high. If you've grown accustomed to the tinny

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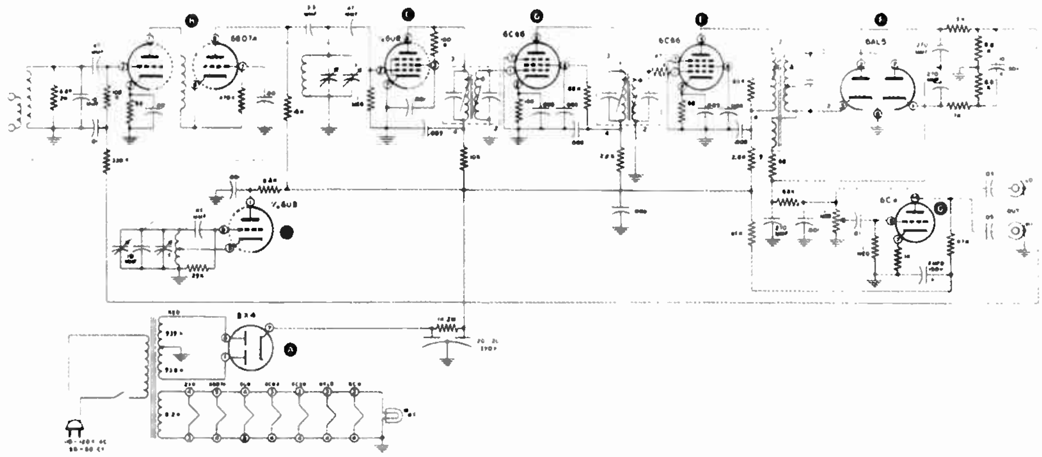
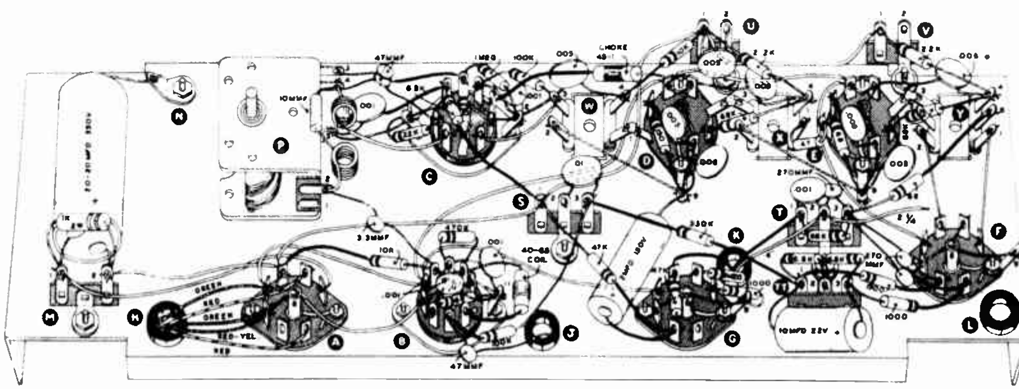
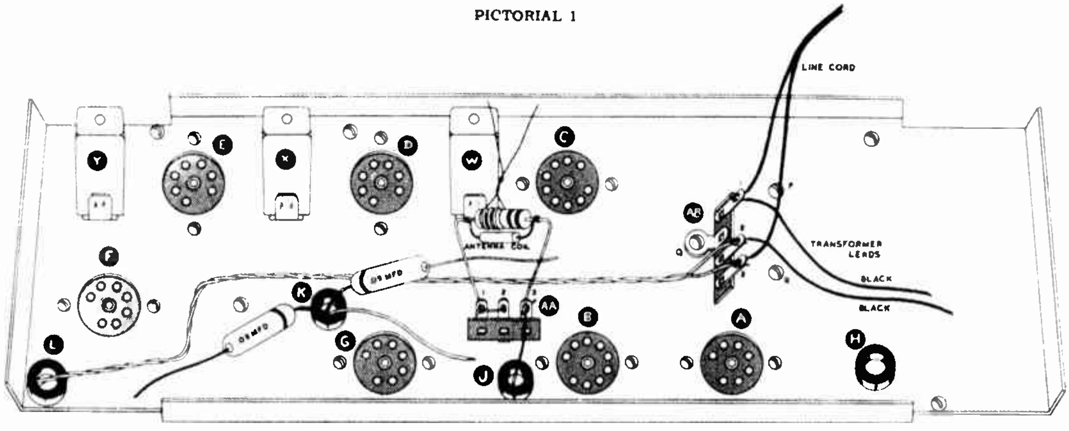


Above is complete wiring diagram of the Heathkit FM tuner. Antenna connects on extreme left; signal output is taken from LO or HI jacks on extreme right. Wiring for the FM tuner is below in picture-diagrams.



PICTORIAL 1



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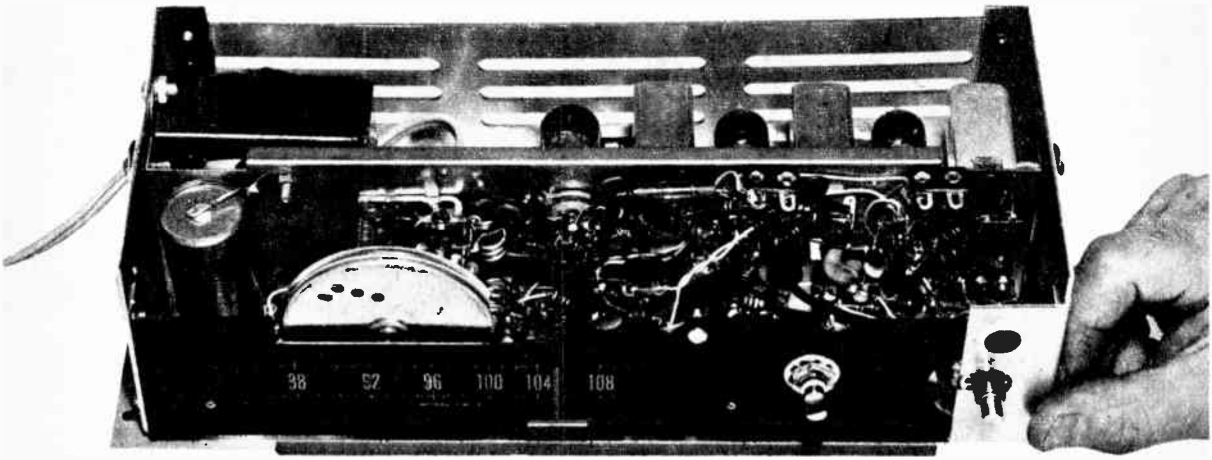

Chassis view of Heathkit FM tuner with cabinet off. Dial is calibrated directly in mcs., from 88 to 108.

music from an AM table-model radio the size of a shoe box, you're in for a surprise the first time you listen to the same stations through a hi-fi system. Many stations broadcast the same programs simultaneously from AM and FM transmitters. Very often it is impossible for the ear to distinguish any difference between the transmissions when they are switched back and forth between AM and FM tuners working into a hi-fi amplifier-loudspeaker combination.

Hi-fi equipment lends itself admirably to furniture "built-ins." The record player and pre-amplifier (and radio tuner) can be mounted in an end table, bookshelf, breakfront, etc. The loudspeaker enclosure can be an entire closet, an interior wall, a divider between rooms, the entire bottom of a lowboy cabinet, etc. The power amplifier, which does not require adjustment or control, can be hidden anywhere, as long as it receives ventilation. Many loudspeaker enclosures are designed as pieces of furniture, to stand by themselves.

The sound system in the author's home was assembled entirely from the well-known Heathkits. The only tools used were a screwdriver, soldering iron, cutting pliers, long-nose pliers, nut driver and hammer. The various units, illustrated on these pages, are as follows: frequency modulation tuner, model FM-3; pre-amplifier, model WA-P2; high-fidelity power amplifier, model W-5M; and dual speaker system, model SS-1.

A separate Garrard Model RC-80 record player is used. Because this set-up can be readily duplicated and adapted to any residence, it is described in detail.

The tuner and the pre-amplifier are built in flat metal boxes of the same size and matching appearance. They measure $12\frac{9}{16}$ inches long, $3\frac{5}{8}$ inches high and $5\frac{7}{8}$ inches deep and have a simulated flat gold finish. The tuner stacks conveniently on top of the amplifier. An AM tuner that duplicates the FM tuner in appearance has made its appearance since the accompanying pictures were made.

The tuner is a seven-tube superheterodyne incorporating its own power supply. The tuning assembly and the inter-stage transformers evidently were pre-adjusted at the factory, as the tuner worked perfectly the first time it was turned on. In weak-signal areas it may be advisable to have the unit "peaked" for maximum performance by a service technician who has a signal generator.

The pre-amplifier uses three dual purpose tubes. It is much more than an amplifier; it really is the control head of the hi-fi system. To it, on the input side, can be connected a record player, one or two tuners, a television set and a microphone (with which you can scare the daylights out of unsuspecting visitors). There are two output connections: one for the separate power amplifier that feeds the loudspeaker, and the other for a tape recorder. A selector switch on the front panel brings any one of the five inputs into play. Next to this switch is a master volume control.

There are two small knobs on the left marked "turnover" and "rolloff." These

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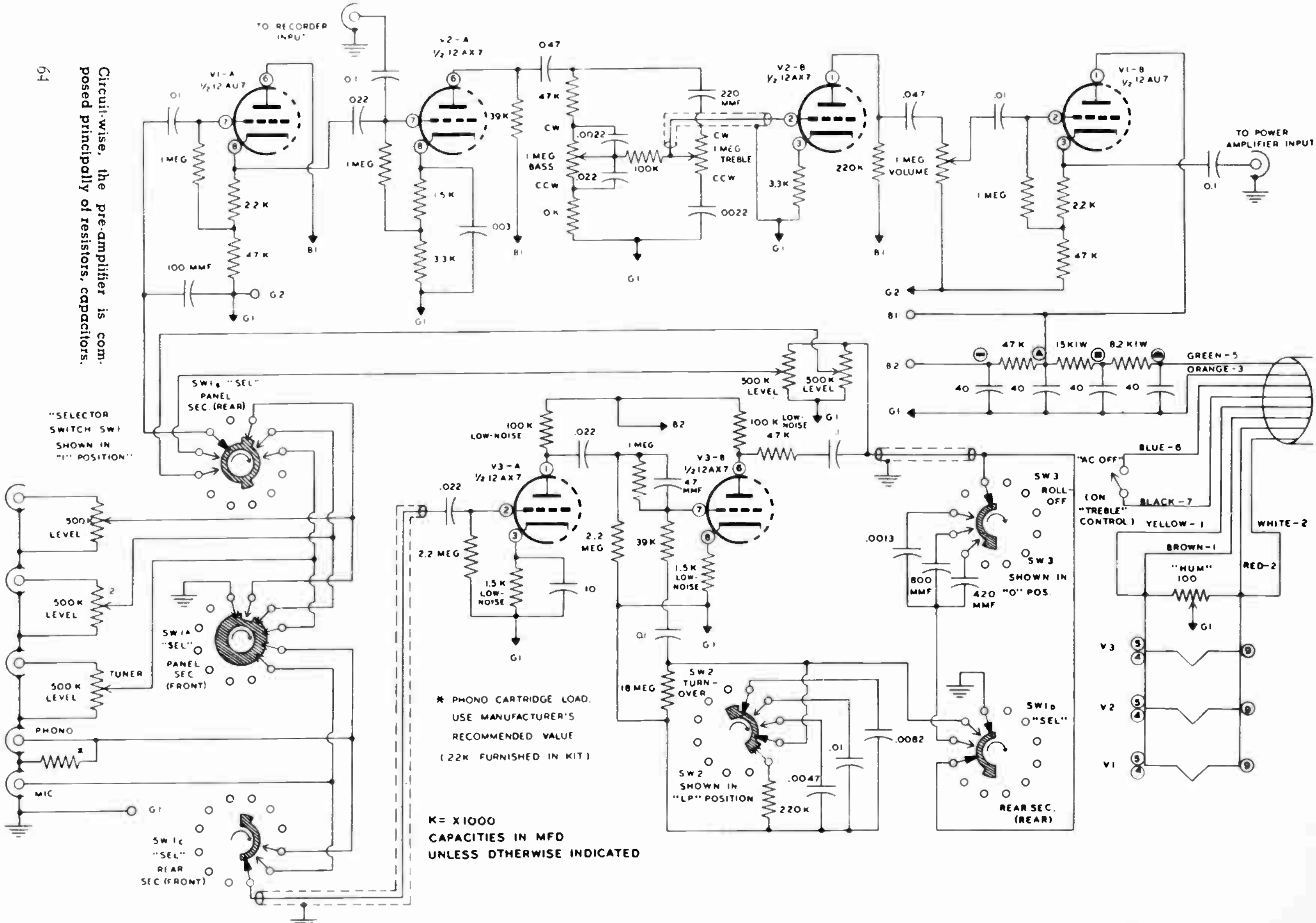
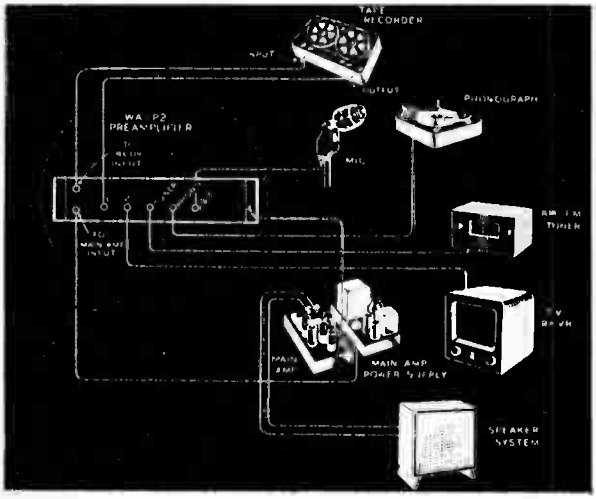
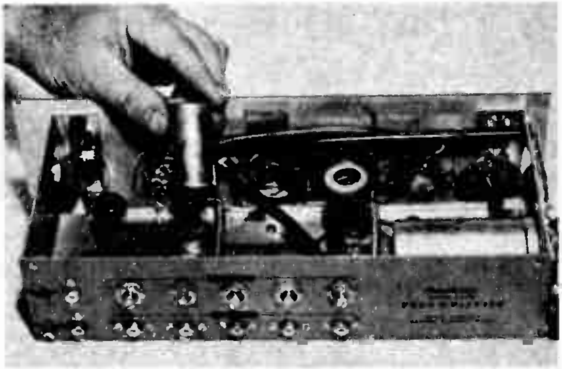
Circuit-wise, the pre-amplifier is composed principally of resistors, capacitors.



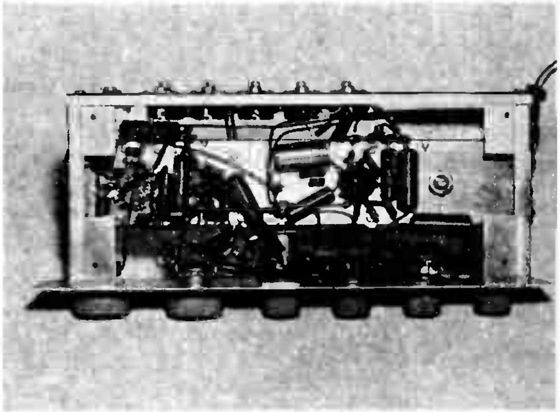
World Radio History



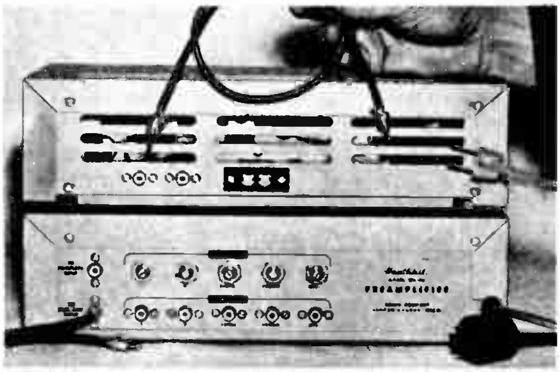
Put to its maximum use, the pre-amplifier can accommodate all "attachments" diagramed here.



Top back view of Heathkit pre-amplifier shows its compact construction. 2 tubes that are shielded.



Underside of chassis, showing part of the wiring.



Back view of FM tuner stacked atop pre-amplifier. Connection between the two is made by shielded cable with plug fittings. Large plug at lower right connects pre-amp to main power amplifier.

control the response of the pre-amplifier so that the most natural reproduction is obtained from records of differing characteristics made by various American and European manufacturers. The American part of the industry is trying to standardize disc specifications, but even if it is successful there will still be millions of existing records that require individual "compensation" in the pre-amp. This situation isn't as serious as it appears, because a record is not harmed in any way by adjustment or misadjustment of the turnover and rolloff knobs on any amplifier. Both disc and amplifier people offer this practical suggestion: "Fiddle with the controls until the music sounds most pleasing to *you*."

The remaining two knobs on the pre-amp panel are the bass and treble tone controls. If these are left in the center or "flat" positions, music sounds the way the orchestras, the singers and the conductors intended it to sound. However, no new owner of a hi-fi system can resist the temptation to twist these knobs back and forth, and if the results are somewhat weird he has only himself to blame. If music has a lot of drums in it and the bass control is pushed to the top and the treble to the bottom, the loudspeaker will all but thump across the floor. If a violin is being played and the treble control is turned way up and the bass way down, half the dogs in the county will be attracted by the high-pitched wailing. The general tendency is

[*Continued on page* 73]

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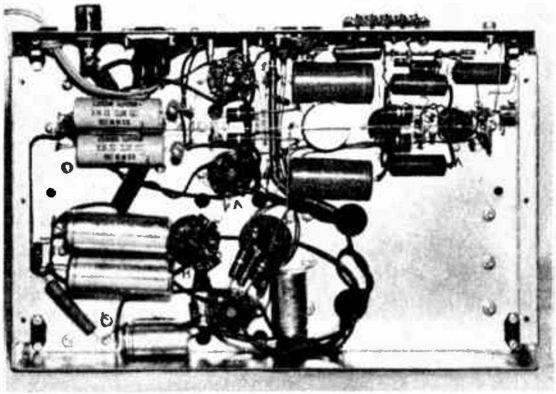
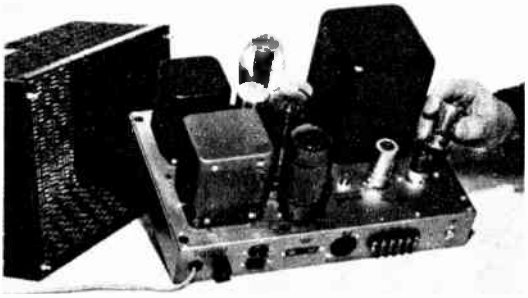
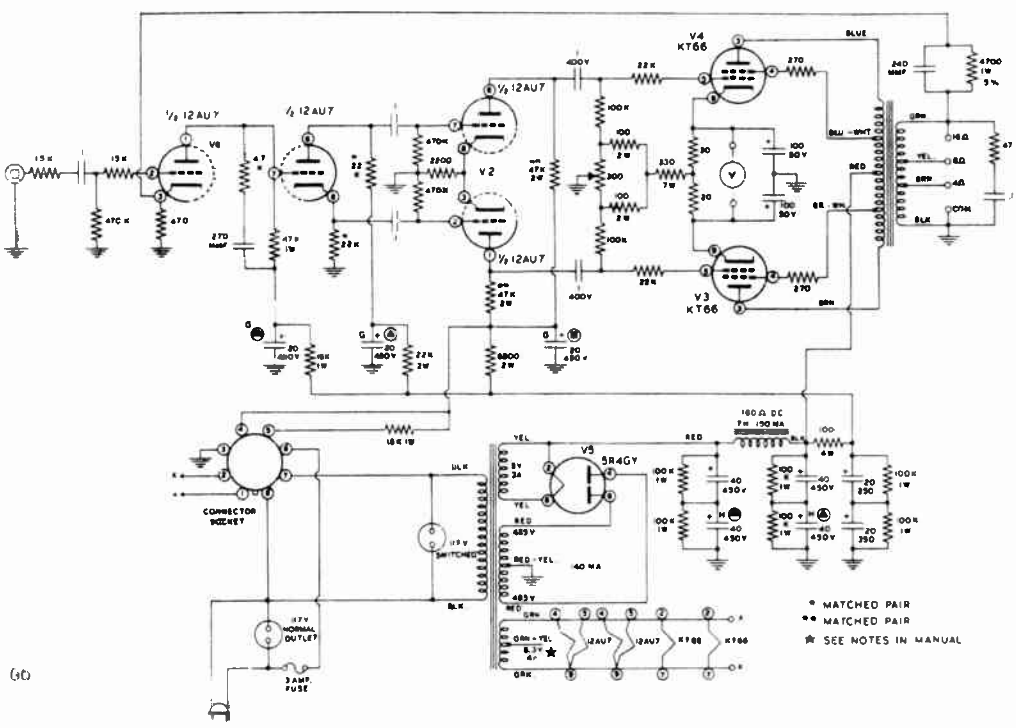




Hardware-cloth steel cover protects the chassis of the Heathkit W-5M amplifier, above left, and allows ventilation of hot tubes. Finger points to protective fuse in holder. All connections are made to bottom apron. The cover is readily removable, left. Large, heavy transformers provide its power-handling capacity. Wiring of the W-5M hi-fi amplifier is relatively simple as evident in schematic diagram and photograph directly above. The cylindrical units are capacitors.



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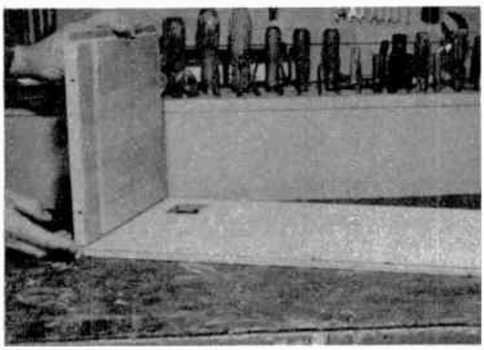
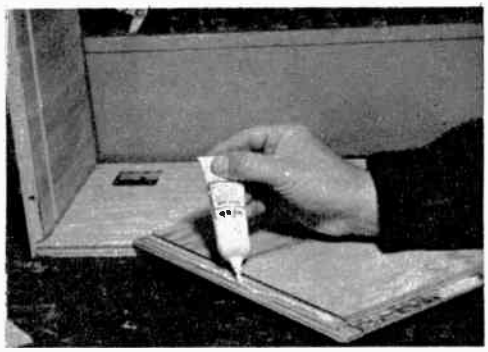
1. Here and on following pages are shown step-by-step assembly of SS-1, hi-fi speaker system. All wood parts are accurately pre-cut. The kit includes all hardware, even glue in squeeze-tube.

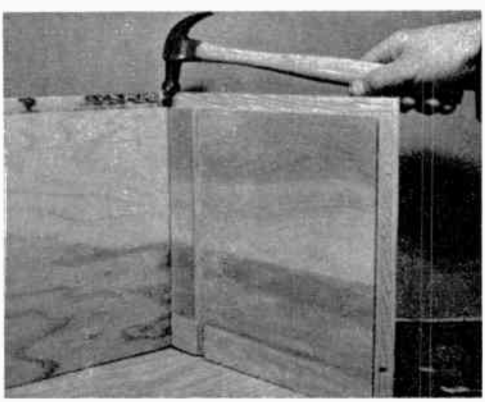
2. First step is to run masking tape along beveled edges to protect them from glue squeezed out of joints as members are joined. Glue remaining on wood makes the final finishing very difficult.



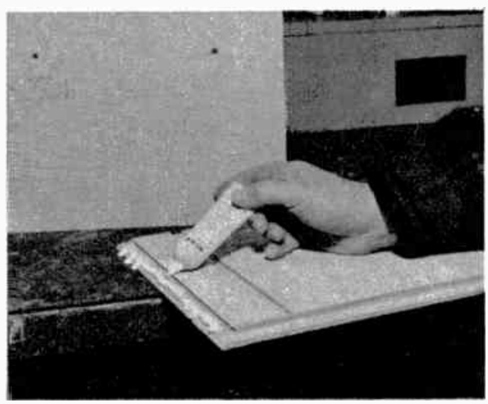
3. Back of box is placed face down on workbench and used as a form to keep the box itself square during assembly. One of the end panels is being positioned. On level table, it will stand alone.



4. Here glue is being applied to the beveled edge of the bottom panel of the box. This will be placed against the forward beveled edge of the end panel as demonstrated in picture No. 3.



5. With beveled edges of bottom and end panels hand-held, a special clamp nail is driven part —not all the way—into facing slots in bevels.



6. Glue is applied to beveled edges of second end panel and top panel. Though a little too much has been applied in this photo, it does no harm.

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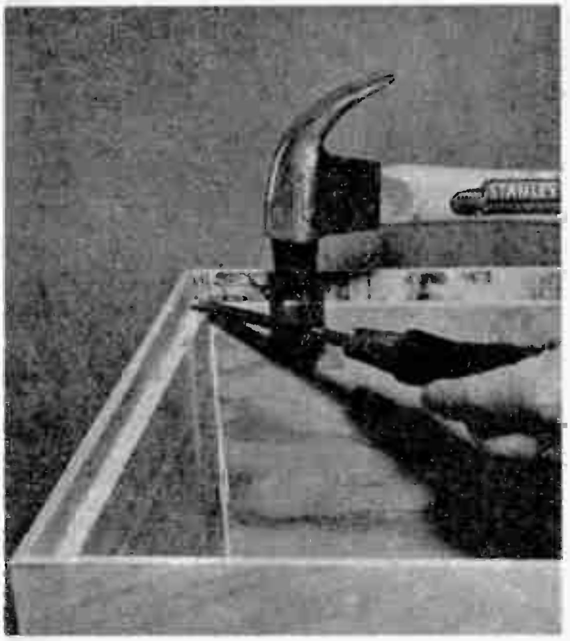
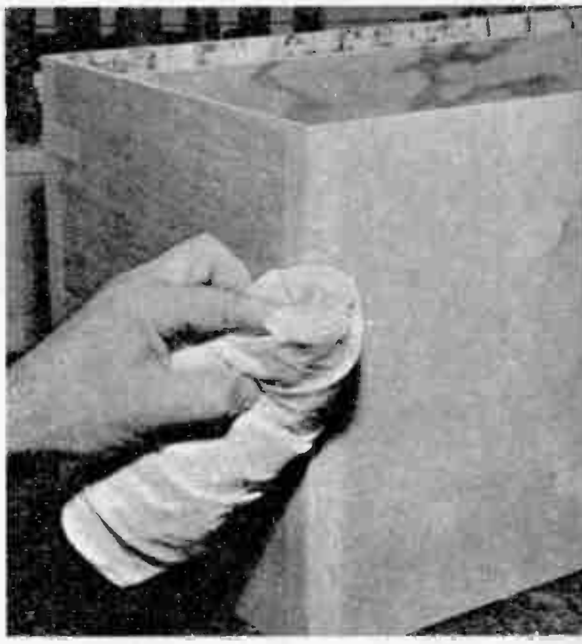


7. With ends, top and bottom of box joined, clamp nails are driven flush with recessed lips. Screwdriver blade is used to avoid damaging corners.



8. Excess glue, squeezed out of joints, is wiped away quickly before it can spread to uncovered surfaces. Allow 15 minutes now for glue to set.

9. After glue has set, masking tape is stripped away. The corner joints are now tight and sharp.

10. In preparing to place speaker mounting board, apply a generous amount of glue to recessed lip.

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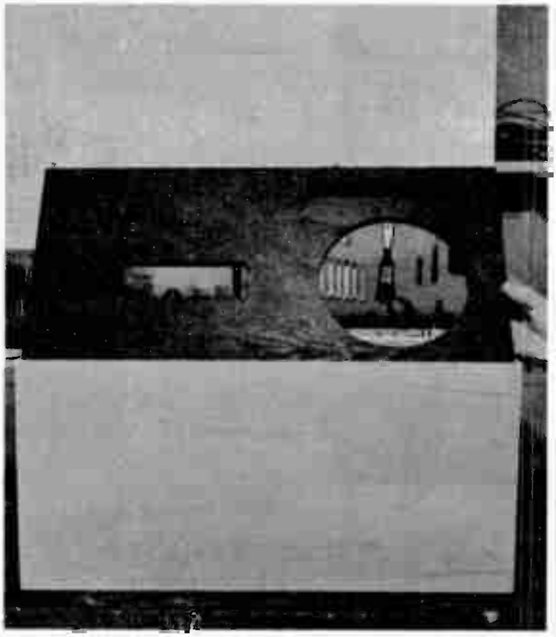
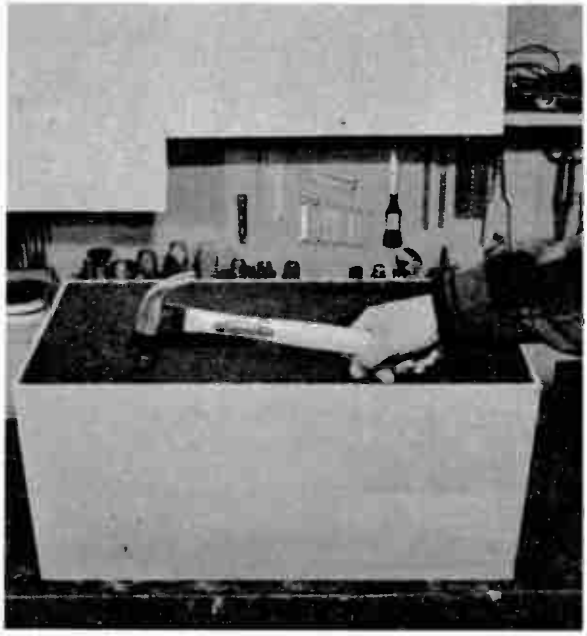
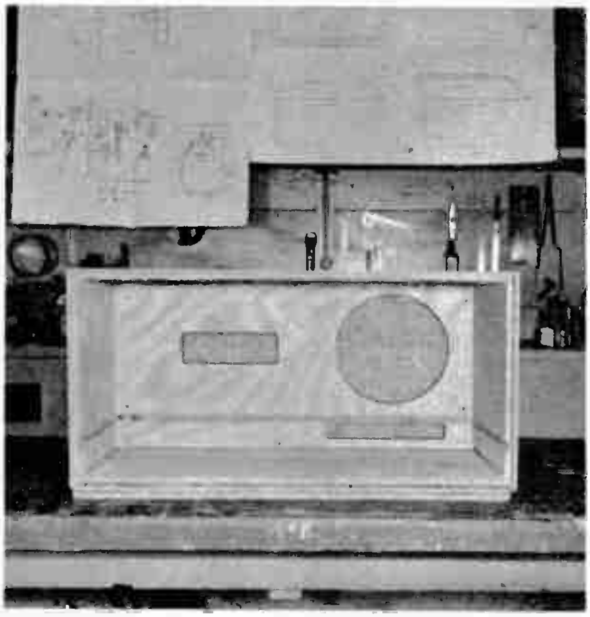


11. Speaker mounting board has round hole for cone speaker, rectangular one for horn speaker, small slot for air escape when cone speaker agitates it.



12. Dropping snugly against the recessed lips of the box, the speaker board is securely fastened with a series of closely spaced finishing nails.

13. Decorative grille cloth hides holes, readily passes sound. It is stretched taut, stapled down.



14. Slots in sides and front will support shelf that holds nothing but acts as acoustical baffle.

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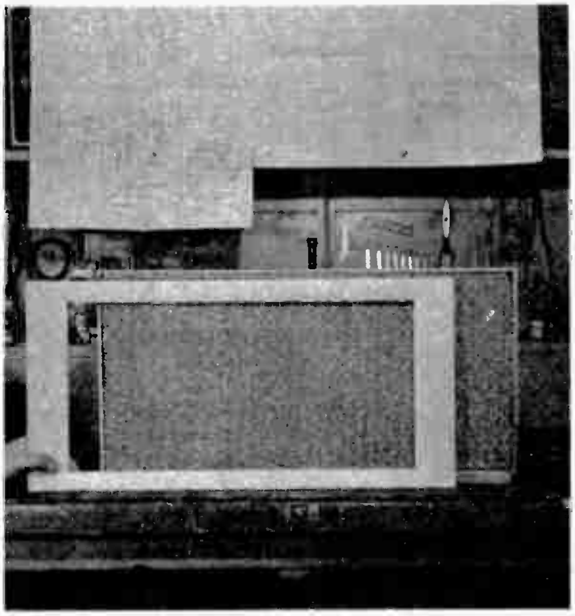
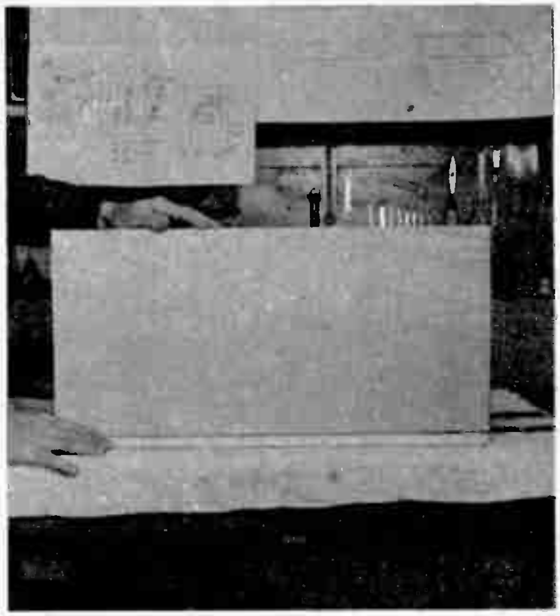
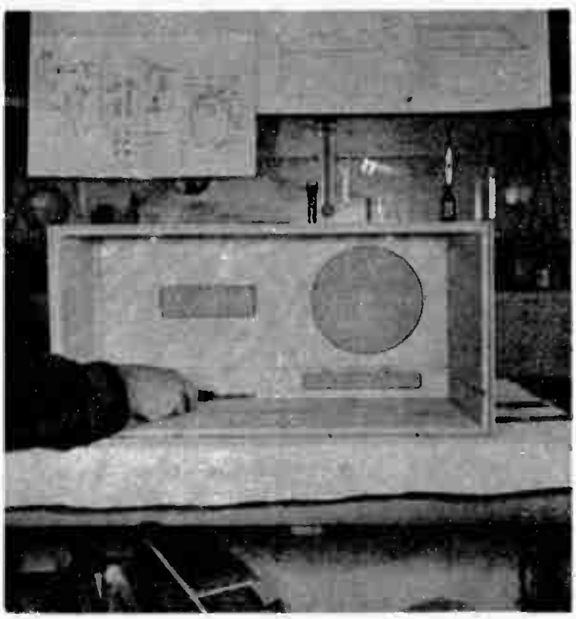
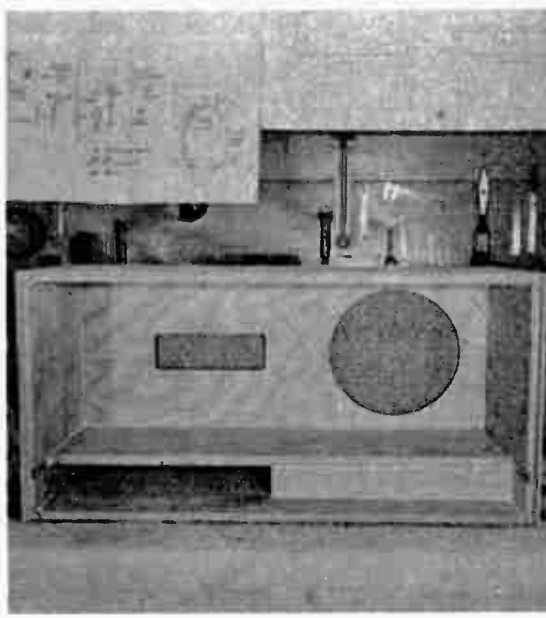




15. The front trim or frame of the SS-1 hi-fi speaker system is supplied completely assembled and it is designed to fit over the entire box-front.

16. Face down on protective cloth, the frame is positioned to meet front edges, secured in this position by couple screws passed from inside box.





17. The box can now be turned over and the rest of screws passed through the speaker mounting board and into front trim. Next comes the baffle.

18. Horizontal baffle is glued in slots in box sides and front, reinforced by short vertical piece that's screwed tight from bottom and baffle.

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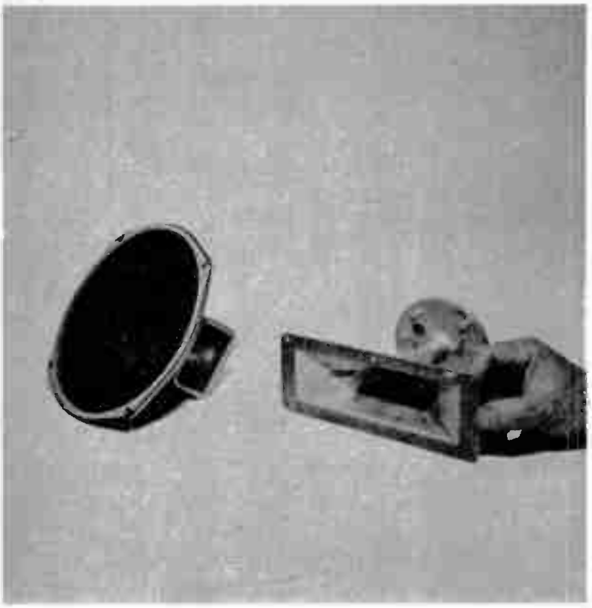
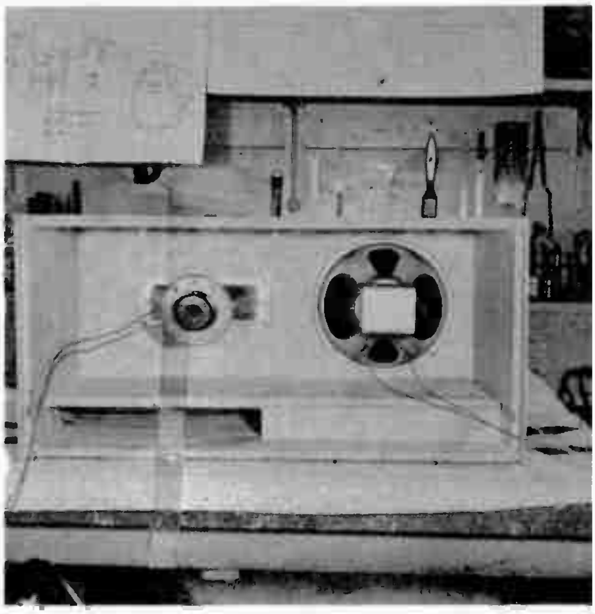
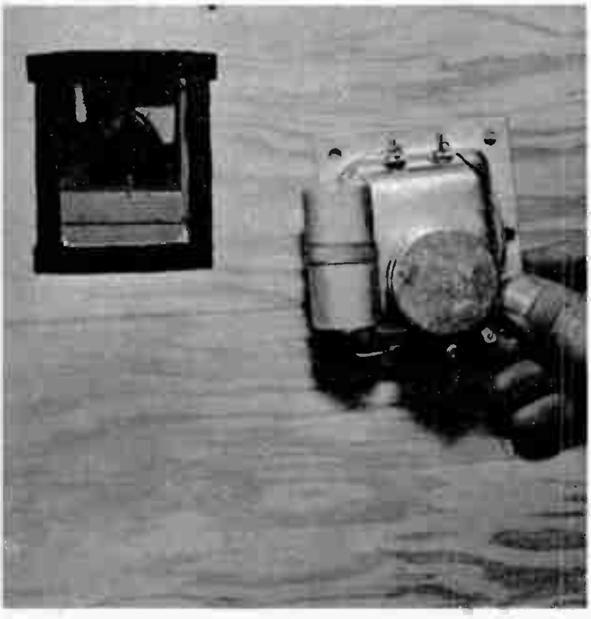


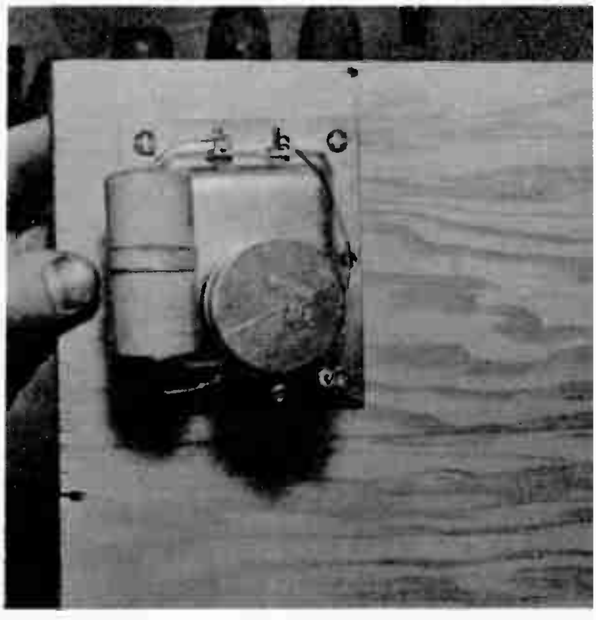
19. These are the loudspeakers supplied with the kit: eight-inch woofer, left, and little horn tweeter. Latter is of cast-aluminum construction.



20. As evident in this photograph, the woofer and tweeter are easily mounted, wood screws being used for the purpose. Note the connecting wires.



21. The back of the terminal plate holds a fixed capacitor and a variable resistor. The hole into which plate fits is edged with soft rubber strips.



22. The rubber strips act as an acoustical seal. In this photograph, the terminal plate is mounted on back surface of back cover of the speaker box.

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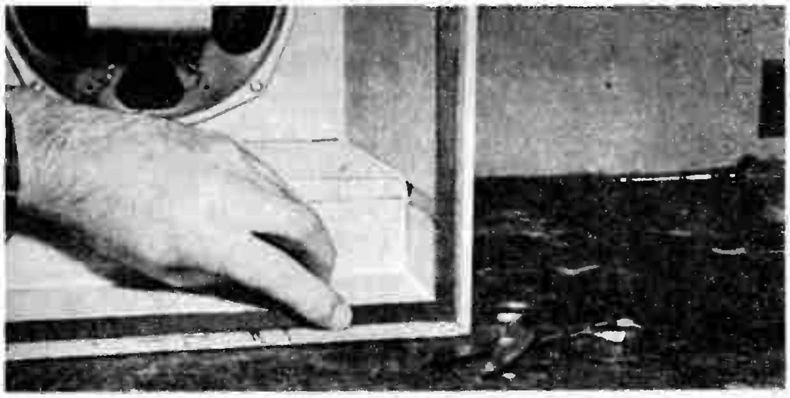
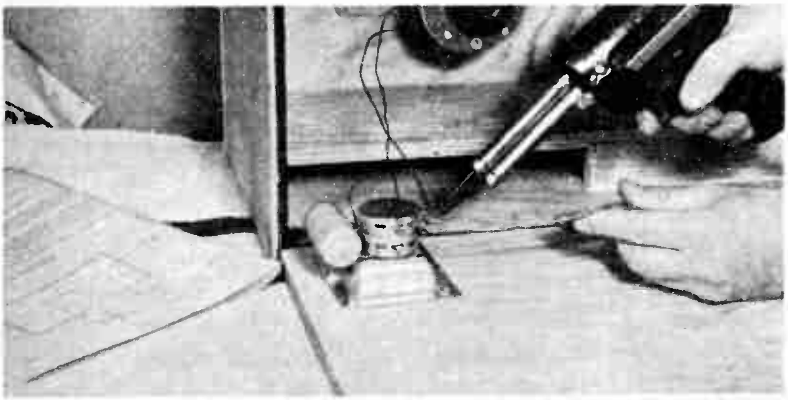
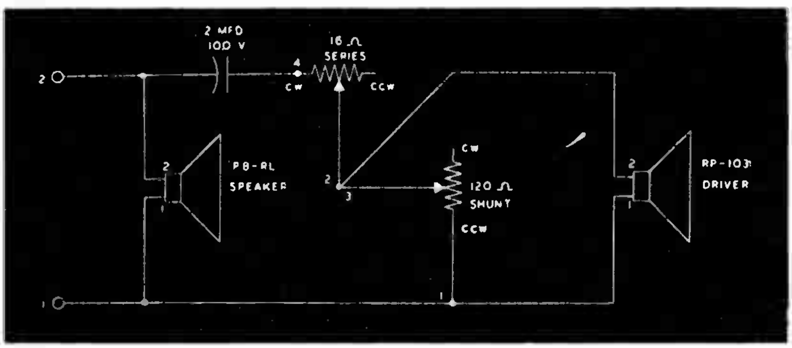


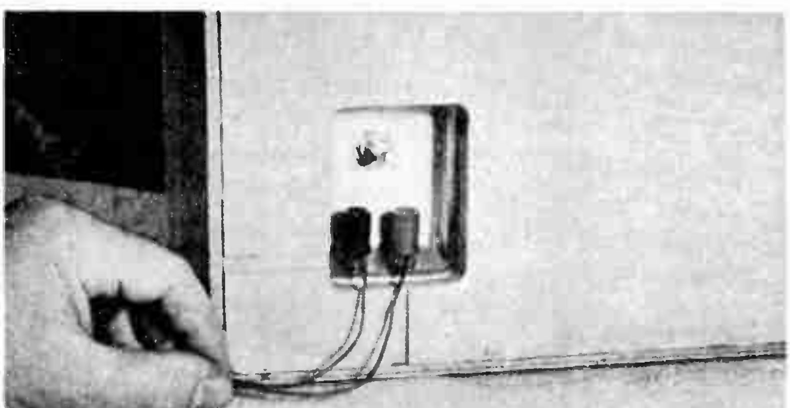
23. Recessed lip of back edges of the box is lined with rubber strip which is self-adhering.



24. With back cover close to box, final speaker connections are made to terminal plate.



25. This wiring diagram shows the loudspeaker connections.



26. Here back has been screwed into place. The two binding posts are for connection of speaker system to hi-fi amplifier. Knurled shaft adjusts volume from tweeter.

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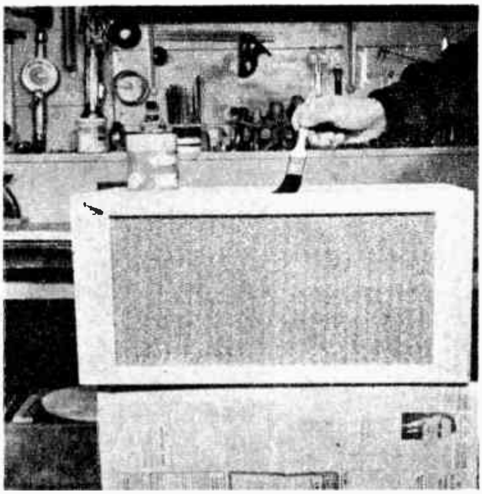
27. Although plywood panels of the loudspeaker box are furnished already sanded, a final treatment with very fine sandpaper is recommended.



28. Light color of the plywood lends itself to any finish. Here the natural grain is being preserved by application of Satinlac, a clear lacquer.

[*Continued from page* 65]

to boost the bass a little and to suppress the treble, especially with records, inasmuch as needle scratch is the equivalent of high pitched sounds.

The pre-amplifier draws its power from the main W-5M amplifier. This is a heavy unit, weighing about 27 pounds. Given the right loudspeakers it can fill a theatre or a ball park with sound. Tamed down to interior house level, it barely coasts. In this relatively unloaded condition, it delivers undistorted sound. The value of the large reserve power (estimated at 500% by the manufacturer) becomes evident when a heavy bass passage occurs in music; the low tones come through strongly and clearly and make a tremendous impression.

It has long been known that a single loudspeaker cannot do full justice to low notes, middle scale notes, and high notes. The practice has been to use two or more speakers of different sizes, or a combination speaker having the equivalent of two or three units mounted on the same axis on a common frame; hence the name "coaxial" speaker. The larger speaker, which favors the low notes, is popularly called a "woofer"; the smaller, which favors the high notes, is a "tweeter." When a hi-fi fan gets really serious about his hobby, he thinks nothing of cascading two or three woofers and two or three tweeters of varying sizes, and running them all at the same time with the power amplifier wide open. If he lives in the woods a mile from the nearest neighbor he can enjoy (?) the same sensation as if he were sitting in the front row at a concert of a 200-piece orchestra.

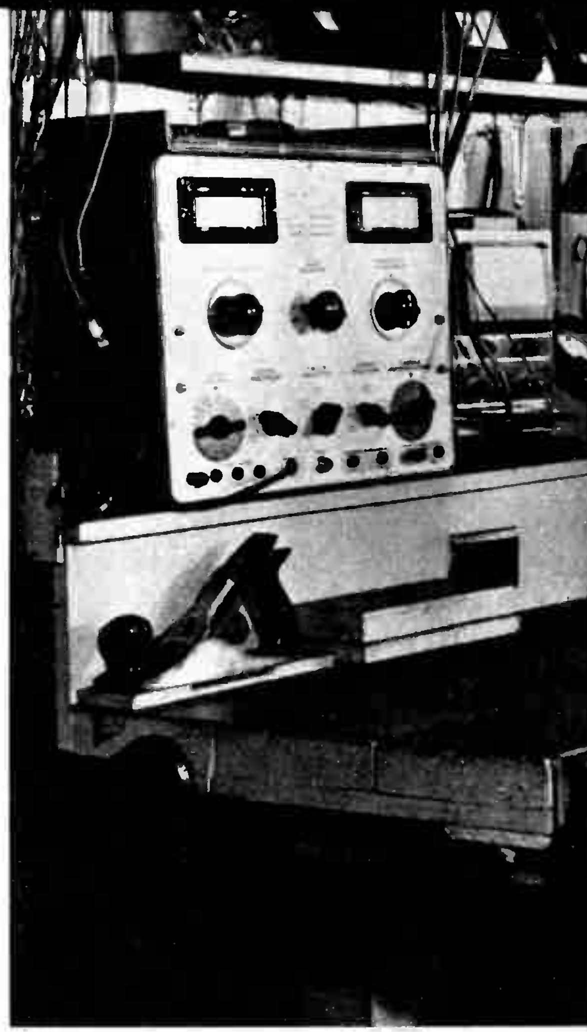
For most homes of ordinary size, a simple woofer-tweeter duo is entirely satisfactory. Not wanting to "load" the living room with a huge cabinet-type enclosure, the writer chose the very compact but acoustically efficient "ducted-port, bass reflex" box of the Model SS-1 system. Measuring only 11½ inches high, 23 inches wide and 11¾ inches deep, this is relatively inconspicuous. Furthermore it makes a fine "tuning seat" when the family decides it would rather see Sid Caesar than hear Mozart that night!

Inside the box are an eight-inch speaker of the cone type and a separate high-frequency speaker of the horn type. The woofer is always in play, but the tweeter's contribution can be adjusted from full to nothing by means of a control on the back of the box. The combination of this control and the treble control on the pre-amp enables the listener to have as much treble as he or she wants.

Because this speaker system is a rather new kit, its assembly is shown in some detail in a series of progressive pictures. Although the job is not much more than an exercise in box making, this particular box must be absolutely tight to function properly as an acoustic chamber. •

World Radio History

Tools of the Trade



ELECTRONICS is a complicated science, and to understand it you must study the theory books pretty diligently. To apply it practically, you need to be manually skilled, because most components are small and must be assembled and wired with care. Fortunately, you can readily develop this skill with practice in the use of rather simple and common tools. The more adept you become with the tools of the trade, so to speak, the more knowledge and enjoyment you will obtain from the equipment you build, adjust, maintain or repair.

In many technical schools the emphasis on theory is so great that some students never get around to learning the nuts-and-bolts aspect of electronics. The writer has encountered graduate engineers who can solve complex equations in a jiffy, but have difficulty making a tight connection with a soldering iron. This lack of appreciation of *practical* electronics is reflected only too clearly in the haphazard design and construction of television and radio sets, in particular. Tubes are put in utterly inaccessible places, parts are cascaded and layered, and wiring is strewn about, all without the slightest regard for subsequent trouble-shooting and the need to remove and replace components when they become defective. In some TV receivers, the mere changing of a blown-out fuse, which by itself costs only a dime, calls for the following: pulling off the front panel knobs, removing the chassis bolts, unscrewing the back safety cover, disconnecting the loud speaker, pulling out the heavy chassis, turning it over, digging in a rat's nest of wires to find the hidden culprit, unsoldering it, soldering in a new fuse, and then repeating the whole business in reverse.

Most of the tools used in electronics work are available from regular hardware stores, some specialized items from radio supply houses. One of the big radio mail order catalogs contains 16 pages of tool listings, four of them devoted to soldering irons alone.

The basic tools needed for getting started in electronics, particularly in kit construction, are pictured on the pages that follow. Some dos-and-don'ts on their practical application are also shown.

An electronic experimenter never really stops buying tools. As new techniques and equipment embodying them appear, he will buy the special little tools they might require. For example, until a few years ago, a man could get by very nicely with a

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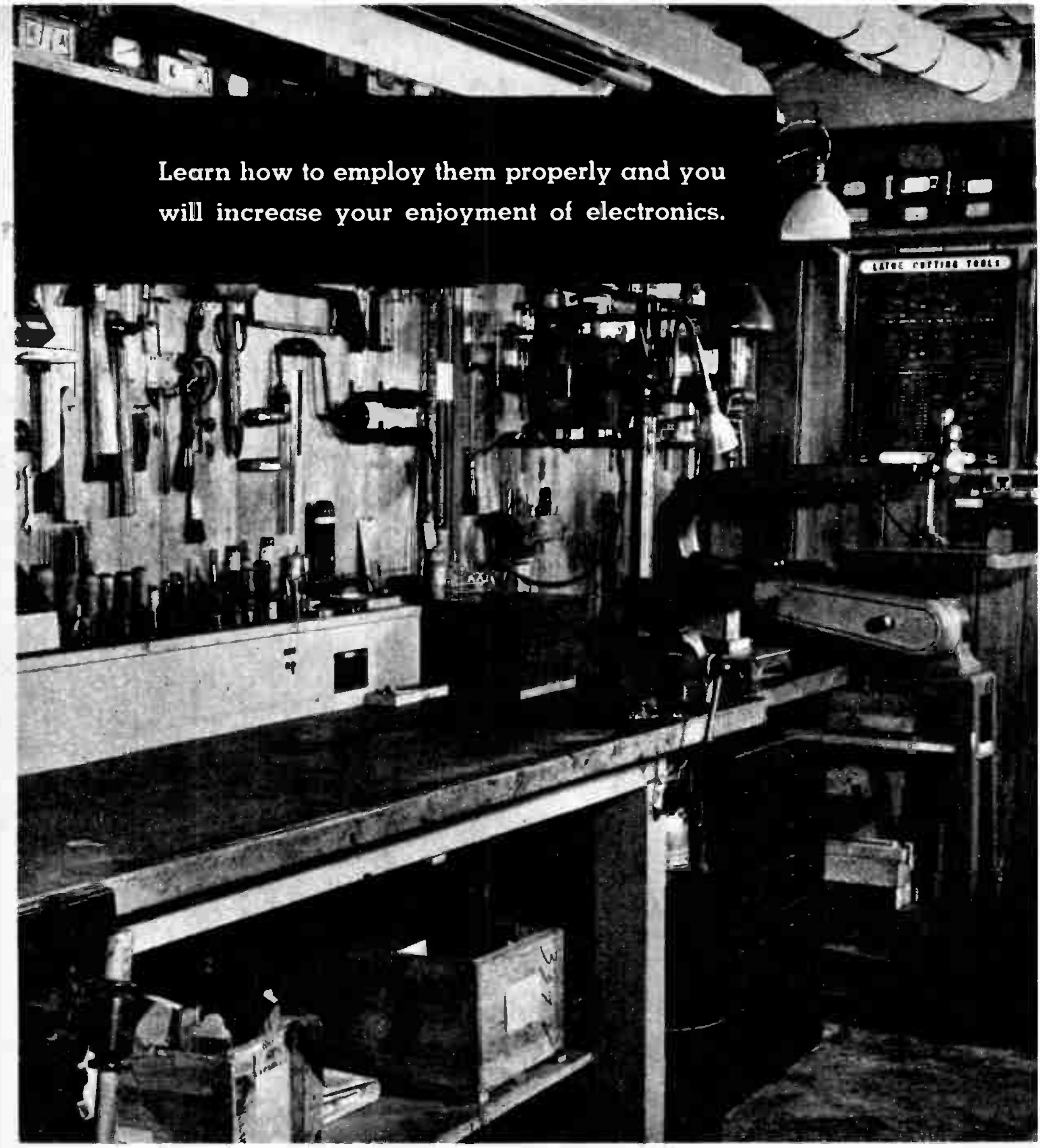

Learn how to employ them properly and you will increase your enjoyment of electronics.

single soldering iron of the straight-barrel, resistance-heating type, having a sturdy copper tip ⅜ or ½ inch in diameter. As tubes and their sockets started getting smaller, and associated components, too, this iron became much too big. So he acquired a very slender one of the pencil type, with a tip small enough to get into a miniature tube socket without burning up half the capacitors and resistors surrounding it. Today, a technician thinks nothing of having three or four irons of different sizes and shapes.

No one ever has enough screwdrivers. You need short ones and long ones, thin ones and thick ones, and certainly two or three to fit the crossed slots of Phillips head screws. •

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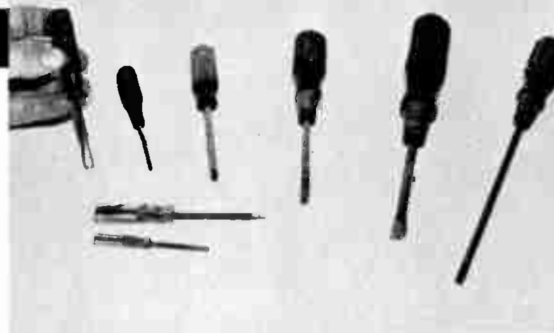
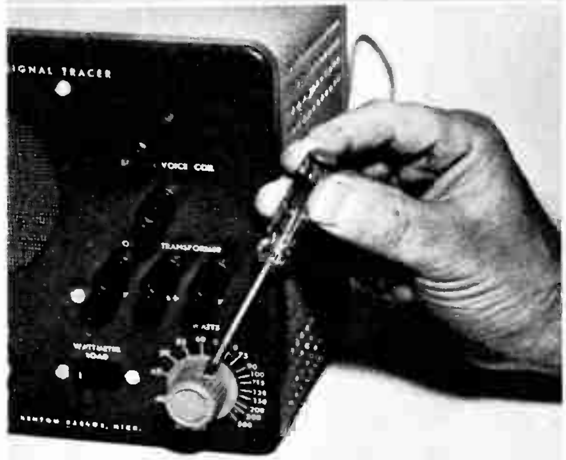
SCREWDRIVERS

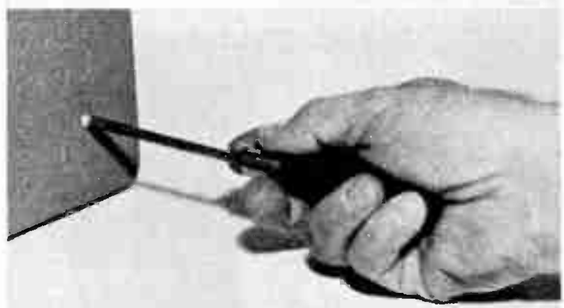
These eight screwdrivers are about minimum for the ordinary run of assembly and disassembly work on electronic equipment. Blade lengths are from two to six inches; blade thicknesses to fit the slots of common No. 4, 6, 8 and 10 screws. Very small, thin screwdrivers, left foreground, are needed to set screws in knobs, dials. Tool third from left is Phillips head screwdriver to fit cross-slotted screws. Handles are wood or plastic.



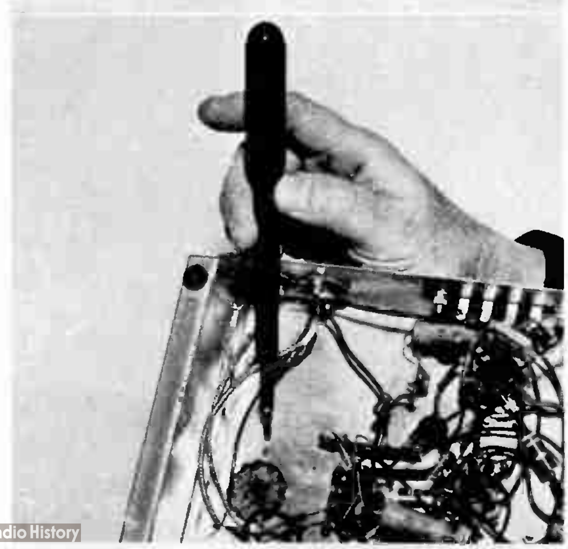
For small screws, this is most convenient method of gripping and turning the screwdriver. Press with the thumb, at the same time rolling it forward slightly. Recessed set screws of knobs and dials often require that the blades of standard screwdrivers be filed down to fit tight openings. Be careful not to churn out the threads when you are tightening screws in molded plastic knobs.



When it is necessary to turn a "tough" screw, use this grip. Get the handle's end into base of palm, under thumb joint, and support the ferrule (part into which blade fits) with the thumb and forefinger. You can thus exert both pressure and turning effort at the same time. Leverage in a screwdriver is determined by handle size; the greater its diameter, greater the lever action.



A spring-blade screwdriver, or a regular screwdriver with screw-holding attachment is invaluable for places that are too crowded for fingers.



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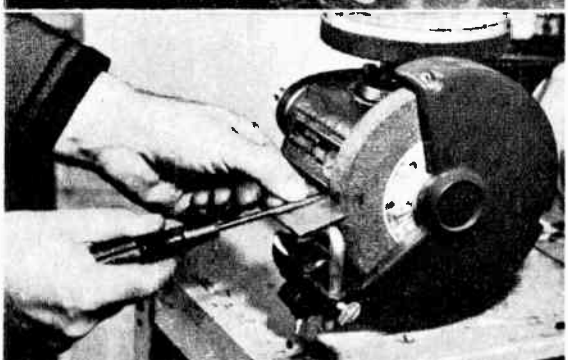
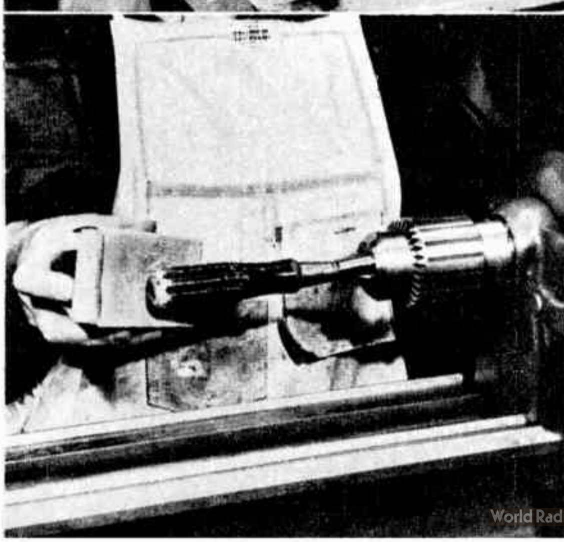
It is important to keep the tip of the screwdriver blade flat and square. It is bound to wear with use, and therefore should be touched up frequently. A sure sign that it needs attention is its tendency to deform the slots of screws when pressure is applied. A few strokes of a fine file usually do the trick. Remove any burrs left by rubbing the blade lightly over fine oilstone.



A screwdriver that has been mistreated or neglected may need to be re-formed on power grinder. Hold blade straight into wheel so that new end surface will be at perfect right angles to shank. If the end is off skew, it will slip out of screw slots.



Because it is pressed into the palm of the hand, the end of a screwdriver handle must be perfectly smooth. It will stay that way if tool is used only as a screwdriver, and not as a chisel to open boxes. An old or worn handle can be restored in a few minutes. Chuck it in a lathe and roll a sandpaper block over the end, as shown. Use very fine paper to obtain a satin-smooth finish.

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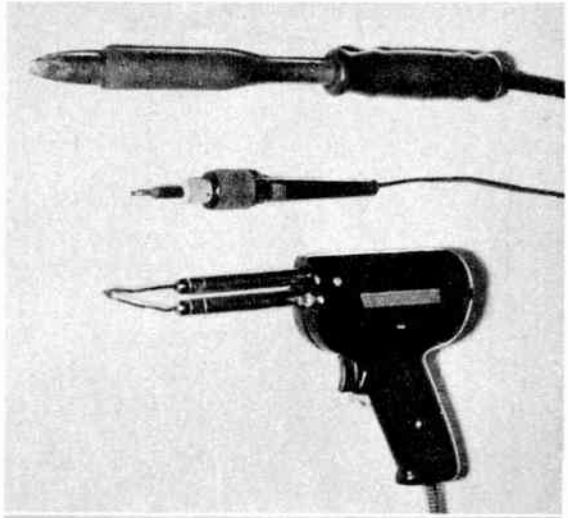
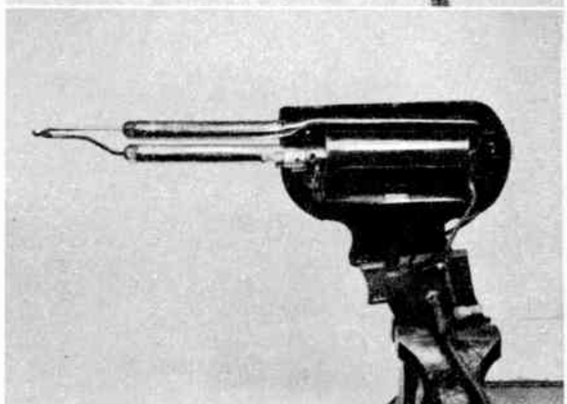
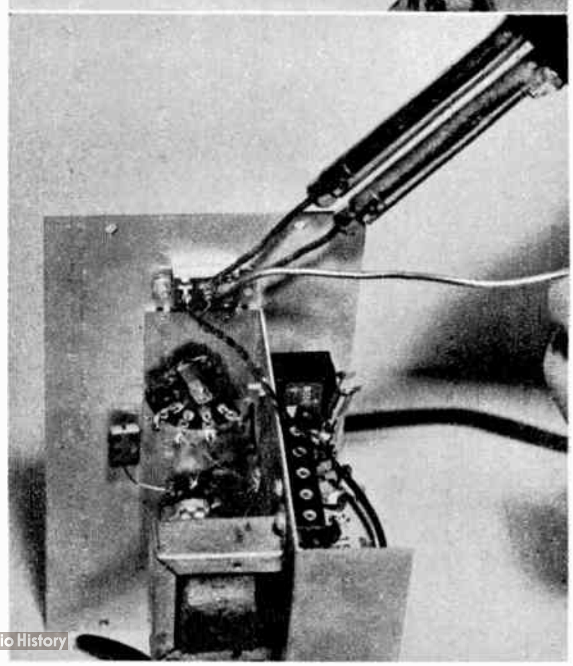
SOLDERING IRONS



Three popular types of soldering irons used for wiring electronic equipment. Top: a heavy-duty straight-barrel resistance iron, about 100 watts. Center: pencil-style iron, with removable screw-in tips. Bottom: gun type; "trigger" is line switch.



Gun-type iron is actually a step-down transformer. Primary winding, connected to power line, consists of many turns of fine wire. The secondary, running through and around primary, is a U-shaped loop of heavy copper tubing, terminating at the left in a copper tip. Step-down transformer action reduces voltage to about one volt, and low resistance of copper tubing and the tip permits current flow of 100 amperes or more. This current heats tip to solder-melting temperature in 3-4 seconds. Quick-heating action of gun-iron saves time and money; current is on only when trigger is squeezed.



In soldering, be sure joints are perfectly clean. Solder, a mixture of lead and tin, is formed like a tube, filled with rosin paste. Rosin, or "flux," prevents joints from oxidizing when hot iron is applied. In typical soldering operation, securing wire to a switch terminal, as shown, apply end of solder to joint and then hot tip of iron. As solder melts, hold iron in position until brownish rosin burns self out. Remove iron and solder and let molten solder "set" for 2 to 3 seconds. Angle the chassis so melting solder tends to run from—not into—device being connected.

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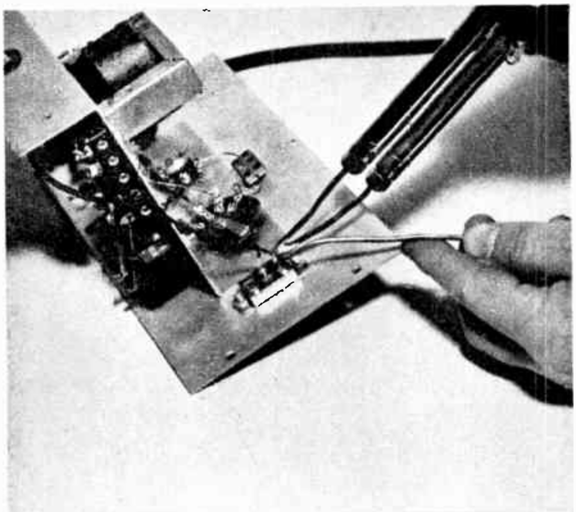
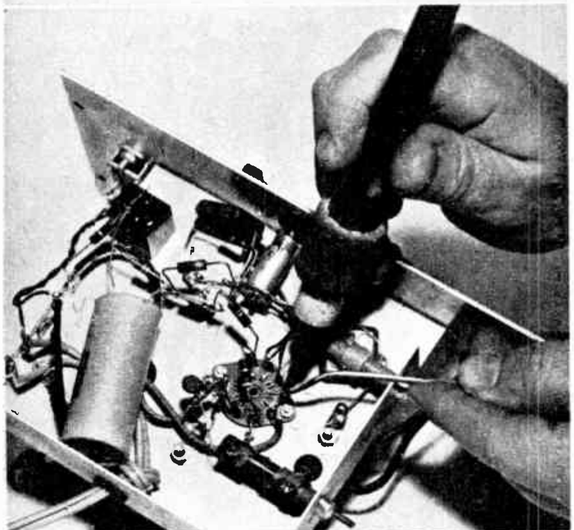


DON'T! If chassis is placed in this position, melting solder and rosin will run into the switch, possibly fouling up contacts inside. Remember that hot solder flows just as freely as water.

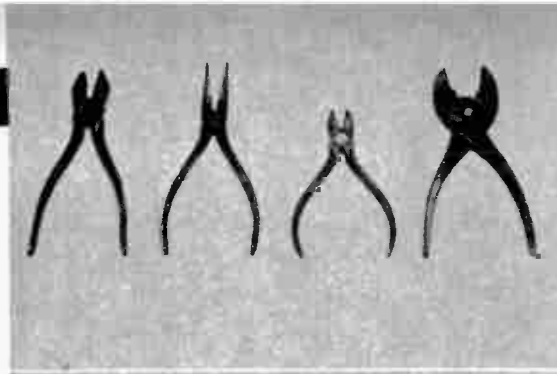


Pencil-type iron is indispensable for making or loosening connections in tight spots like this.

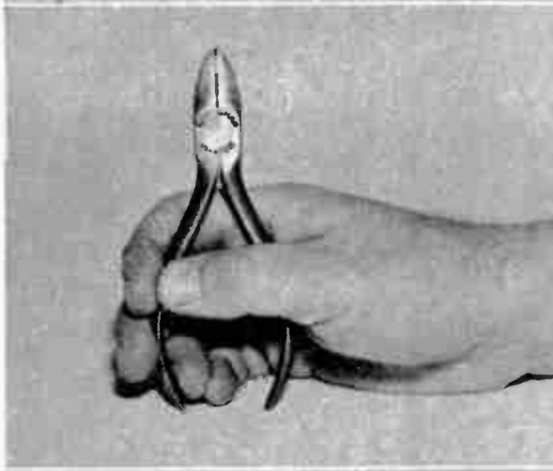
Tips of soldering irons must be kept smooth and clean. Frequent filing eleminates pitting. Use a fine file. To "tin" a tip after cleaning, plug in the iron and hold solder against it as it heats up. Copper wire loops of gun-type iron are readily replaceable. It is ordinarily impossible to solder aluminum. Solder merely forms globules on it, which run off. The tips of all soldering "irons" are made of copper; they're not iron at all.

World Radio History

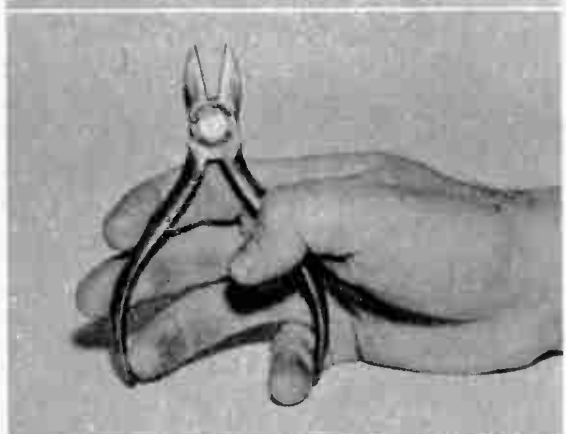
PLIERS



Left to right: 6-inch "electrician's pliers," with blunt flat nose and side-cutting jaws; long-nose pliers, having tapered, pointed ends and no cutting edges; diagonal side-cutters; slip-joint or "gas" pliers. With these four tools, you can do all holding and cutting jobs normally encountered in electronics assembly and repair work.



Side-cutter is probably most frequently used of all pliers. Shown is proper position of fingers for quick manipulation of handles. Note that the right handle nests in crotch of thumb and left handle is between forefinger and middle finger, on outside, and the bottom two fingers on inside.



To open side-cutters without dropping the tool, merely straighten the fingers, while bending the thumb over right handle. To cut, close fingers.

Because jaws are sharp-pointed, side-cutters can be used in close quarters for trimming ends of connections. This tool is intended for relatively light wire, no larger than No. 18. That is the size of "bell" wire and stranded wire usually used for lamp cords. For No. 14 wire and larger, use cutting edges of electrician's pliers. DON'T use side-cutters for holding, squeezing or as wrench.

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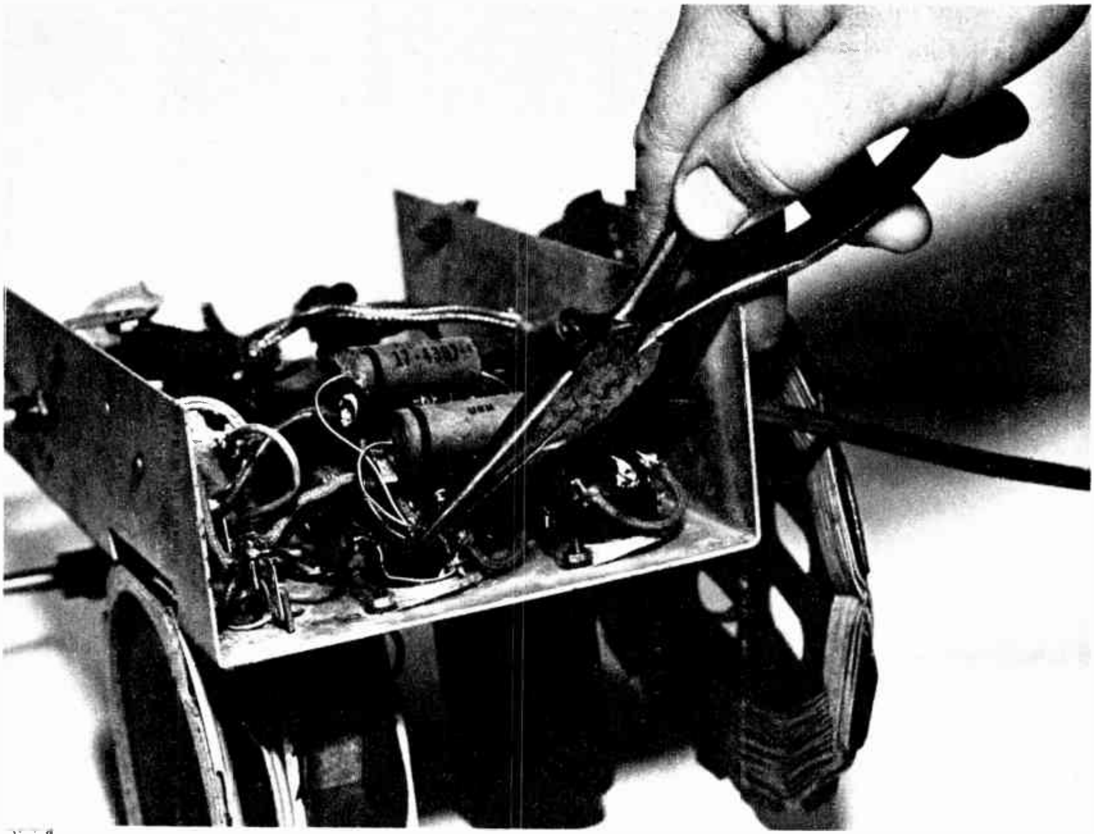

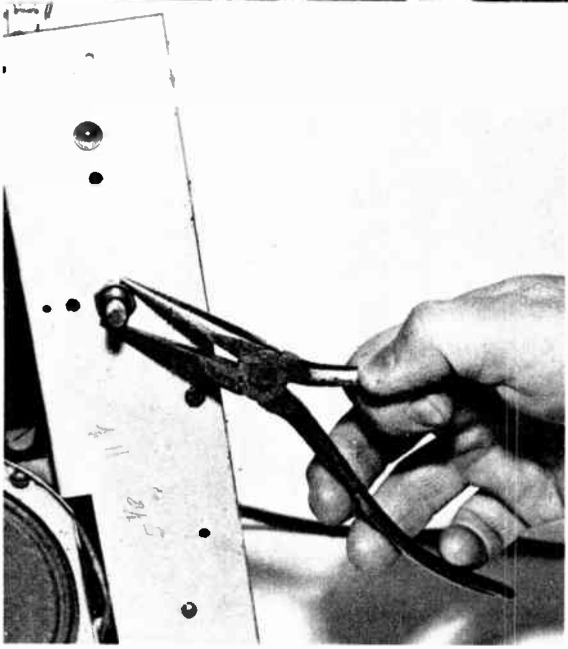

Long-nose pliers are for light bending and holding. Use them especially to place wires in the holes of soldering lugs and terminals and avoid the use of fingers for the purpose. Oil of skin may make soldering joint difficult or impossible.

DON'T use long-nose pliers on sizable nuts such as those to be found on volume controls, switches, etc. It is sure to twist the tool's fine ends out of alignment and render them useless for fine parts.

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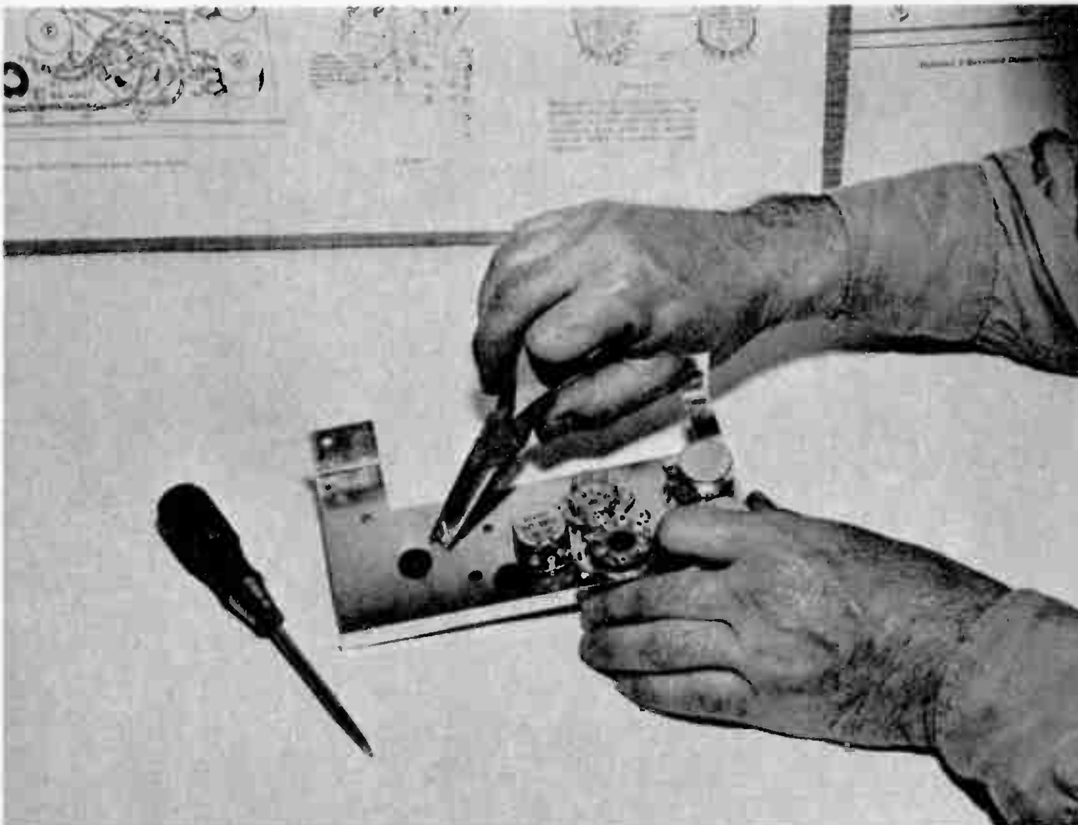
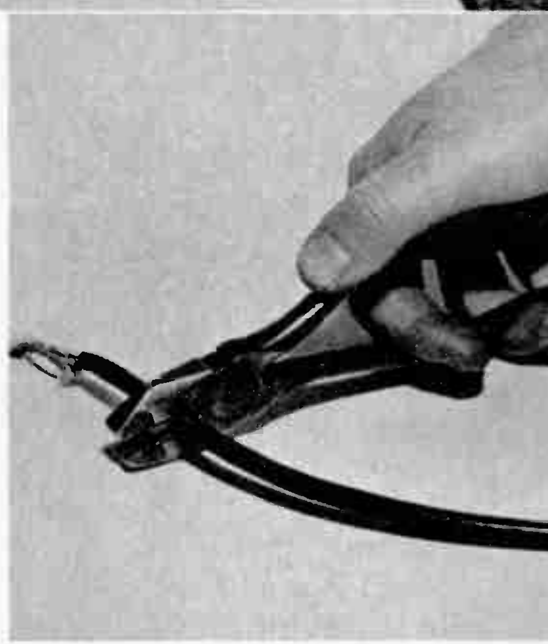
PLIERS



It is safe, however, to use long-nose pliers for very small nuts, although a wrench is preferable.



Electrician's pliers are for cutting heavy wires. Tool gets its name from its original use with No. 14 and heavier wires used for power circuits.

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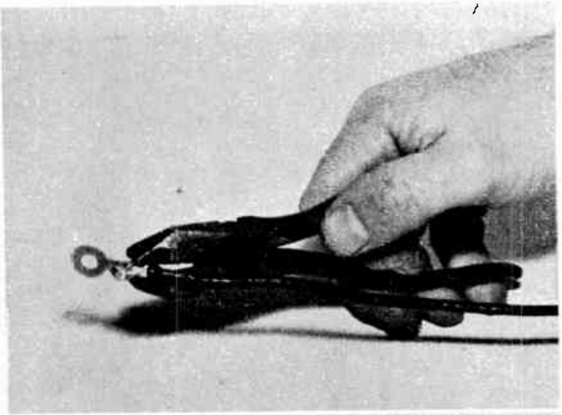
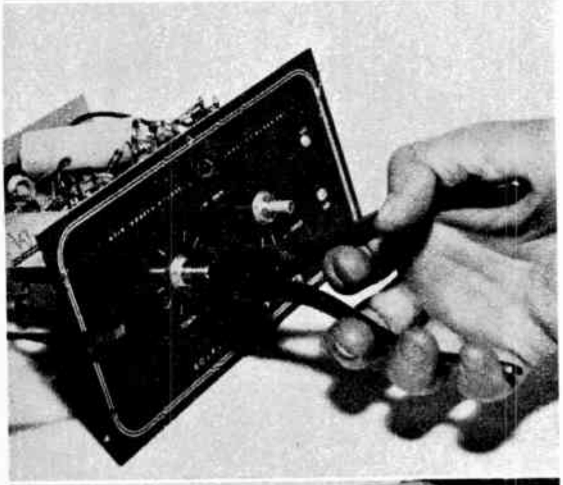


Blunt, strong jaws of electrician's pliers are also fine for holding and squeezing jobs. Typical use for them is to close the ends of a terminal lug around the end of the wire that's soldered to it.



Flat jaws afford a good grip on hex nuts if the shaft of the control device is not so long that it will extend out into the joint of the tool.

Serrated jaws of slip-joint pliers are designed to grip round objects. This tool is most useful for bolts, antenna rods, instrument shafts, etc.

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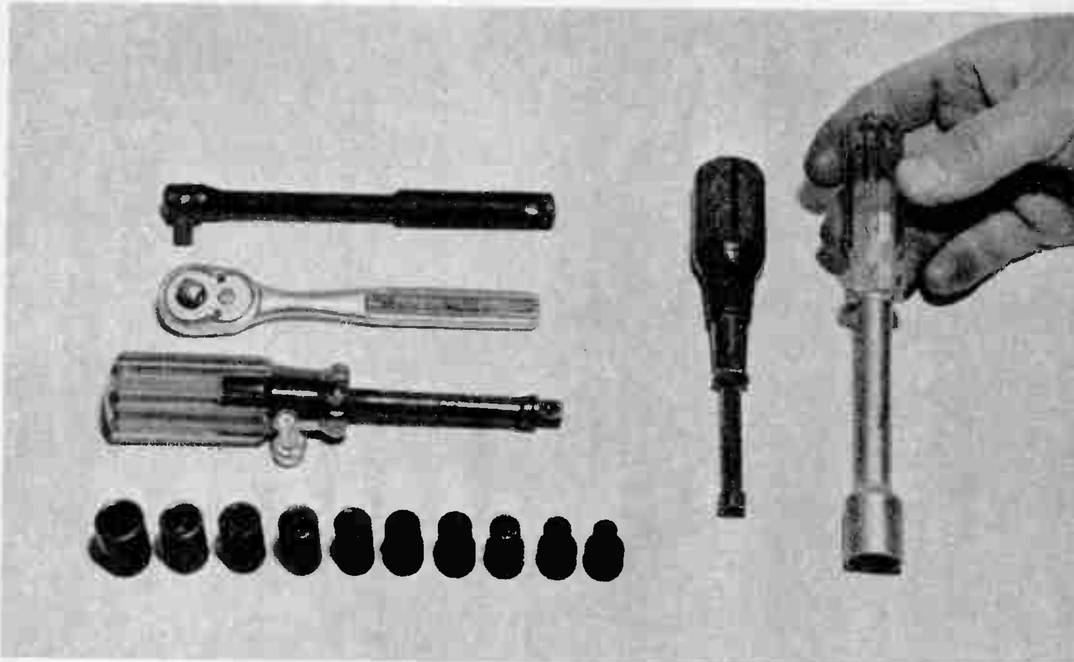
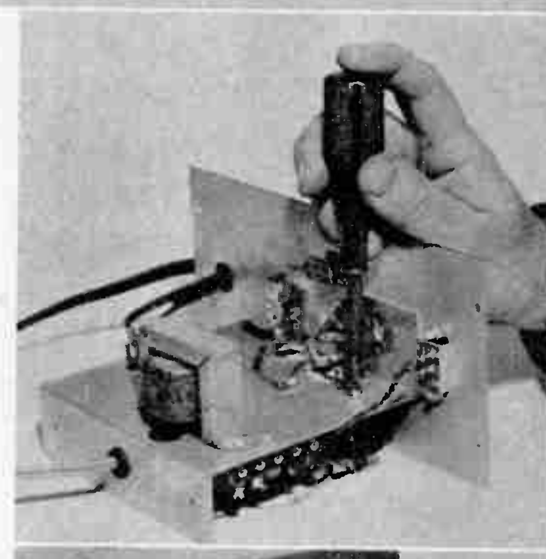
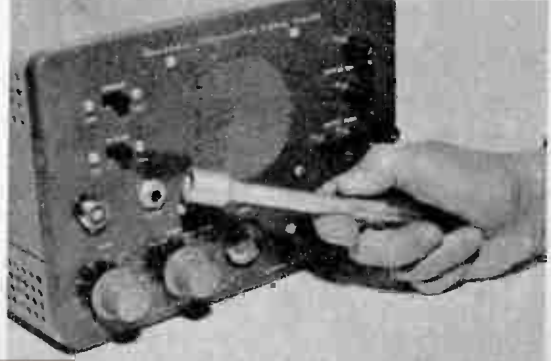
WRENCHES



Combination spread out horizontally, left above, is a ratchet socket wrench set. Individual nut wrenches, 3/16 to 7/16 inch in size, bottom row, snap on square ends of any of three holders above them. Top, adjustable angle handle; center, ratchet handle; bottom, screwdriver-type driver. This is an extremely useful handful of tools. Individual nut-drivers, on right, are much like screwdrivers. One on extreme right has a hollow shank and is especially designed for volume control shafts.



Most common hex nut found in electronics-chassis assembly is ¼ inch. Nut wrench in this size is particularly handy. Use just like a screwdriver.



Superior to pliers for tightening and loosening large hex nuts of jacks, switches, volume controls, etc., is a hollow handle wrench. It does a fast job without scratching panel or marring nut itself.

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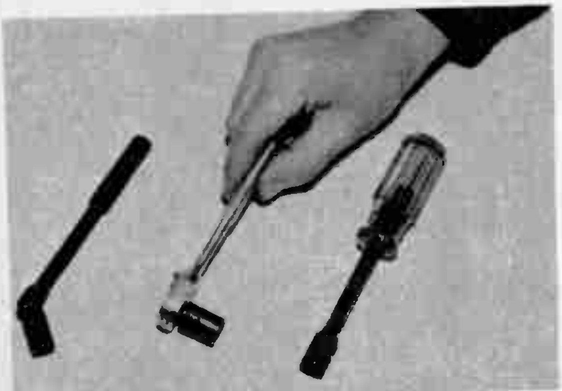
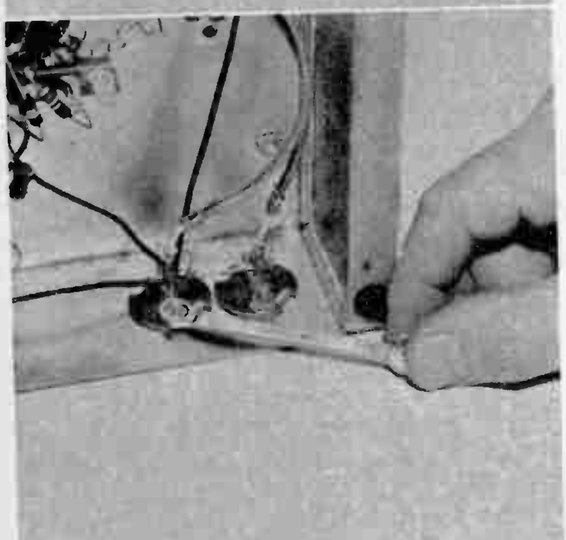
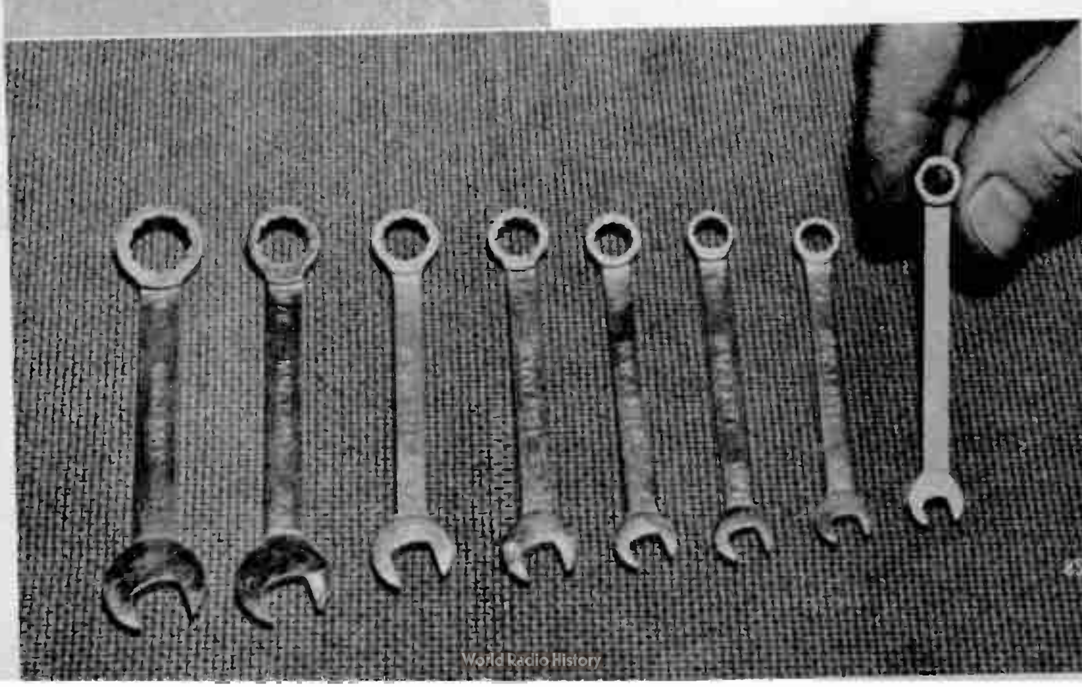


The three handles of the socket wrench set give a choice of driving angles. Ratchet handle, in center, is reversible for forward or back action with same motion. The angled handles afford great leverage; be very careful not to overtighten nuts.

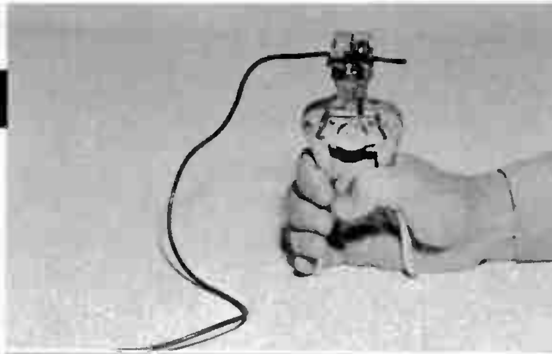


The little double-ended wrenches, shown directly below, constitute an "ignition set," so-called because they were originally designed for auto repair and maintenance. As shown at left, they solve the tightening problem in areas too small for handle-type wrenches. Although they appear small, their length gives more than enough leverage.

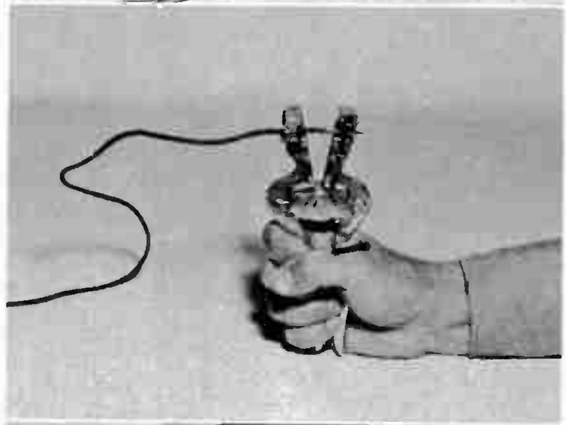


World Radio History

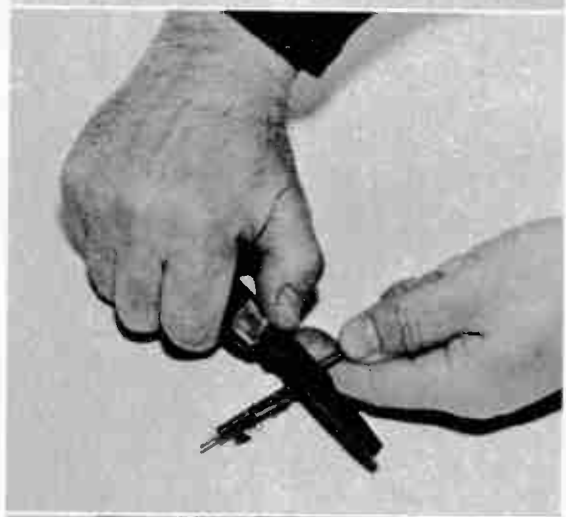
INSULATION STRIPPERS



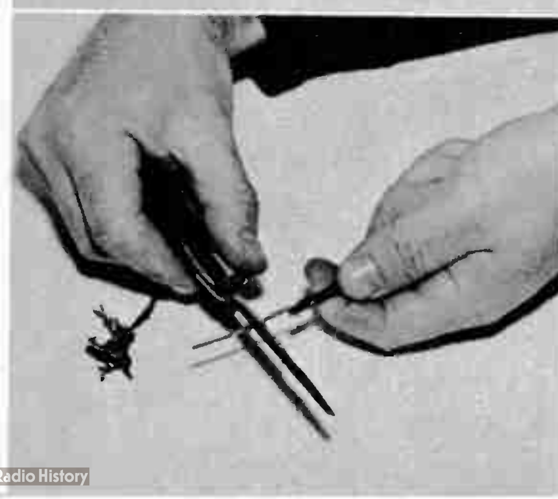
When wiring complicated equipment, you can save time by using a wire-stripper to remove ends of insulation. This tool has toothed cutters in its jaws, and works like a reversed pair of pliers. All you have to do is place the wire in jaws . . .



. . . and squeeze the handles. Wire remains clamped in the left jaw. Right jaw, containing cutters, moves outward and strips off the insulation. One set of cutters accommodates four sizes of wire.



Old-fashioned method of paring off insulation with a knife isn't as fast or neat, but it still works. Hold the knife at a flat angle and use a slicing cut as if you were sharpening a pencil.



With the insulation off, scrape wire clean with the BACK edge of the blade, to avoid nicking.

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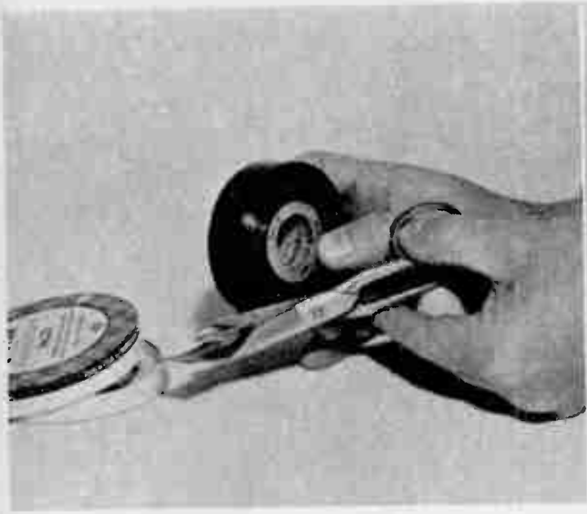
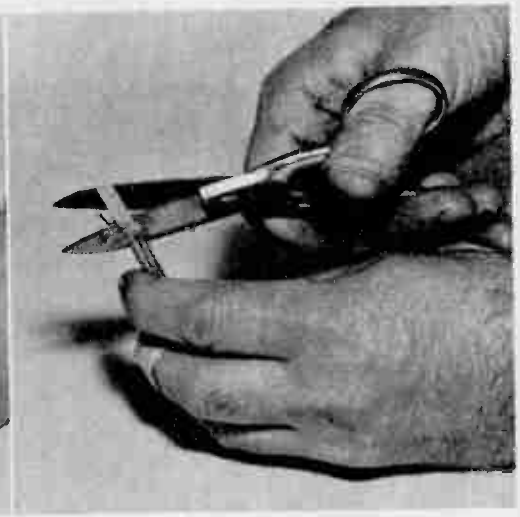
SCISSORS

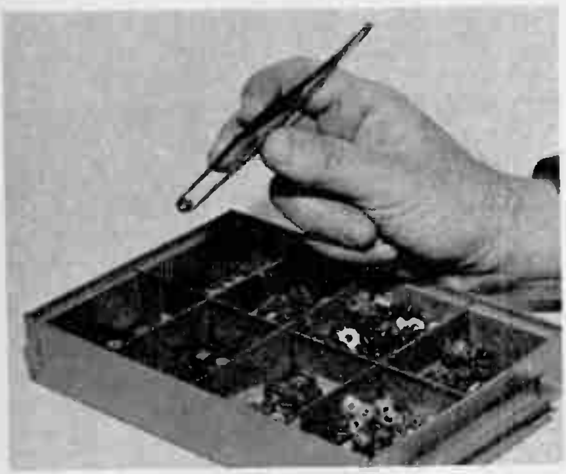




A pair of scissors having short, heavy blades is much safer than a knife and more practical than diagonal pliers for many cutting purposes. Instead of trying to tear insulating tape from its roll, use scissors for quicker, neater job.

The job of trimming copper braid from connector cables, a nuisance with pliers, takes minutes with scissors. High-grade scissors hold their cutting edges for a surprisingly long period of time, as the thin wire of the copper braid is very soft.

TWEEZERS



Ever try to pick up a tiny washer, nut or similar small item with your fingers? You can save time and temper by using a pair of these long tweezers.

BRUSH

Clean off a chassis in a jiffy with a cheap, new paint brush, 1 inch wide. Soft bristles get into corners, and cannot damage small, delicate parts.

World Radio History

Circuit Tester

. . . or "one-meter laboratory," as it is frequently called, is the basic testing and trouble-shooting tool of the electronics art.

A circuit tester is easier to read when in an inclined position and much less likely to fall over or be pulled over on its face. Here a small Weston Model 697 meter has been fitted with a simple box made of plywood scraps. Bottom of box has "feet" of rubber-head tacks which discourage it from sliding.

THE INSTRUMENT known variously as the AC-DC circuit tester, the multimeter and the volt-ohmmeter (or "VOM") is the basic testing and trouble-shooting tool of the electronics art. It is often referred to as the "one-meter laboratory" because of its versatility and all-round usefulness.

As produced in almost identical form by a dozen different manufacturers, the circuit tester contains a single meter which is made to read a very wide range of voltages, currents and resistances by means of resistors connected in series or parallel with it. In the smaller tester shown on these pages there is a choice of twelve ranges: in the larger one, a choice of 44!

Because the DC and AC voltages in electronic equipment represent the lifeblood of the circuits, the tester's primary function is to measure them. Its next most important job is to check circuit continuity, which is another way of saying that it measures the resistance of the wires or of individual fixed and variable resistors. Only rarely is it important or necessary to measure current in amperes, milliamperes or microamperes, although the circuit tester can do that job, too.

General operating instructions come with all meters. Here are some hints and suggestions in picture form that are not usually found in the manufacturers' literature. •

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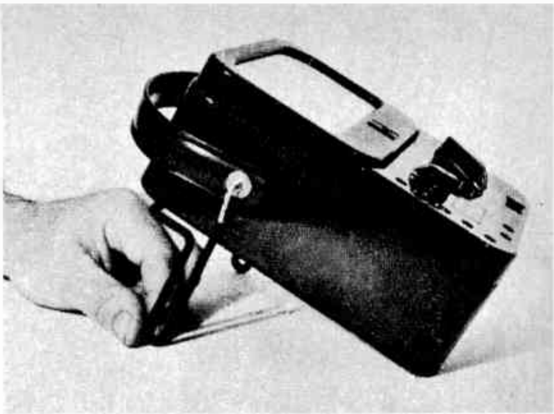
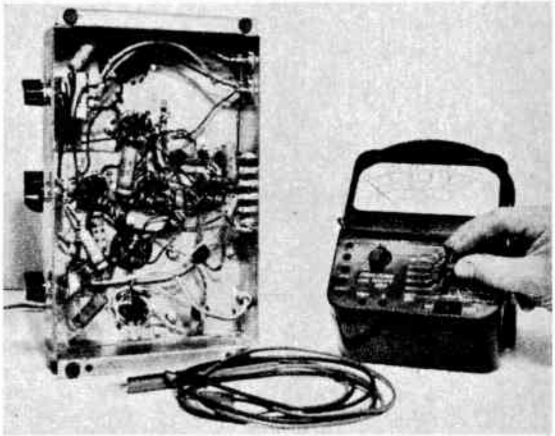
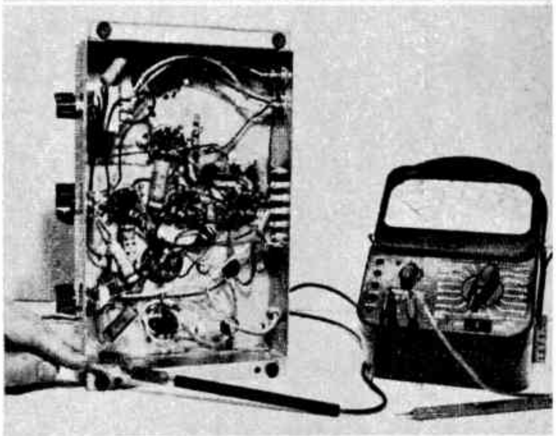


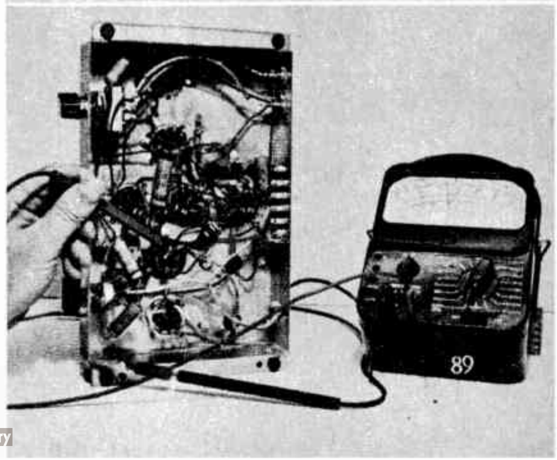
Tilted back on rubber-covered wire feet, this Precision Model 120 circuit tester is firm and stable on table top and meter is face up for convenient viewing. The feet assembly is sold as an accessory and snaps into holes in strap-handle rivets. A similar support can be bent out of a wire coat hanger to fit most testers of this style.



In basic operation of checking circuit voltage, first step, before connecting test leads, is to set range switch to nearest value. For instance, if "normal" circuit voltage is supposed to be 300 volts, set range switch to 600-volt scale. If voltage is correct, it will then read about mid-scale. Always start with high range setting; then work down if needle movement isn't great enough for easy reading. Also set AC-DC switch on the meter (Precision Model 120 shown here and in following pictures) to AC or DC, as required.



Connect test leads at meter. For DC measurement (most usual one in amplifiers, receivers, etc.) attach alligator clip to end of negative lead and fasten to clean spot on chassis. Latter is invariably minus side of DC circuit in equipment.



Holding positive test probe well away from its exposed metal end, test voltage by touching latter to appropriate point in circuit. One-hand method practically eliminates danger of shock. (Turn page.)

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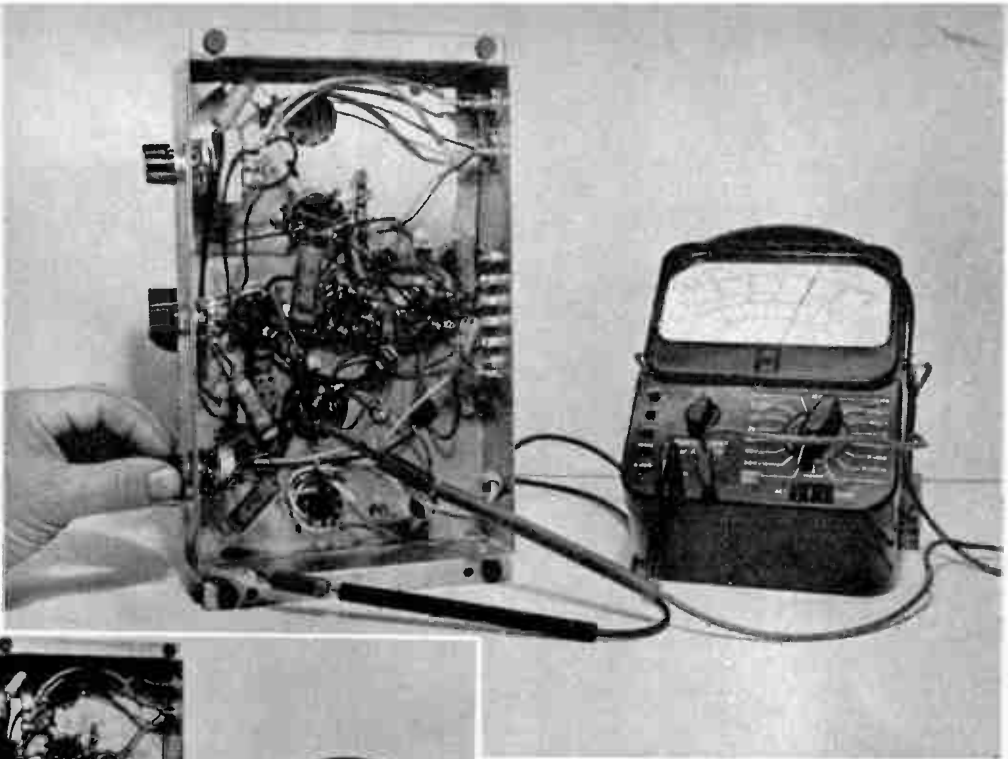
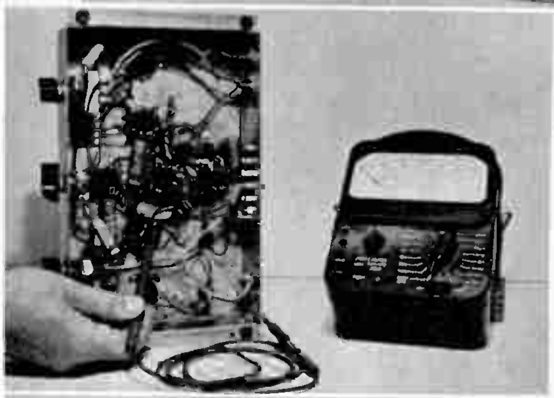


It is often desirable to have meter connected while adjustments are made in equipment under test. With equipment turned off, attach positive lead with snap-on alligator clip, just as with the negative lead, thus leaving both hands free.



In some equipment, charges remaining in large fixed capacitors can cause nasty sting long after circuits have been turned off. Before poking fingers into any chassis, discharge all capacitors with a test lead from the circuit tester. Clip one end to chassis and touch suspected points with probe end. Small, snappy spark at point of probe shows how much energy some capacitors store.

Preparatory to making resistance or continuity checks with circuit tester, "zero" the meter by short circuiting test leads together and turning the ADJ-OHMS knob until needle swings to 0.

To measure resistance of a fixed resistor, clip one test lead to one terminal and touch other lead to second. Be sure circuit tester is set to DC.

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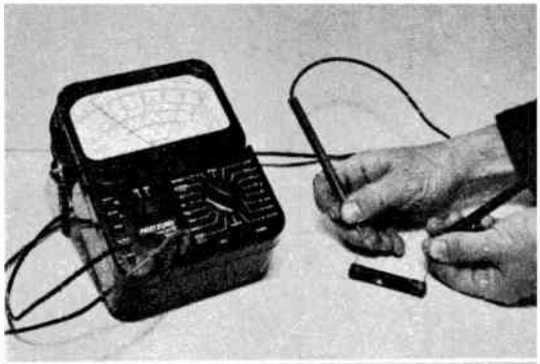
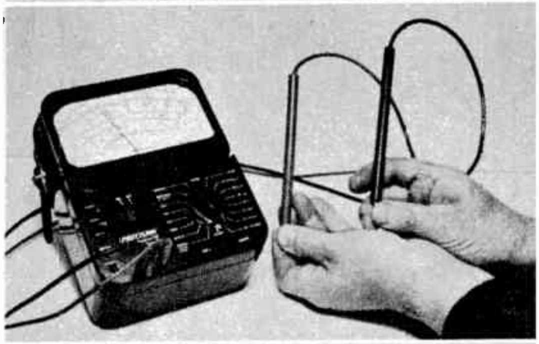
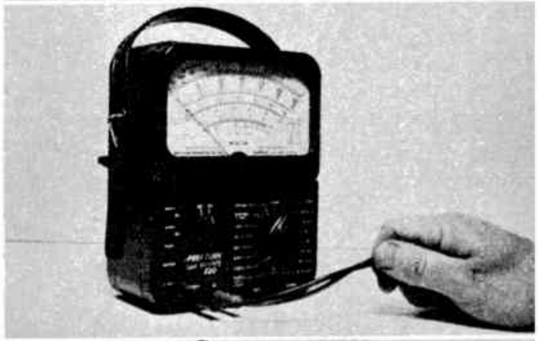


Touching both tips to both resistor terminals and holding them in place with fingers may give misleading reading because body resistance then parallels the resistance of the unit under test.

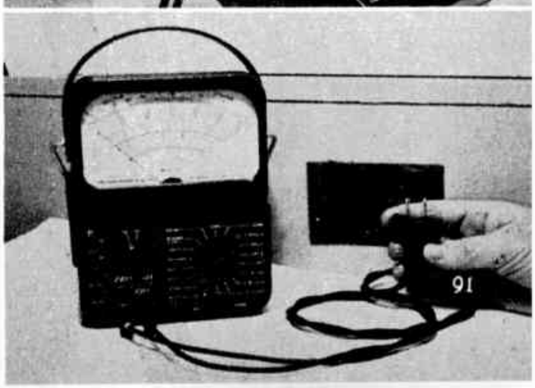


Electrical resistance of body is in line with values of resistors commonly used in electronic equipment, as this simple finger test shows. Indicated value on meter is about 500,000 ohms. Resistance is relatively low when fingers are damp and clean; higher when they are dry and dirty. A sensitive meter will fluctuate even when the pressure of fingers on the test leads is changed.



DON'T try to move circuit tester by pulling leads.

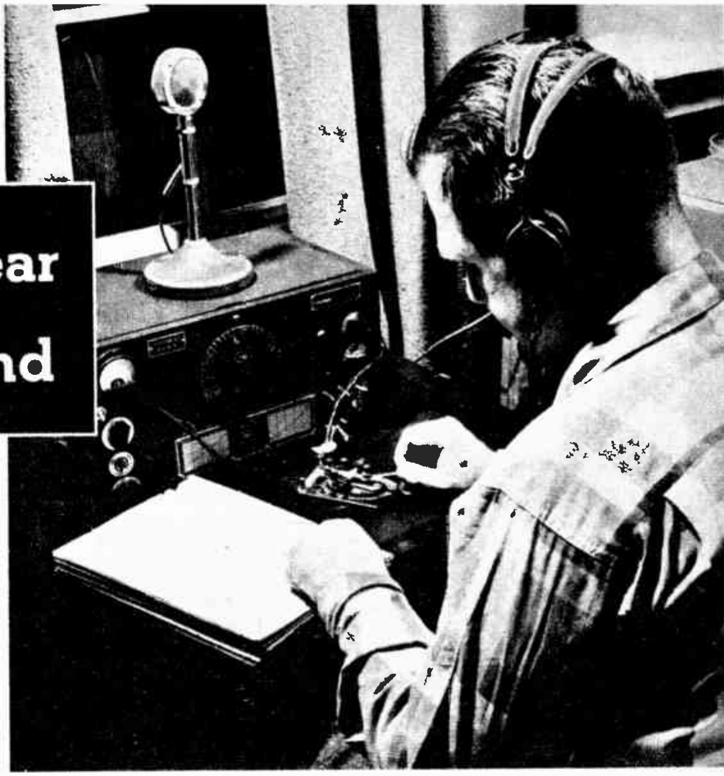
DON'T be careless with tools in the presence of a meter. Remember that repairs are expensive.



DON'T try to check AC line voltage by means of regular test prods; if they touch, there'll be a grand short circuit and blown fuse. Instead, make a simple test cord with regular attachment plug on one end and pins on other to fit meter jacks. It is interesting to observe the line voltage variations as appliances go on and off.

World Radio History

Ham of the Year ...and He's Blind



Holder of the Edison Amateur Radio Award for 1955, Bob Gunderson taps the key of his station W2JI0. He uses voice also, has friends all over the world and is regarded as an expert.

A BLIND electronics designer, who invented more than 30 types of special test instruments that open the swiftly-expanding electronics field to the blind as an occupation, has been awarded General Electric's fourth annual Edison Radio Amateur Award.

He is Robert W. Gunderson, 36, who operates amateur radio station W2JI0 at his home at 984 Waring Ave., the Bronx, New York, N. Y. Mr. Gunderson is editor of The Braille Technical Press, the only monthly electronics magazine for the blind. The Edison Award judges recognized as an outstanding public service his unceasing struggles to maintain this publication.

Time does not hang heavily on this blind man's hands. In addition to publishing the 15,000-word monthly magazine, Mr. Gunderson teaches three nights a week at the New York Institute for the Education of the Blind and works three days a week as a radio consultant in a New York City radio parts store, Hudson Radio and Television. In his "spare" time he actually manufacturers the test instruments for the blind, which operate by making a variety of sounds. Occasionally, he takes on free-lance electronic design jobs for small radio manufacturers.

Mr. Gunderson's wife, Lillian, who is not blind, serves as secretary-treasurer, proof-reader, typist and file clerk for the non-profit publishing corporation. While salaries from The Braille Technical Press get rather slim at times, the couple enjoy in their comfortable three-room apartment a more normal life than that led by many so-called "normal" people. Mr. Gunderson goes about his work in New York City without aid of a dog or even a cane. He relies entirely on his sense of hearing, which has developed acutely inasmuch as he has been blind since birth. While he can make use of sound reflections from upright objects, he can't "hear" holes in the ground. Another enemy to unsighted free movement is a cold that plugs up his ears. "It's like a sighted person having to walk in a dense fog," he explains.

He has had his share of the "thrills" of metropolitan life. Once a girl accosted him on the subway and threatened to start screaming for help unless he gave her five dollars. He outwitted her by cupping his ear with a hand and pretending to be deaf as well as blind. On another occasion when he had difficulty opening a revolving door, a policeman angrily grabbed his shoulder and demanded to know if he was blind. When Mr. Gunderson patiently said that was precisely the trouble, the policeman explained that an inebriated man was lying on the sidewalk with his head in the door!

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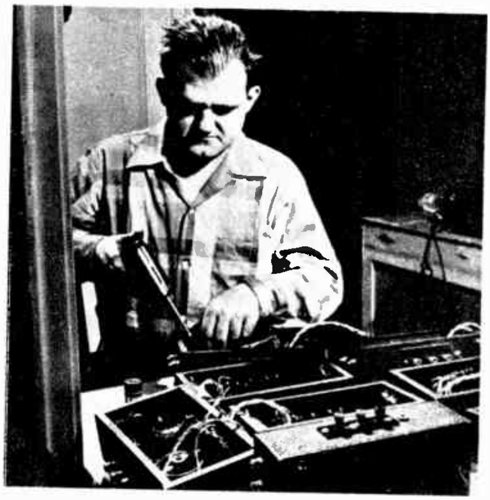
"Eyes" for blind technicians: Bob Gunderson and some of the special test instruments he has developed. They indicate circuit condition by audible note instead of by meter, enabling the blind to trouble-shoot and adjust various equipment.

Bob's dexterity with a soldering iron is hard to believe. Starting from scratch, he has assembled countless pieces of the most complicated electronic apparatus. The author of this book has observed him at work and can vouch for his skill.



Mr. Gunderson is a graduate of the New York Institute for the Education of the Blind, an accredited private school which accepts pupils from kindergarten through high school, and learned radio on his own hook as do most radio amateurs. His work has been directly responsible for many of the 600 radio operator licenses that have been issued to the blind, and for the fact that literally scores of blind persons have been able to take up electronics as an occupation.

Mr. Gunderson says that most persons' reaction after meeting him is to lose a great deal of their fear of blindness because they realize that blindness is not synonymous with helplessness. Another reaction—one that he hopes for—is an inclination to lend financial assistance to The Braille Technical Press, Inc.

Here is a partial list of the "auditory" instruments and adapters Mr. Gunderson has developed: tube checker adapter, phasemeter, Q-meter, inductance and capacitance bridges, field strength meter, grid dip oscillator, antennascope, vacuum tube voltmeter, multi-tester, distortion analyzer, direct reading capacity meter, primary and secondary frequency standards, carrier shift and modulation meters, continuity checker, and volume level meter. •

Editor at work: Bob edits the Braille Technical Press, a monthly electronics magazine published for the blind, with the able assistance of his wife Lillian, who is possessed of normal sight.

World Radio History

For Would-Be Hams...
Code is a Must!

Besides, it adds to your enjoyment of all aspects of short-wave radio.

Aspiring hams practice code under supervision of Signal Corps personnel at Fort Shafter, Hawaii. Class is part of training program of the Military Affiliate Radio System, well known as "MARS."

"I WANT TO GET an amateur radio operator license and install my own station. However, I intend to use only voice transmission. Must I still learn the code?" The answer to the question is a definite "Yes," and there is little likelihood that it will be anything else in the future.

The code requirement for the novice class license is only five words per minute. Anyone who doesn't have the mental capacity and alertness to achieve this easy speed certainly has no business playing with ham transmitters, which are all loaded with high voltages.

Code is a stumbling block only to people who decide in advance that it's a nuisance. A more tolerant attitude is conducive to faster learning. Say to yourself, "Knowing the code not only enables me to get my FCC ticket, but also increases the enjoyment I can get out of my investment in expensive receivers and transmitters."

Practice, and only practice, is the way to learn the code. Practice alone, with a friend, or with a group, but practice. Sheer repetition imprints the dits and dahs on your brain, and after a while that wonderful organ responds to them automatically.

Two recent items of code practice equipment are illustrated here. The first is the Philmore Model TC-50, a factory-assembled job consisting of a key, a high-pitched buzzer and a pair of "D" size flashlight batteries on a wooden base, with the Continental Code attached to the latter so that you can't miss it. The buzzer peeps loudly and can be heard readily by any number of code students in an average room. The other item is a transistorized code practice oscillator in kit form, the Lafayette KT-72. This produces a highly pleasing tone, adjustable in pitch, for earphone operation only. Several pairs of phones can be connected in series for small group instruction.

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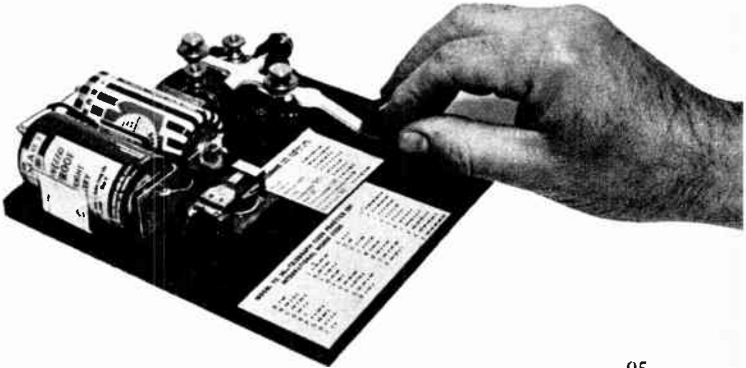
Only two characters are used in the Continental Code: a very short sound, most often referred to as a "dit" and shown in print as a dot, and a decidedly longer sound, called a "dah" and shown as a dash. Ideally, a dah is three times as long as a dit and the spacing between characters of the same letter is about equal to the time required for a single dit. The combinations of dits and dahs that form letters are purely arbitrary.

The cipher, 0, is usually stricken through with a diagonal line thus Ø, to distinguish it from the letter O. In voice communication it is always spoken as "zero" and never as "oh," mainly because Ø is the designation of one of the ten amateur call districts into which the United States is divided. This district includes the states of Colorado, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota and South Dakota.

The dot-and-dash code internationally used in radio communication is generally called "Continental." It must not be confused with the American Morse Code, which was named for the inventor of telegraphy and used for many years on the extensive wire telegraph circuits in the United States. An important difference is that in Morse the spacing between characters varies to form different letters. For instance, "dit-dit-dit" is the letter S, the dashes representing single spaces, but "dit—dit-dit" is R and "dit-dit—dit" is C. Morse is now virtually a dead language, the clicking telegraph sounder having been replaced almost completely by the teletype machine and the telephone. •



Philmore Model TC-50 is compact ready-to-use code practice set. Powered by two flashlight cells, it measures about six inches square and is easily carried. Philmore Mfg. Co., New York 3, N. Y.

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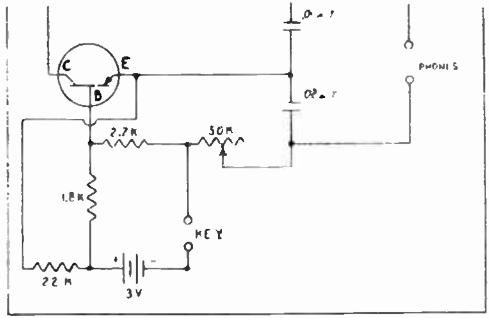
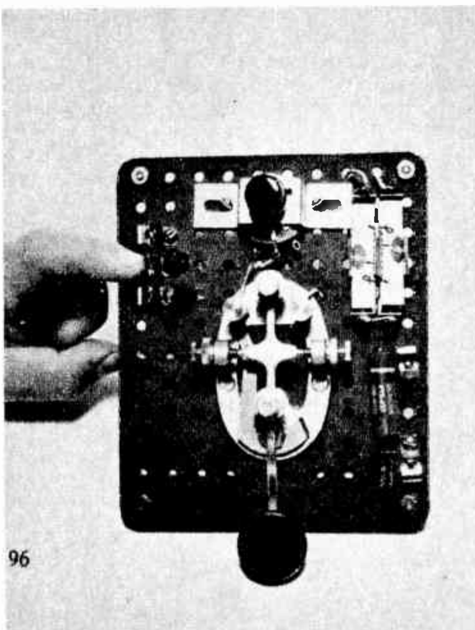
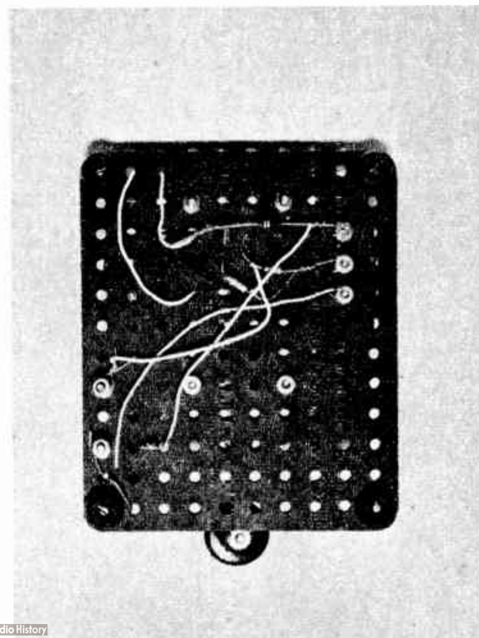
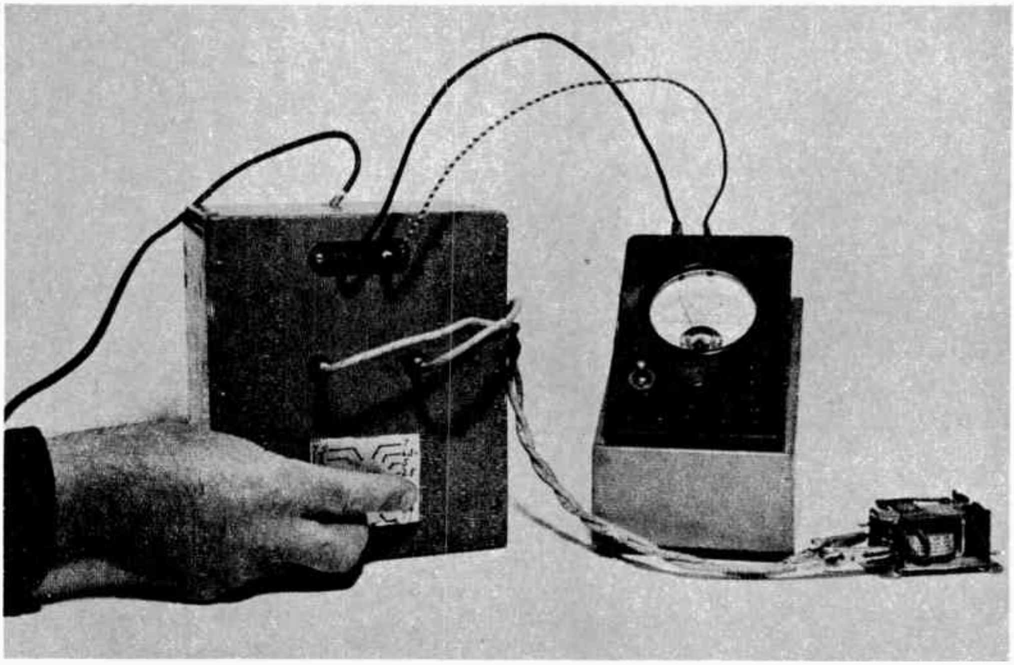
wiring in picture form; right, schematic equivalent of picture diagram. Directly below, finger points to tiny transistor that is used as tone oscillator. Knob above key adjusts tone pitch. Earphones connect to binding posts at bottom right of same picture. Photo lower right shows underside of complete transistor oscillator. The holes in peg-board are very convenient for passing wires. The unit comes in kit form. Lafayette Radio, NYC 13.







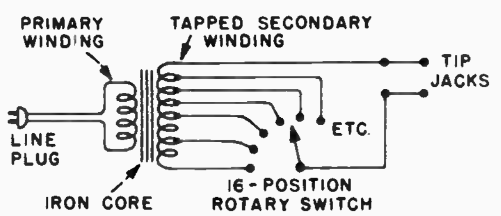
World Radio History



Voltage Box

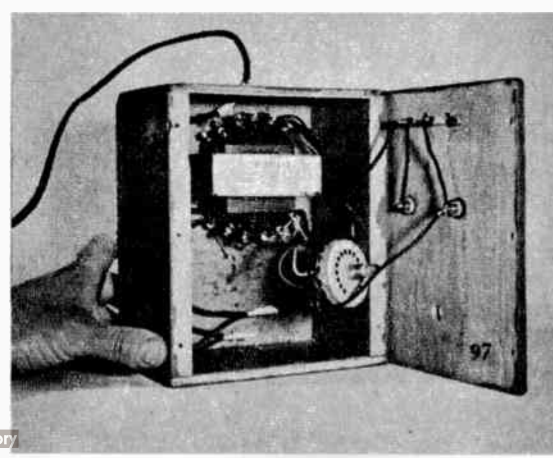
AC voltmeter is connected to one pair of tip jacks, while device under test (a relay in this case) is connected to other pair. Voltage plate on box front is cardboard, with figures inked in.

Primary winding of transformer goes directly to line cord; tapped secondary to switch, tip jacks.



WILL a relay marked "14 volts AC" work on 12, or 10, or 8? Will a small heater fan from a wrecked car run at all on AC, and if so, at what voltage for coolest operation? These and many other questions that arise in practical electronics work can be answered quickly by a "voltage box."

It's not the box that's important, but the contents: a special transformer with a tapped secondary that gives sixteen different voltages from 1.1 to 117. This is listed as a "tube checker transformer" in the standard radio parts catalogs. In addition, you need a 16-position rotary switch and two pairs of tip jacks. Construction and wiring, as shown, are very simple. •



Inside of voltage box, with rotary switch off of mounting hole. Box, of plywood, is about 6x7x4 in.

World Radio History

RME Model 4300 receiver in use in Webster Soules' amateur radio station, W8HCW, Buchanan, Mich. The small box to the right contains loudspeaker.

The World at Your Finger Tips

With a high-grade communications receiver, you will discover the short waves are a never ending source of radio enjoyment.

CONSIDERING your own amateur radio station? A good receiver is a basic requirement. Very few people attempt to build their own, because the initial alignment of the numerous circuits requires equipment that costs as much as a factory-made set. Sets start at about $50 and run to about $1,000; the most popular and widely used models are in the $125-500 class. Four are described here.

One feature of all high-grade communications receivers that will strike you as odd is that a loudspeaker is not included, but must be added as an external accessory. Any small speaker serves. "High fidelity" sound in short-wave reception is definitely undesirable; in fact, in most sets the "fidelity" (but not the intelligibility) is deliberately cut way down, and, at the same time, the "selectivity" (the ability to separate interfering stations) is increased appreciably. Many listeners use earphones in preference to loudspeakers altogether, as they give better response to weak signals and don't disturb other people.

RME—Electro-Voice Model 4300 Receiver

Shown on this page, this six-band set is designed exclusively for the amateur frequencies between 1.75 and 30 megacycles. The circuit employs a tuned radio-frequency amplifier stage followed in order by a tuned detector, oscillator, crystal filter, two intermediate-frequency stages, second detector, noise limiter stage and two audio stages. The receiver is temperature compensated to provide rock-steady operation after about 20 minutes of warm-up. Very high selectivity is available. The smooth-acting tuning knob has two speeds: fast for quick scanning of a band, and slow for fine adjustment.

The mechanical construction is unusual in that the front panel, which contains thirteen knobs, is a solid casting of aluminum. Electro-Voice, Inc., Buchanan, Mich.

World Radio History

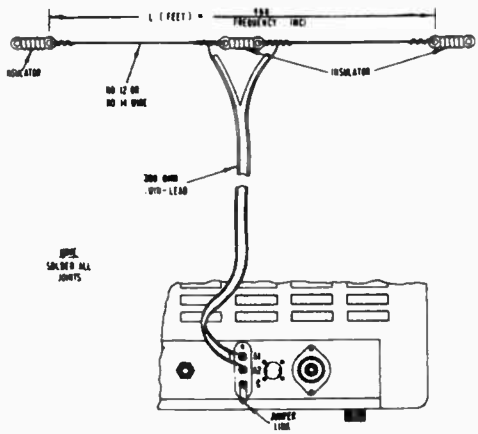
Hallicrafters SX-100

A 14-tube dual-conversion superheterodyne, the SX-100 covers the entire short-wave spectrum from 1.72 to 34 megacycles, with calibrated band spread on the amateur 80, 40, 20, 15, 11 and 10 meter bands. In addition, it takes in the regular broadcast band from 538 to 1590 kilocycles, making it an "all-wave" receiver of considerable usefulness. It brings in foreign and domestic short-wave broadcasts, amateurs, police, aircraft, ships at sea and numerous other types of stations. Provision is made for selectable-sideband tuning. This simplifies the reception of single-sideband stations, and is also valuable for eliminating certain forms of interference between regular AM stations.

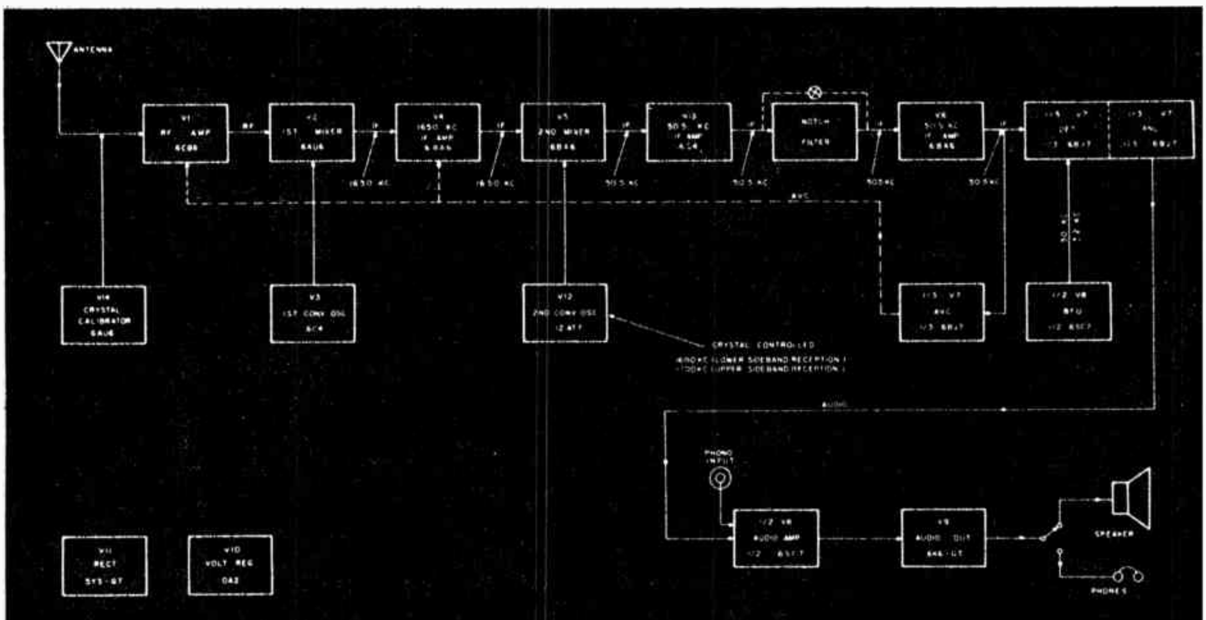
There is a built-in 100 kilocycle crystal oscillator whose sole purpose is to give marker signals at every 100 kc. on the dial for checking the calibration accuracy. This oscillator itself can be cross-checked with the standard-frequency signals transmitted by WWV and WWVH, the stations of the National Bureau of Standards in Beltsville, Md., and Maui, Territory of Hawaii, respectively. These transmissions are on 2.5, 5, 10, 15, 20 and 25 megacycles.

Hallicrafters Co., Chicago, Ill.

Modern design and balanced appearance make the Hallicrafters SX-100 receiver, above, a particularly attractive piece of electronic equipment.



"Dipole" antenna gives good results on short-wave bands. As formula, right, indicates, best overall length of wire for the 20-meter amateur band is about 33½ feet (468 divided by 14 megacycles).



BLOCK FUNCTIONAL DIAGRAM OF CIRCUITS OF THE SX-100 RECEIVER

Large tuning knob in center of the National NC-300 receiver moves pointer over the drum dial at its top.

National NC-300

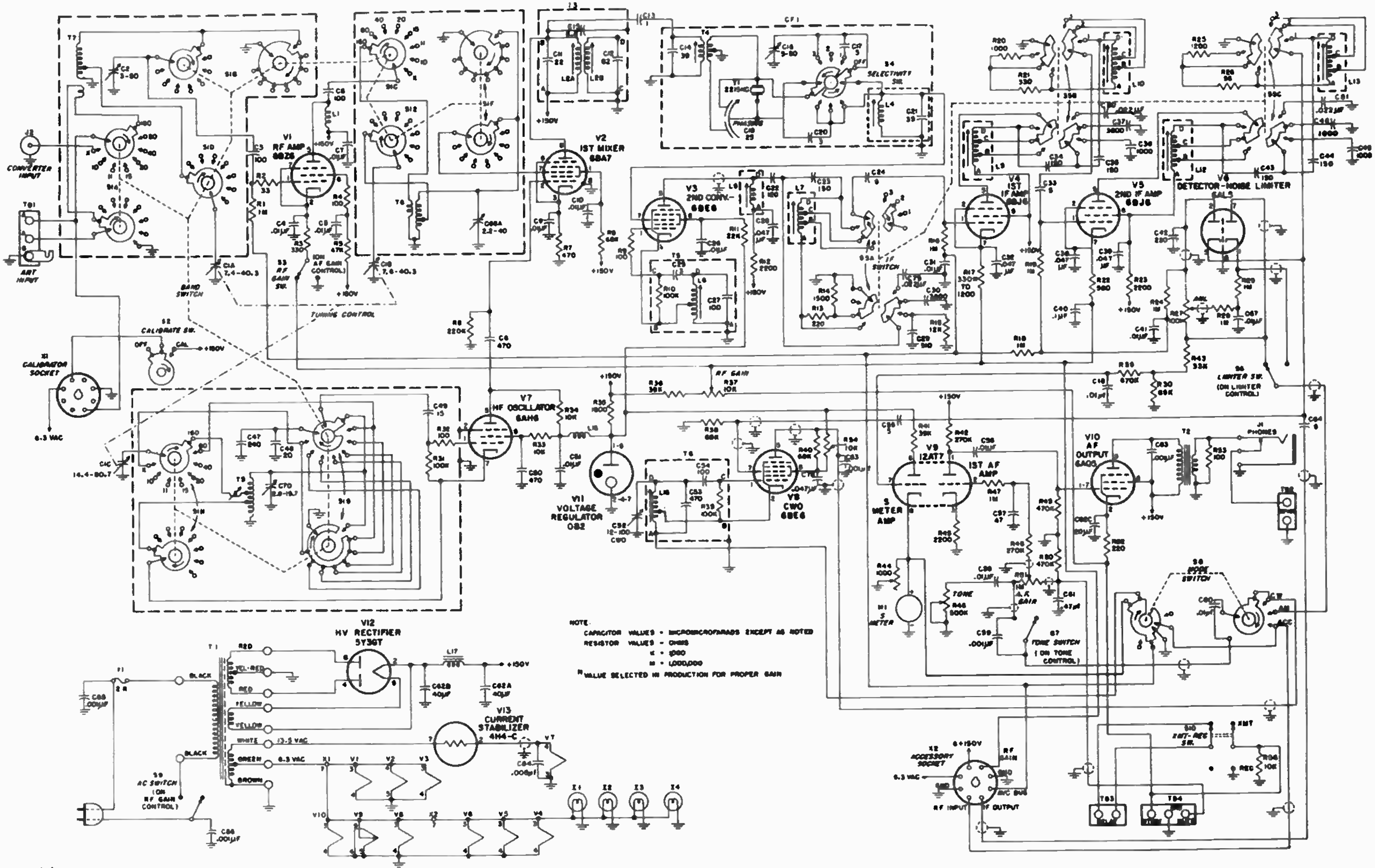
The NC-300 is a strictly amateur-band receiver of high quality. It features a double-conversion superheterodyne circuit using ten tubes plus rectifier, voltage regulator and current stabilizer. Frequency coverage includes the 160, 80, 40, 20, 15, 11 and 10 meter bands, each represented by an individual, calibrated dial scale on a long drum at the top of the chassis. As the band-changing switch is turned, the correct scale comes into position. There is also an "X" band, which functions as a tunable intermediate frequency amplifier for use with suitable broad-band crystal converters for reception on 6, 2 and 1¼ meters. These converters are available as accessories.

The tuning control is exceptionally smooth. It makes use of a heavily-weighted tuning knob coupled to a free-moving gear train. To tune quickly from one part of the dial to another, the operator merely spins the knob, and away it goes. To tune slowly, he holds it in his hand and turns it slowly.

The selectivity of the intermediate amplifier section of the receiver can be set to 500 cycles, which is invaluable for the reception of C.W. (code) signals through heavy interference; to 3.5 kilocycles, for readability of phone signals; or to 8 kilocycles, for listening to several "net" stations that are supposed to be on the same frequency but often are slightly off. Additional selectivity control is furnished by a crystal filter.

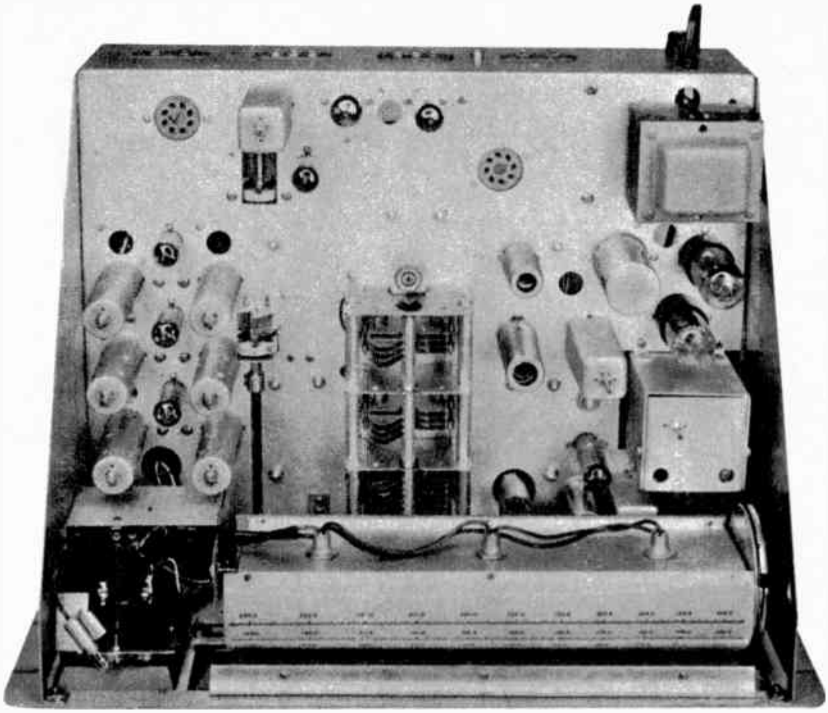
National Co., Inc., Malden, Mass.

World Radio History

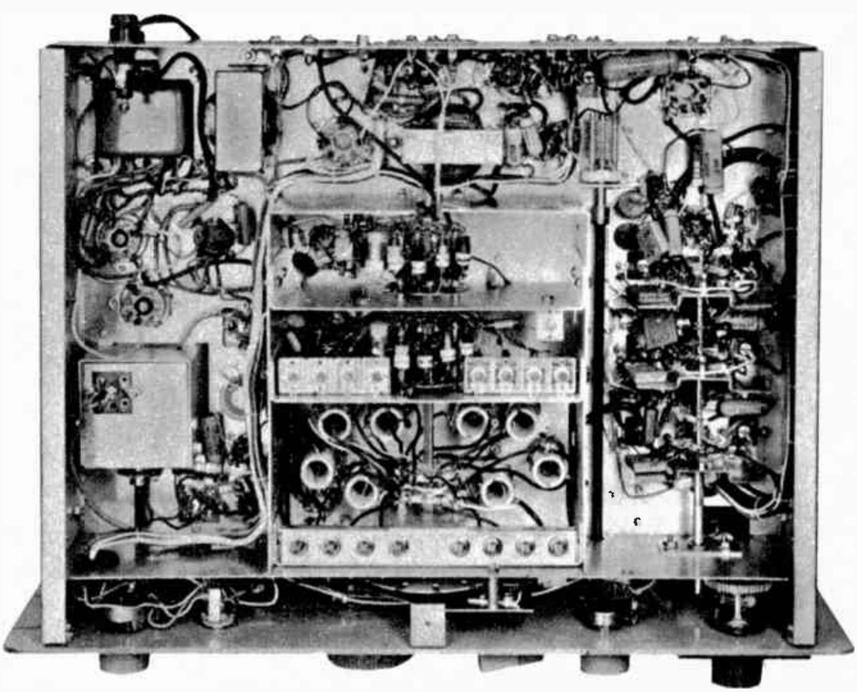


COMPLETE WIRING DIAGRAM OF THE NATIONAL NC-300 RECEIVER

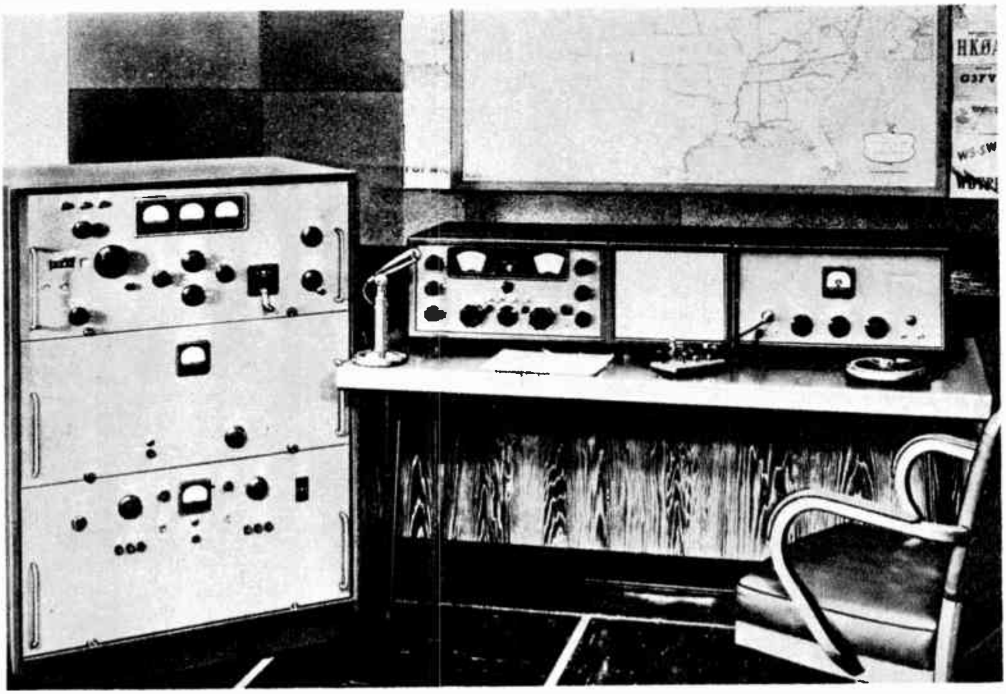
World Radio History



Large drum dial of NC-300, which turns as band switch is turned, is well illuminated by three lights set into it, as evident in chassis view above. Empty sockets at the rear are for connection of optional accessories such as 100-kilocycle crystal calibrator, converters, etc. The underside of chassis, shown in photograph below, is crowded but orderly. The chassis slips out of the cabinet readily for inspection.



World Radio History



At a ham station such as this one, you can spend many pleasant hours!

GPR-90 Receiver, GPT-750 Transmitter

This inviting set-up is best described as a "dream" station. Standing on the floor by itself to the left is the GPT-750 transmitter, rated at a full kilowatt. It tunes from 2 through 32 megacycles. The top section in the cabinet is the master oscillator-power amplifier; the center section the modulator; and the bottom section the power supply. This transmitter is intended to replace the now-obsolete BC-610, which was one of the most successful radio transmitters of World War II and which also was very popular with hams who bought them afterward as surplus.

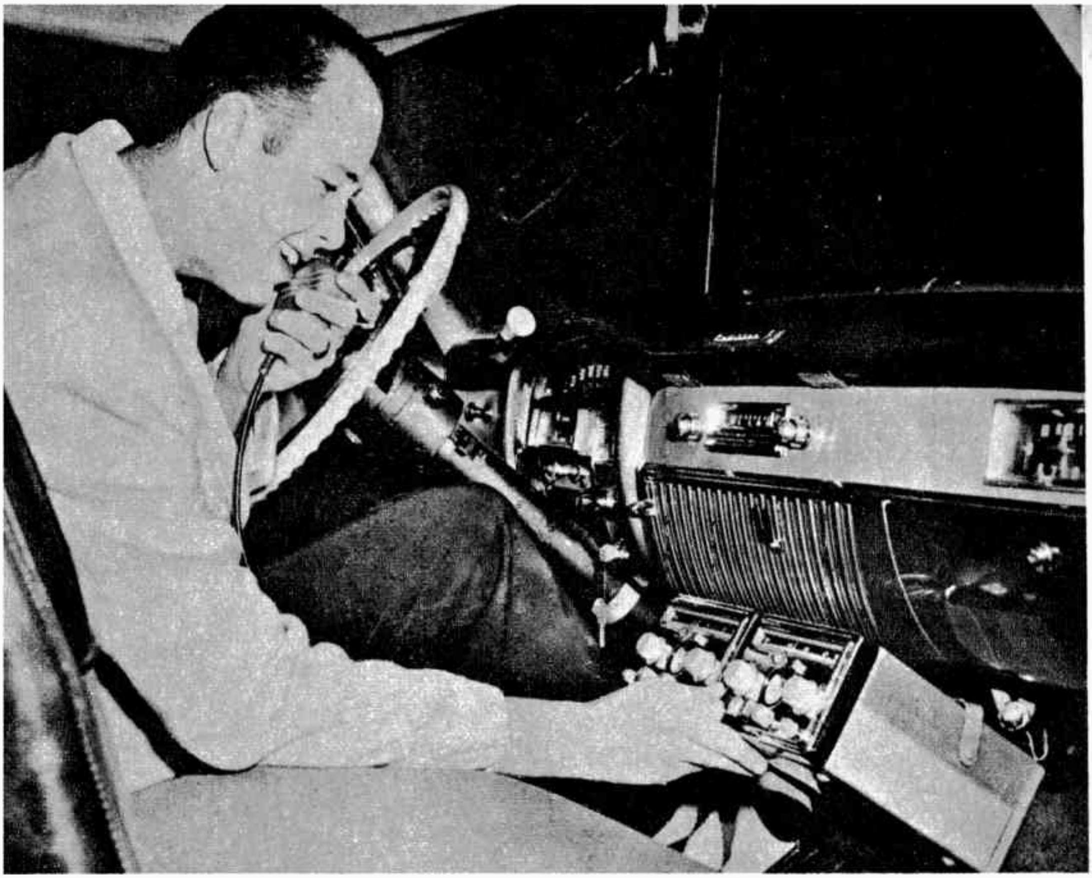
On the right end of the operating table is the Model RTC remote control amplifier, which works into the GPT-750 transmitter.

Of major interest is the GPR-90 receiver, at the left end of the table. This is a 15-tube communications receiver of advanced design. It covers the wide frequency range of 540 kilocycles to 31 megacycles in six accurately calibrated bands with full electrical bandspread. It has high sensitivity, selectivity and stability, and is ruggedly built for continuous operation. The selectivity is variable in six steps from 200 cycles to 5 kilocycles, in five crystal and one non-crystal positions. There are an "S" meter for showing relative signal strength, a noise limiter circuit to knock out strong interference impulses, and an audio selectivity control. On the rear of the chassis is provision for various accessories, emergency power supplies, loudspeaker, standby relay, etc. The front panel controls are as follows: main tuning dial, bandspread tuning dial, band selector switch, antenna trimmer, selectivity switch, crystal phasing control, audio filter switch, audio filter bandwidth switch, standby switch, dial locks, noise limiter switch, audio gain control, phone jack, automatic gain control-manual switch, beat frequency oscillator switch, radio frequency gain control and power on-off switch, beat frequency oscillator pitch.

The center unit on the table is a small loudspeaker.

Technical Materiel Corp., Mamaroneck, N. Y. •

World Radio History



What ham wouldn't be happy with this neat radio station in his car? Bill Nico of Burbank, California, K6BSW, makes a minor tuning adjustment on his Gonsett G77 transmitter as he talks into the microphone.

Ham Shack on Wheels

A "mobile" radio station in your car will enable you to talk to other amateur operators everywhere as you travel the open road.

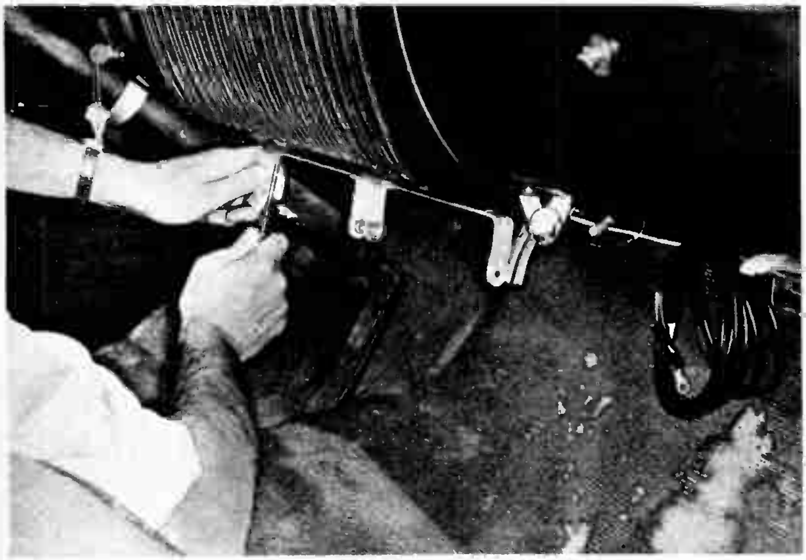
IT'S EXCITING to contact other "ham" operators from your short-wave station in your basement, attic or den "shack." But you don't know what radio thrills are until you install a receiver and a transmitter in your car, and talk to hams everywhere *as you drive on the open road.*

"Mobile" operation is such fun, and affords so many opportunities for interesting local and distant contacts, that many hams now spend as much time, money and energy on their car rigs as they do on their home stations. Mobile hams provide the major part of Civilian Defense communications, and perform valuable service during floods, storms and various other disasters.

Many states recognize the usefulness of mobile operation by issuing automobile license plates corresponding to the hams' call letters. These plates obviously are distinctive and well worth having.

Because of space and power limitations in most passenger cars, a mobile rig must be small and compact. For receiving purposes, it has been the practice until recently to use a short-wave converter working in conjunction with the broadcast re-

World Radio History

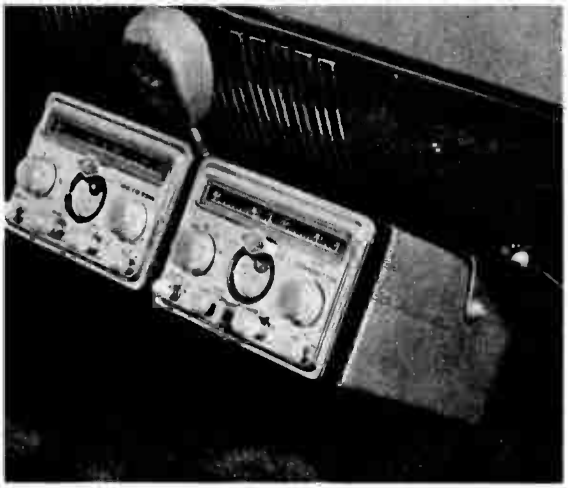


U-shaped brackets for receiver and transmitter cases are being bolted to underhanging lip of dash above transmission hump. Most cars have holes provided there for attaching accessories. Coiled lead will run between battery-generator circuit, receiver, transmitter.

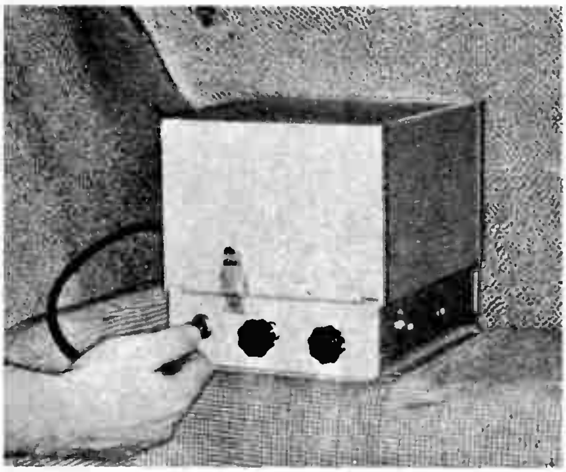
Here Nico attaches transmitter and receiver cases to U-shaped brackets' arms. The receiver unit is on the seat.

Transmitter is eased into its case on right. Receiver is already in case on left, where it is usually placed, nearer operator, as it requires more "knob-twisting." Both chassis are easily installed, removed.

World Radio History

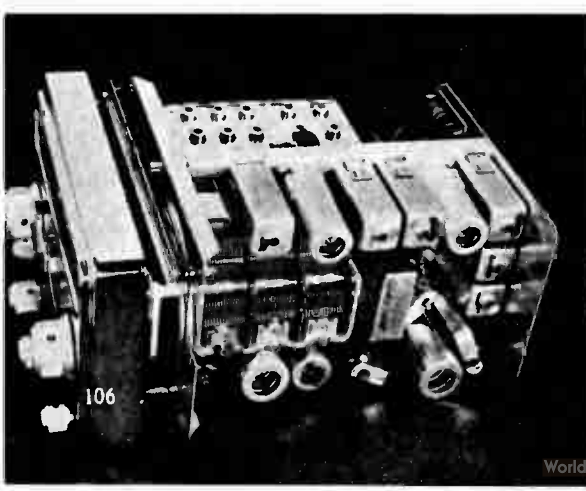


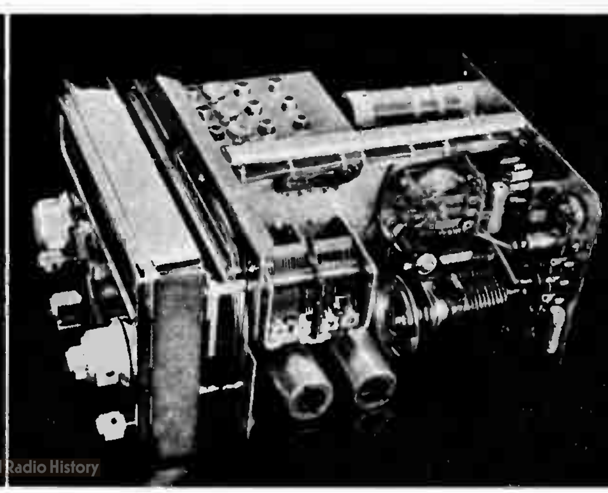
Microphone hangs on dashboard hook above Gonsett G66 receiver and matching G77 transmitter. Units are only 6½ x 4½ x 9 in. in depth. Receiver covers 6 bands including regular AM broadcast band. As band switch turns, a drum dial turns and correct slide rule-type tuning scale comes into view. A similar arrangement is used in the transmitter. Angled units permit driver to read at a glance.



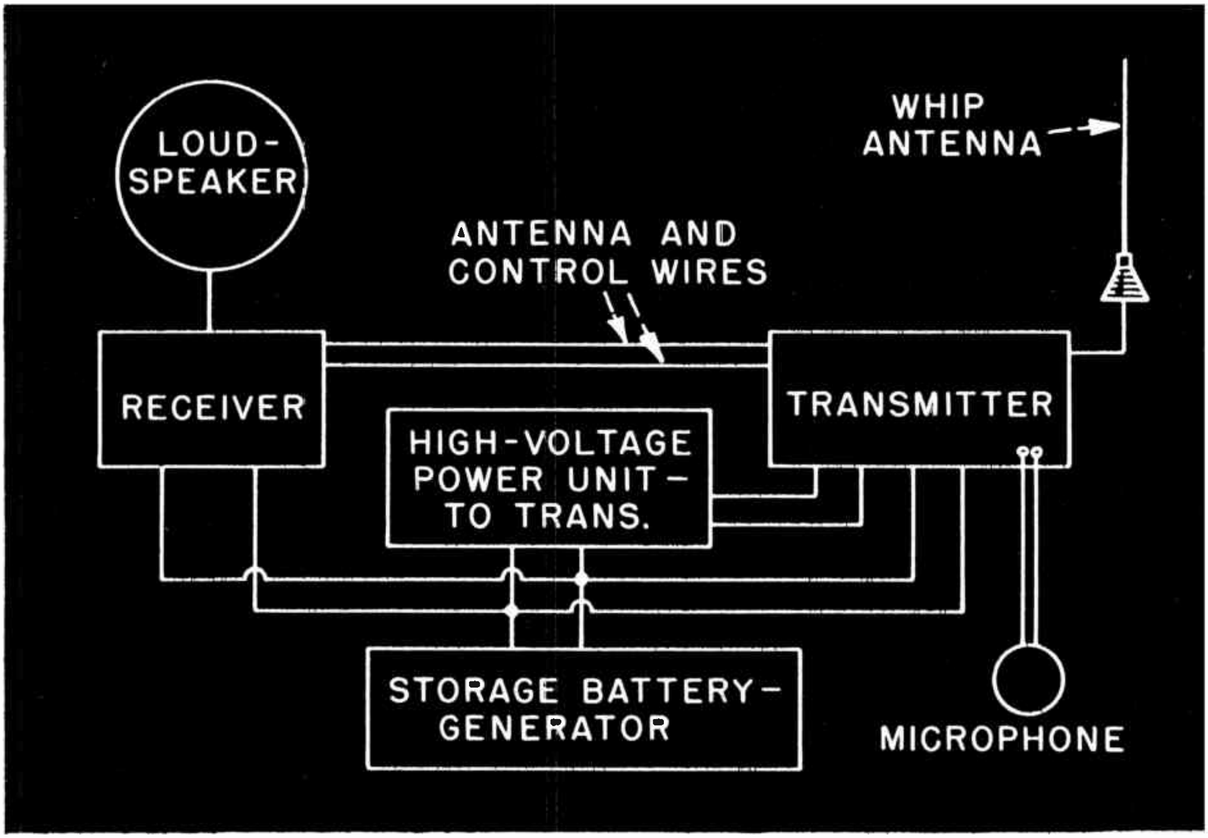
Heavy-duty vibrator power supply furnishes 500 to 600 volts for transmitter operation. Since it requires no adjustment, it is hidden away in trunk. It can also be mounted in engine compartment if space is available there or under the dashboard.

No space is wasted in the Gonsett G66 receiver, at left below. A 9-tube superhet of high sensitivity and selectivity, it features double conversion and effective noise-limiter circuit. Supplementing it is 3-way power unit for operation on 6- or 12-volt car systems or regular 115-volt AC house lines. The G77 transmitter, at right, uses an identical chassis. Its power rating is 50 to 60 watts. Five amateur bands are covered with choice of crystal control or variable frequency oscillator. Operation is fully press-to-talk from mike. Receiver works and transmitter is in stand-by condition until mike button is pressed; then receiver is automatically cut off, antenna is switched from receiver to transmitter which goes on the air instantly. Connections to both are made at back by easily separable plugs and jacks.





World Radio History



Block diagram shows general interconnection of a mobile rig's basic units. Receiver can be operated with transmitter off; antenna connection goes through latter. Same condition prevails when transmitter tube filaments are on, but mike button is not pressed. When button is held down, receiver is disabled, antenna is switched to transmitter, and high-voltage power unit goes on. Transmitter is then alive and operator can talk into the mike. When mike button is released, receiver pops back on and the transmitter goes off.

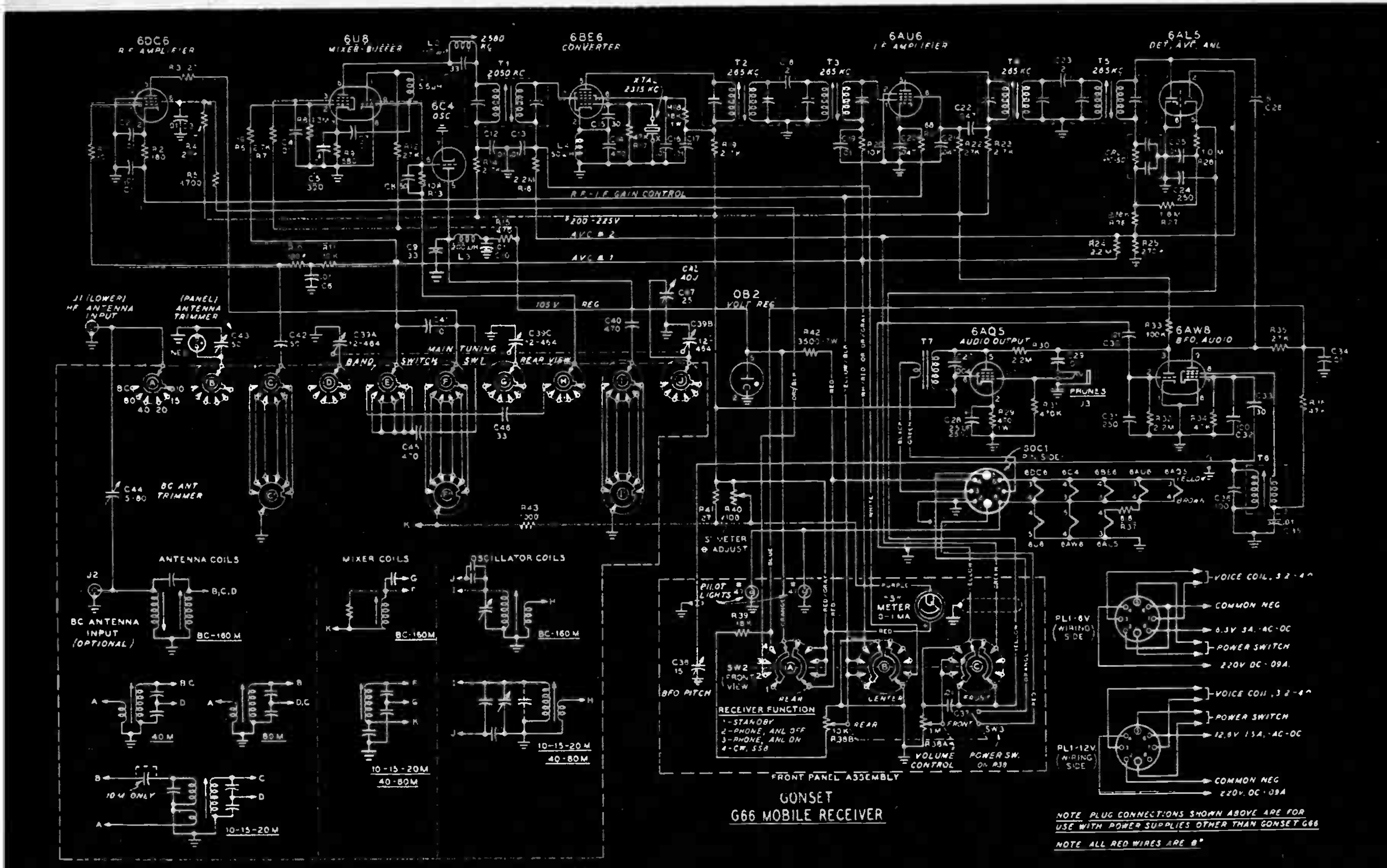
ceiver already in the car. The trend now is toward completely independent short-wave receivers designed especially for mobile service. The transmitter generally is of low power, not above about 50 watts. The restricting element in transmitter operation is the electric-energy source in the car, the combination of the storage battery and charging generator. The standard generators found in passenger cars are often replaced, by some ambitious hams, by the much heavier units intended for use in radio-equipped police cars and taxis.

The filaments of the transmitter tubes work directly off the storage-battery-generator circuit. The plate power comes from a dynamotor or vibrator unit that raises the six or twelve volts of the battery to between 200 and 600 volts. Because of the heavy current drain of the transmitter, it is almost always necessary to race the engine slightly during transmitting periods. When the car is in motion, this is taken care of automatically. Sometimes, when a ham is off the side of the road and is engaged in a particularly interesting contact, with the car stationary and the ignition off, the transmitter drains the battery to the point where it is unable to turn over the engine.

You can spot a mobile rig a long way off on the road by its whip antenna, usually mounted on the rear bumper.

To give an idea of what a mobile rig involves, we are glad to present herewith a series of pictures illustrating an actual installation from beginning to end. These were made especially for this book and show Bill Nico, K6BSW, of Burbank, Cal., and the very newest Gonsett G66 mobile receiver and G77 transmitter. •

World Radio History



Complete schematic diagram of Gonsett G66 mobile receiver. Note use of 2315 kc. crystal oscillator, with 6BE6 converter tube, top center, for second conversion of signal from 2050 kcs. to 265 kcs. (2315 — 2050 = 265).

World Radio History

With electric drill, holes are bored for mounting whip antenna. Lead-in from antenna to equipment up front is easily snaked through trunk and under seats and floor mats. Antenna, in trunk, fits on powerful coil spring and "gives" if it brushes obstruction.

A couple of turns of the wrench and antenna is ready for service. Note license plate bearing the station's call letters. Ham calls are issued by the Federal Communications Commission and Nico had only to show his FCC license to get special plate.

World Radio History

New Transmitter in Kit Form

Superbly packaged, the Heathkit DX-35 boasts voice modulation, impressive power and low cost, as well.

OF ALL the construction projects available to the electronics technician or experimenter, the one that carries the greatest anticipation of pleasure and excitement is probably the builder's first "ham" transmitter. Test equipment is useful and hi-fi equipment provides entertainment, but a short-wave transmitter —if successful—is a link to the entire outside world.

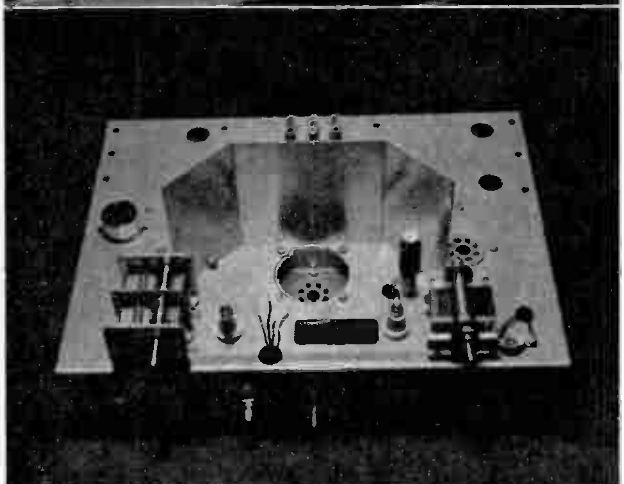
For the beginning ham, the assembly and wiring of a transmitter is a fine way of spending the several weeks that invariably elapse between the taking of the amateur radio operator license examination and the receipt of the actual "ticket" from the Federal Communications Commission. The builder learns how to identify numerous small parts, how to read a schematic wiring diagram, how to make good connections, etc.

A transmitter in knocked-down kit form represents a wise investment because it is certain to work if assembled and wired cor-

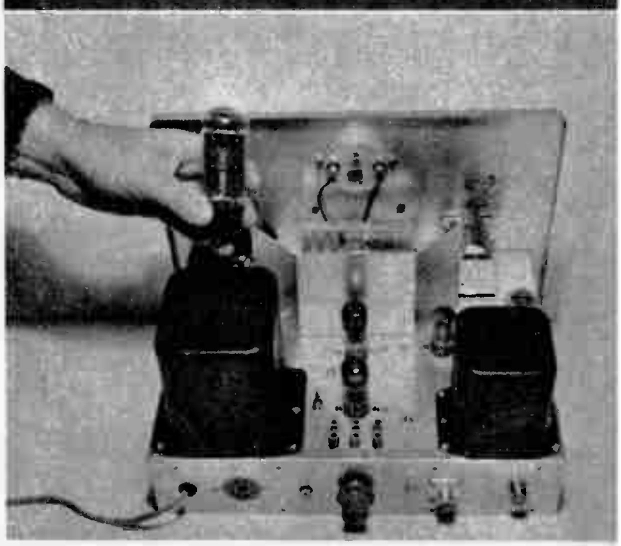
World Radio History

In photo at left, the new DX-35 transmitter is tested at ham station W2DJJ. Receiver under it is a National NC-183D. Operator talks into Electro-Voice No. 605 table-model mike as he adjusts transmitter. This compact ham station occupies basement corner.

Transmitter kit as it comes from manufacturer is being unpacked, top right. Note formed, drilled front panel, left of photo. All tubes and hardware are included.



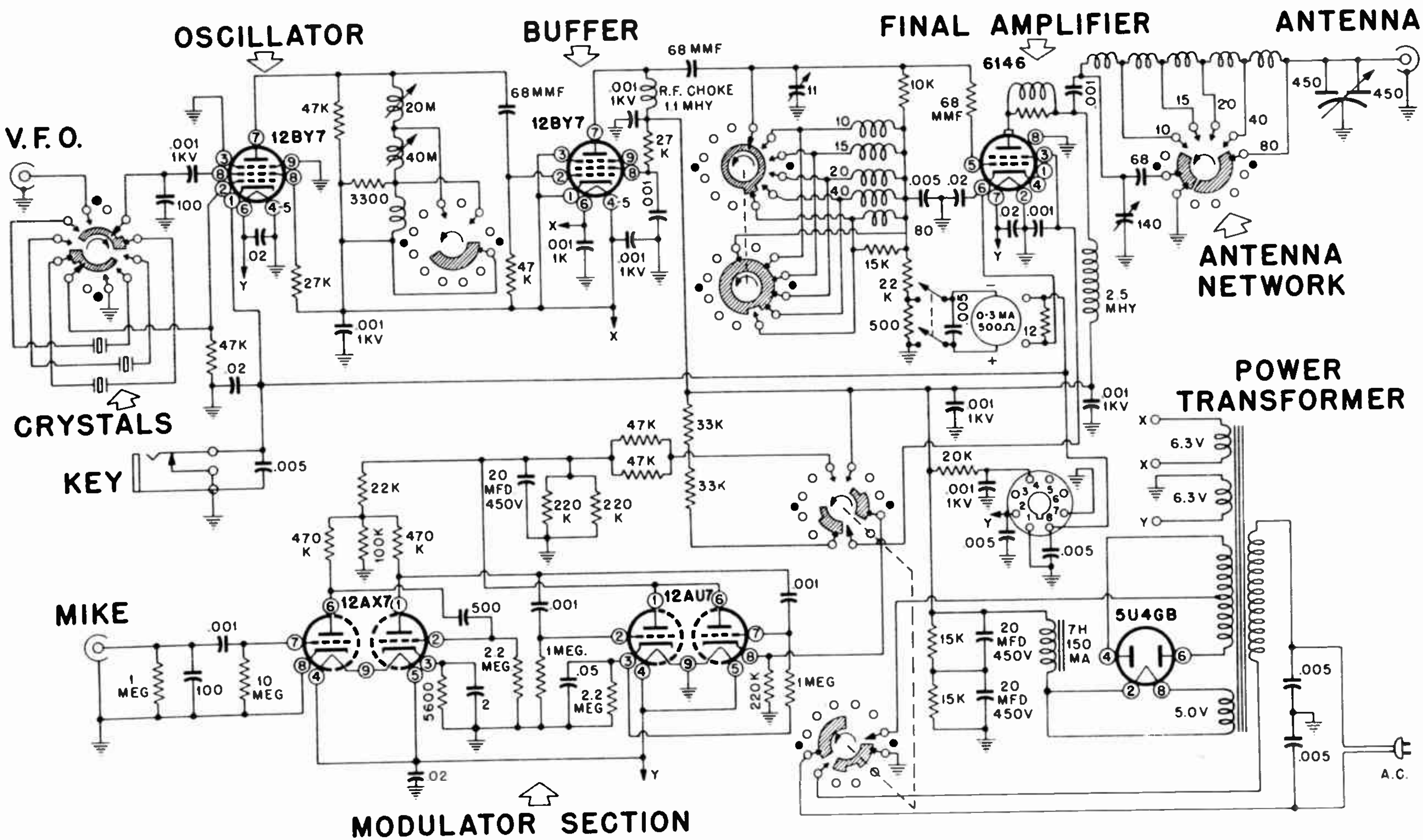
Chassis with major parts mounted. The large hole in its center is for 6146 power amplifier tube.



Chassis view of the completed transmitter. The rectifier tube, in hand, fits in socket behind large power transformer, at left foreground. Smaller unit at the lower right is filter choke in high-voltage DC supply circuit.

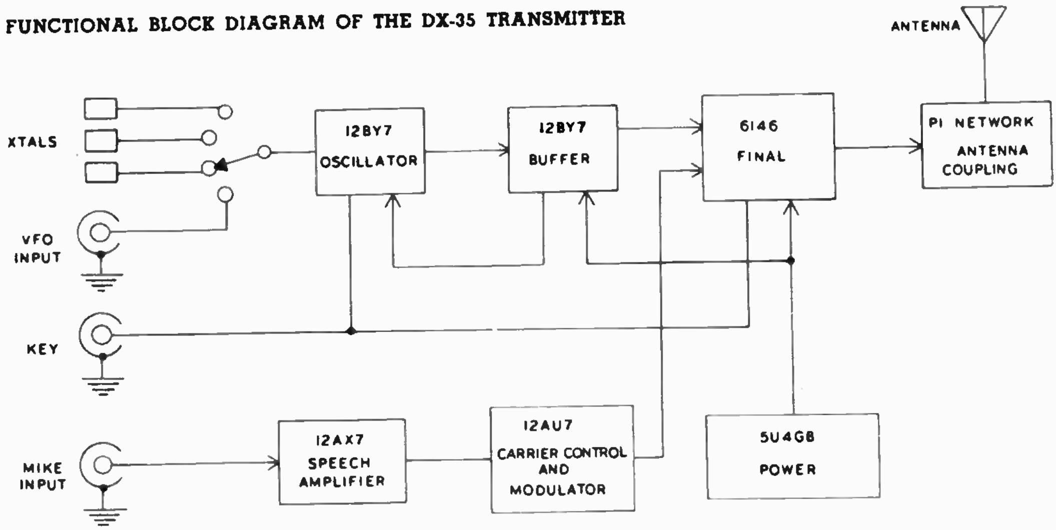
World Radio History

COMPLETE SCHEMATIC DIAGRAM OF THE DX-35 TRANSMITTER



World Radio History

FUNCTIONAL BLOCK DIAGRAM OF THE DX-35 TRANSMITTER



rectly. With the chassis, panel and cabinet furnished already formed and punched, the uninteresting mechanical work is eliminated, and the ham can concentrate on the more important technical aspects of the assembly and wiring. An excellent sample of kit packaging is the new Heathkit Model DX-35 Amateur Transmitter. The author of this book made a trip to the Heath plant to pick up one of the first kits off the production line. He took it back to his own shop, put it together strictly according to the step-by-step instructions, and was gratified to make contact with another ham the first time he put the unit "on the air."

The DX-35 is an advanced version of the Heathkit AT-1. The latter was designed only for C.W. ("continuous-wave," dot-and-dash radiotelegraph) communication, and was intended as a simple "first" transmitter for "novice" hams, the lowest F.C.C. license category. It seems, however, that novices advance rapidly out of that class, and go to voice operation immediately when they qualify for their regular licenses. The DX-35 satisfies this requirement, in that it incorporates voice modulation, as well as increased power and other improvements. Costing less than $60 complete with tubes, but less microphone, key and crystals, this big rig is sure to make a hit.

Circuit Description

The DX-35 is rated at about 65 watts input on C.W. and 50 watts on controlled-carrier phone. This is enough to make an impression on the air, but not enough to raise hob with neighbors' TV reception. Refer to the block diagram and the detailed schematic diagram for general circuit functioning. The transmitter starts with a 12BY7 oscillator, with a choice of three switched crystal frequencies. An external variable frequency oscillator (VFO) can be hooked in if desired. The oscillator is followed by a 12BY7 buffer stage and then a 6146 final amplifier stage, with a self-contained antenna tuning network.

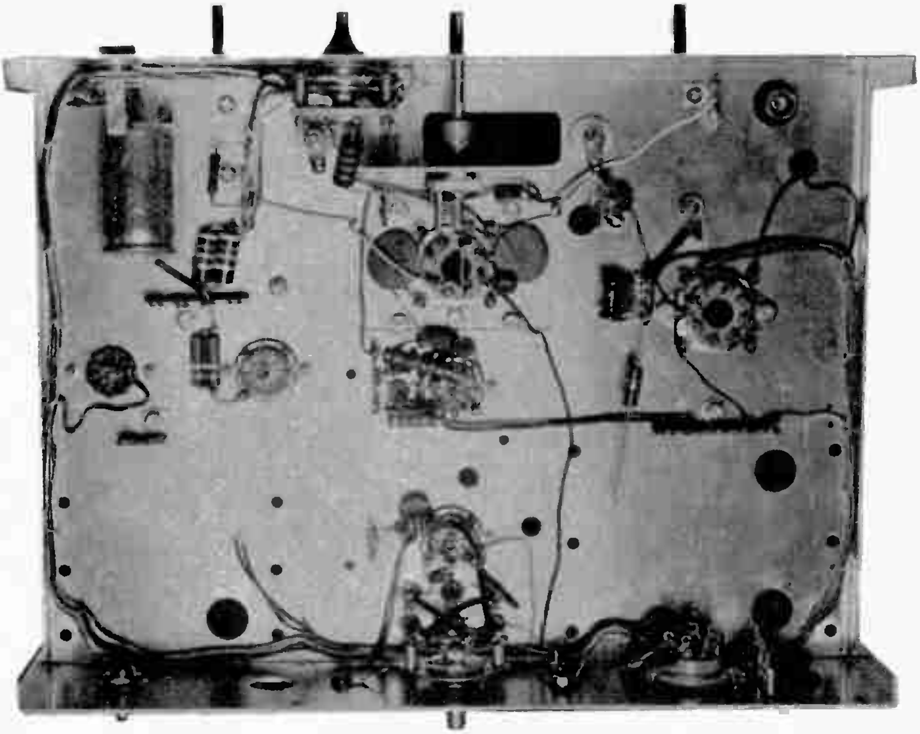
The modulator section contains a 12AX7 speech amplifier and a 12AU7 modulator. Screen modulation of the 6146 amplifier tube is used. A 5U4GB rectifier tube furnishes the required high-voltage DC.

Operation on any of the six most popular ham bands is possible: 80, 40, 20, 15, 11 and 10 meters. Band changing is accomplished by a front-panel switch. Tuning is very simple, as there are only two main adjustments. The meter in the center of the front panel can be switched to read either grid or plate current of the final amplifier tube. After a little practice, the operator can change frequencies in about ten seconds.

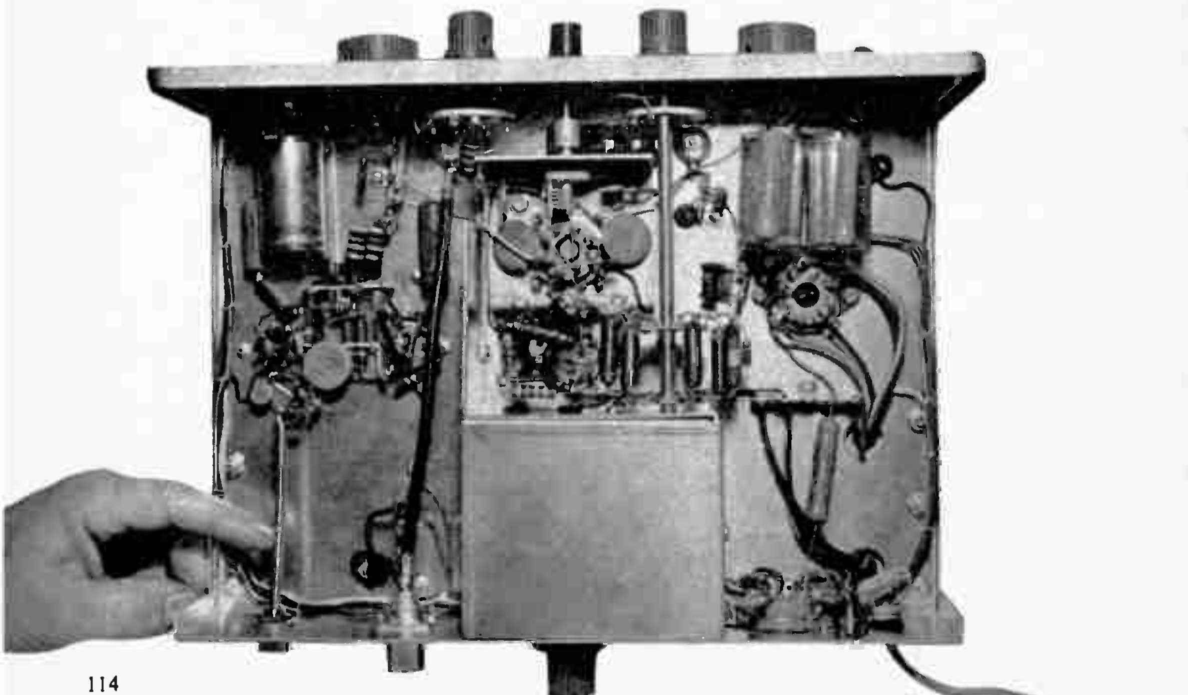
The completed transmitter, in its two-tone gray finish, presents a professional appearance. Although the word "transmitter" sounds imposing, the actual DX-35 is a compact box measuring 13 inches wide, 8½ inches high and 9 inches deep. Only when you try to pick it up do you realize that it's full of iron; it weighs 21 pounds.

On the front panel are the amplifier and antenna tuning knobs, the meter and its switch, key jack, pilot light, function switch, band-change switch and a "drive" control. On the back apron of the chassis are connectors for mike, antenna and VFO

World Radio History

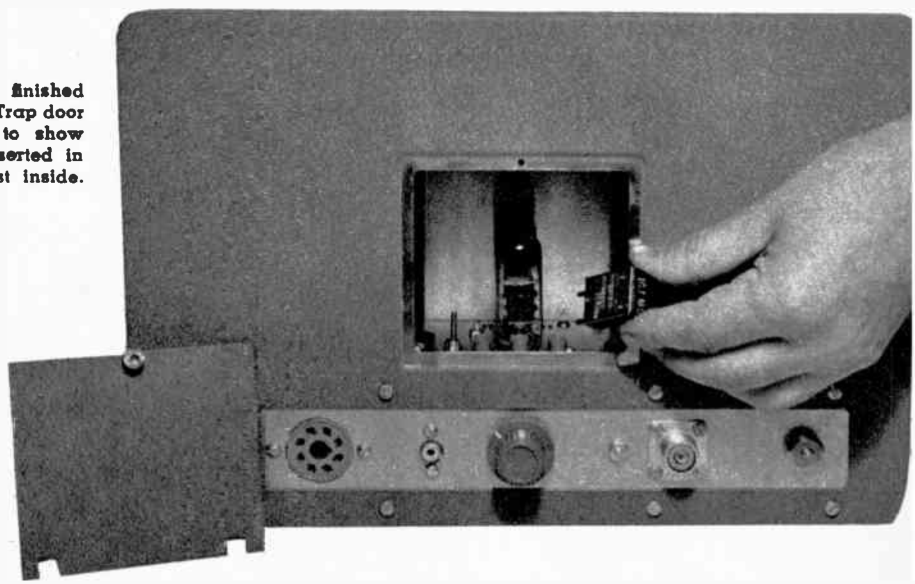


The photograph above affords an under view of the DX-35 transmitter's chassis with some of the small parts as well as a small portion of the wiring in position. The photo below shows the underside of the completed chassis. The box, lower center of the picture, is shield for components of oscillator section.



World Radio History

"Neat" is the way most hams describe the finished DX-35. The hand offers some idea of size of unit.



Here is back of the finished transmitter's cabinet. Trap door has been removed to show how a crystal is inserted in any of 3 sockets just inside.

and a four-position crystal-VFO switch. Access to the three crystal sockets is through a small trap door in the back of the cabinet.

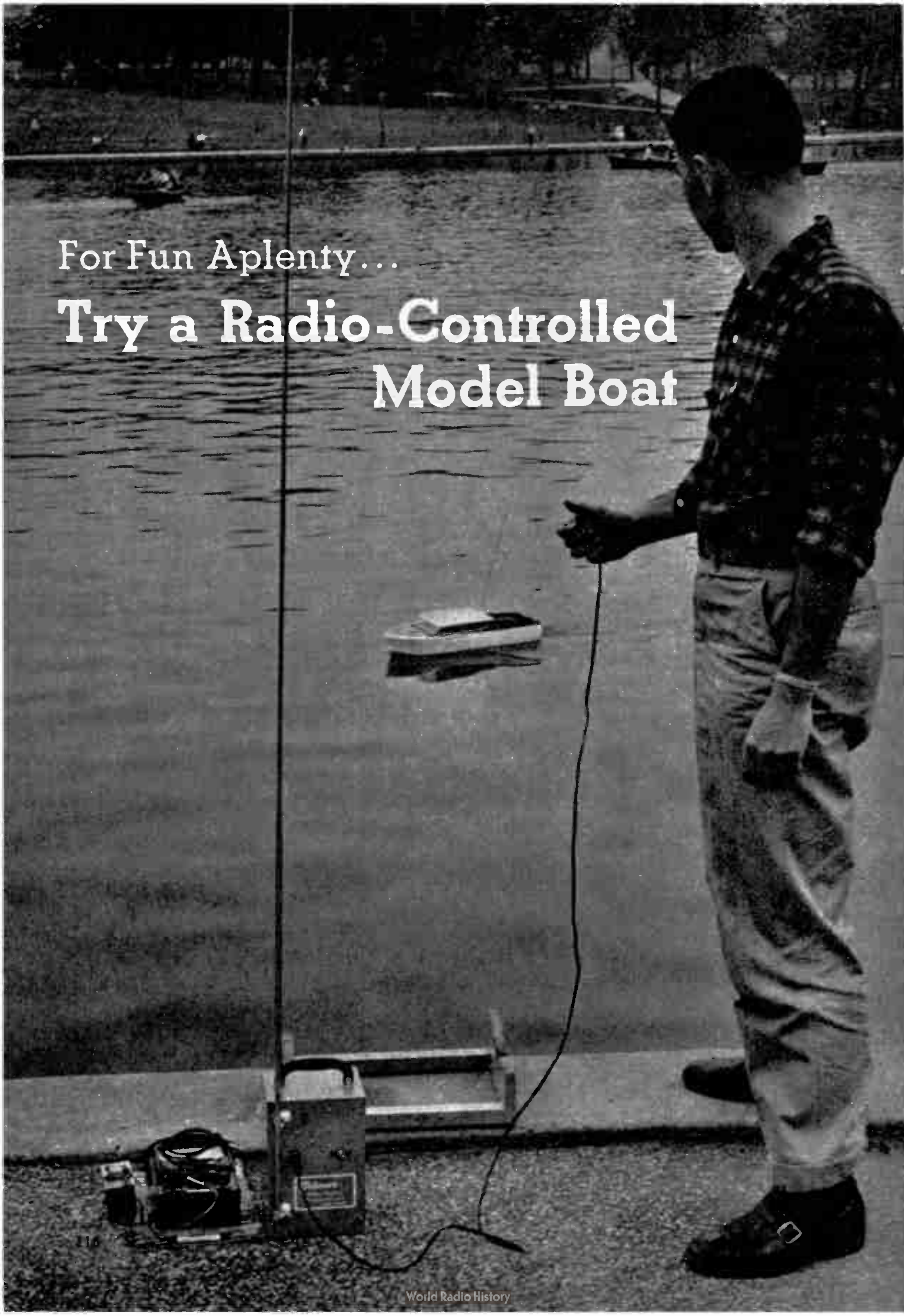
The total power requirement from the AC line is about 175 watts, so the transmitter can be plugged into any outlet without placing a strain on wiring or fuses.

The antenna tuning network accommodates any of the standard types of amateur antennas. For his initial tests, the writer used 28 feet of old bell wire, strung from a basement window a foot above the ground to a back-yard fence about five feet high. (Location: suburban Long Island.) To his surprise, he had no trouble "working" other hams in such places as Dallas, Tex., and Lexington, Ky.! When he gets around to putting up a decent antenna on the roof, the DX is sure to improve. •

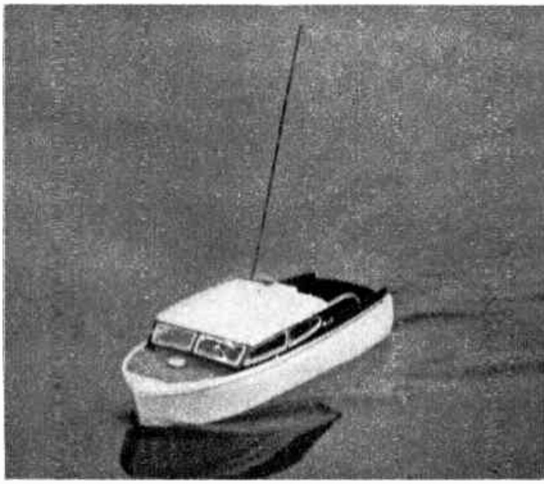
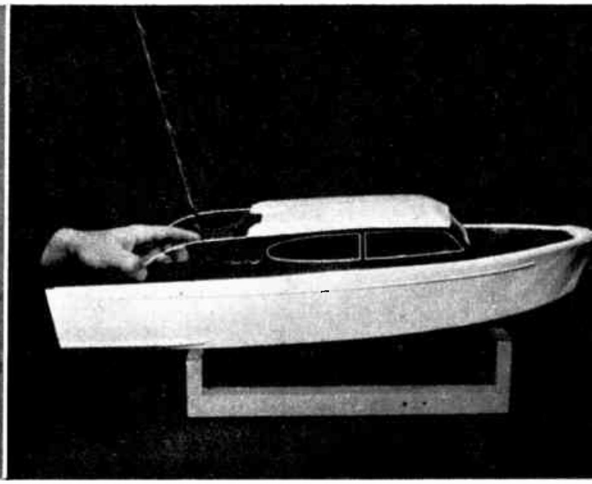
World Radio History

For Fun Aplenty...

Try a Radio-Controlled Model Boat



World Radio History



As shown on opposite page, you can press the control button and make the boat go where you want it to go! Next to transmitter, on left, are circuit tester, spare storage battery. Above left, the R/C boat majestically makes its way across a lake. Note antenna wire attached to right side. Above right, for easy transport, model boat is supported on a simple wooden cradle. Finger points to the antenna.

ITS PROPELLER kicking up a rippling backwash, the white cabin cruiser seemed doomed to destruction as it headed for the jagged rocks on the lakeshore. People in row boats shouted out in alarm and rowed frantically toward the point of the impending crash. However, at the last moment the cruiser executed a smart turn to the right and sped into safer waters.

A marine disaster averted? Far from it! Just a week-end scene at any small body of water where owners of radio-controlled model boats demonstrate their skill in making the sleek craft obey electronically-transmitted orders.

The most enthusiastic R/C boat fans are men who got their original training with R/C model airplanes. One of them explains his switch of interest this way:

"First I spent about $40 and two months of winter Sundays putting together the plane and learning how to make a temperamental little gas engine run for more than five seconds. Then I spent more money on a receiver for the plane and a transmitter for use on the ground. Fifteen seconds after I got the plane launched on its first flight, the signals from another transmitter in the next field sent it crashing into a tree. All I could salvage was a handful of resistors and capacitors, worth about fifty cents.

"Now take the boat game. With an electric motor turning the prop, the boat starts running every time you turn on the switch. No fiddling with messy fuels and critical mixture adjustments. Weight is no problem, and you can put in a decent receiver and a rugged steering control. And—this is most important of all—if anything goes haywire with the transmitter, the receiver, the batteries, or the motor, all that happens is that the boat stops. It's still afloat, and you can retrieve it in one piece. Yes. R/C boats are all fun and no heartbreak!"

It's fun for the owner and even more fun for uninitiated spectators. When trial runs are held in model boat basins and lakes in public parks, children of all ages appear in droves, as if by magic, to watch the proceedings. Allow a youngster to push the control button a couple of times to make the boat go left or right, and he is thrilled speechless.

A typical R/C project involves three elements: first and foremost, a model boat; the receiving and control equipment in the latter; and a low-powered portable radio transmitter that emits signal impulses. The combination shown on these pages has proved exceptionally successful, and a description of it might therefore be of interest.

Hobby stores carry a large selection of excellent scale-model boats in kit form. For convenience in transportation, a boat between about 24 and 30 inches in length is recommended. The one illustrated is a Sterling 28-inch model of a 32-foot Chris-Craft cruiser. With a beam of 9¼ inches, there is ample space for all the electronic equipment.

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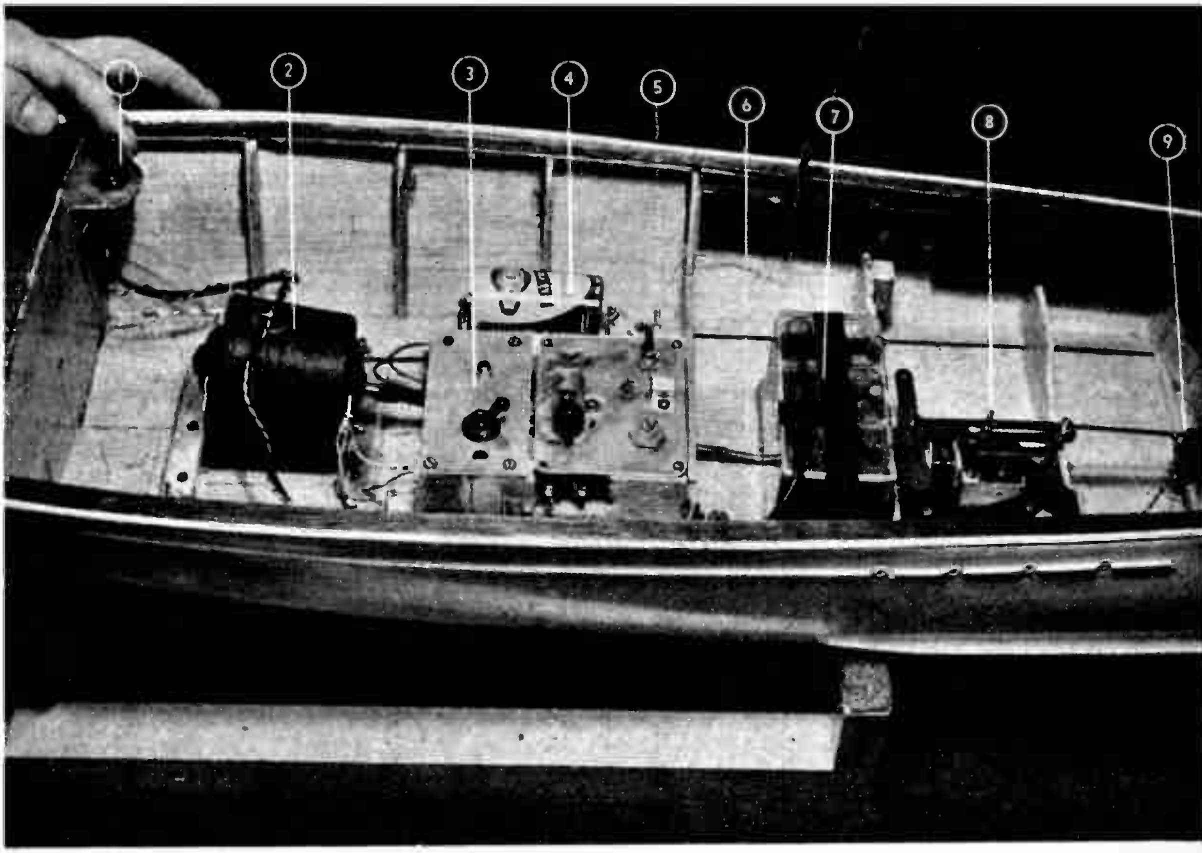

Inside of the R/C model boat, with the superstructure removed: 1. Drive motor switch. 2. Drive motor. 3. On-off switch and meter jack of receiver. 4. Flashlight cells for receiver. 5. Receiver panel. 6. Propeller drive shaft. 7. Storage battery. 8. Rudder escapement. 9. Rudder post. Various parts are distributed to balance boat in water; motor is forward, storage battery toward stern.

The propeller is driven directly by a small six-volt DC motor intended for use as the fan blower of a car heater. Motors of this type are obtainable cheap at auto junk yards or as "new surplus." Electric energy comes from a miniature six-volt storage battery measuring only 3¼ by 1¾ inches by 2½ inches high. Radio surplus firms have thousands of these batteries on hand. One charge is good for about two hours of running time. For a whole afternoon of R/C activity, merely carry two such batteries and switch when the first one shows signs of pooping out. They can be charged easily with any standard auto-battery charger, with the addition of a series resistor to cut the charging rate to about ½ ampere. (The circuit tester pictured on page 88 is ideal for measuring this current.)

The motor is controlled by an ordinary toggle switch. When the boat is to be run, it is placed in the water, the radio receiver is turned on, and the motor switch is turned on. The boat then takes off. The radio control is exercised, in this simple, basic arrangement, only over the rudder movement. This is enough for a beginning, because the boat can always be directed back to the starting point.

The rudder itself is actuated by an "E.D." clockwork escapement mechanism, a British-made device that is widely used by model-boat builders everywhere. In its neutral position the escapement holds the rudder straight. When a signal from the shore-based transmitter is received on the boat, it energizes a magnet on the escapement, causing it to unlatch and to move the rudder to the right or the left. It locks there until a second impuse is received, and then it clicks back to center. A third signal makes the rudder latch over to the other side. With only a little practice, you can make the boat turn circles, figure eights, corkscrews, etc., to the delight of on-

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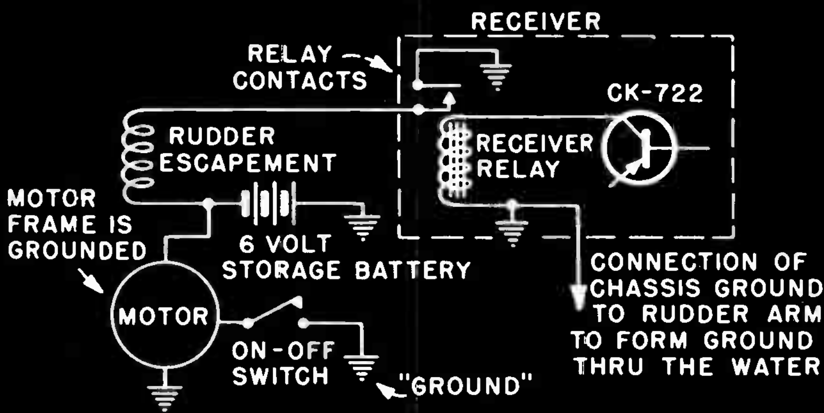
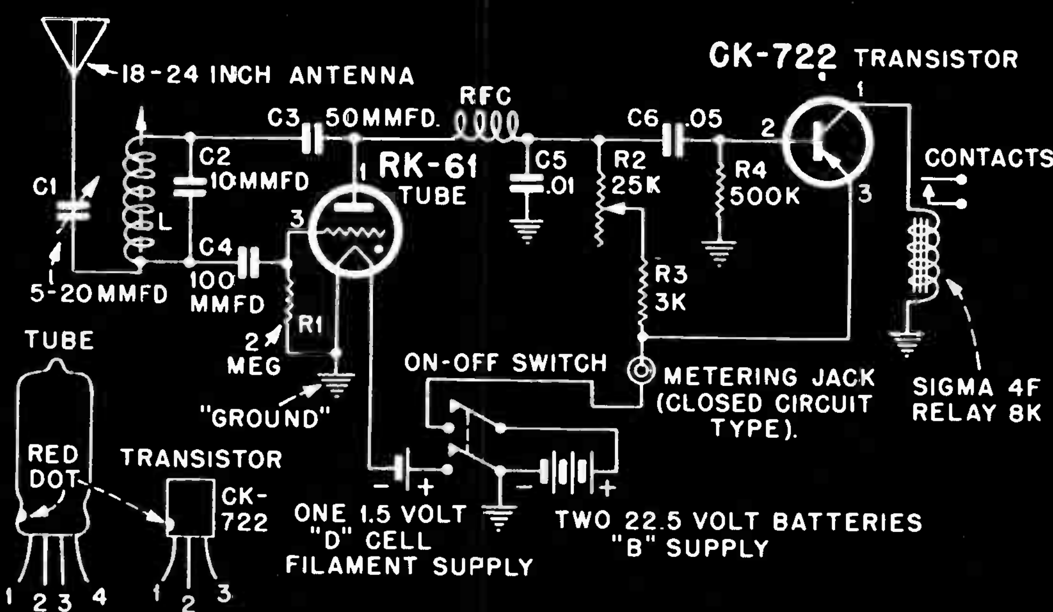


Diagram above of boat wiring shows connections of receiver relay, rudder escapement and motor drive.

Wiring diagram of R/C boat receiver. Parts are as follows:

R1. 2 megohm ½ watt resistor
R2. 25,000 ohm miniature potentiometer
R3. 3,000 ohm ½ watt resistor
R4. 500,000 ohm ½ watt resistor
C1. 5 to 20 mmfd. trimmer capacitor
C2 10 mmfd. ceramicon fixed capacitor
C3. 50 mmfd. ceramicon fixed capacitor
C4. 100 mmfd. ceramicon fixed capacitor
C5. .01 mfd. ceramicon fixed capacitor
C6. .05 mfd. ceramicon fixed capacitor
RFC. 100 microhenry, 75 milliampere choke, National R-33
L. 18 turns No. 26 enameled wire, close wound on ⅜" diameter slug-tuned coil form, Cambridge-Thermionic LS-5
RK-61 Raytheon tube
CK-722 Transistor
Relay, Sigma Model 4F, 8,000 ohm coil
Sockets for tube and transistor
"D" cell holder and one "D" cell
"B" battery holder and two 22½-volt hearing aid batteries
On-off switch, double-pole single-throw toggle
Metering jack, single closed circuit, Telex miniature No. 8570
Meter plug to fit jack, Telex miniature No. 9231
24 inch length of piano wire, for antenna
2 phone tips and 2 tip jacks, for storage antenna



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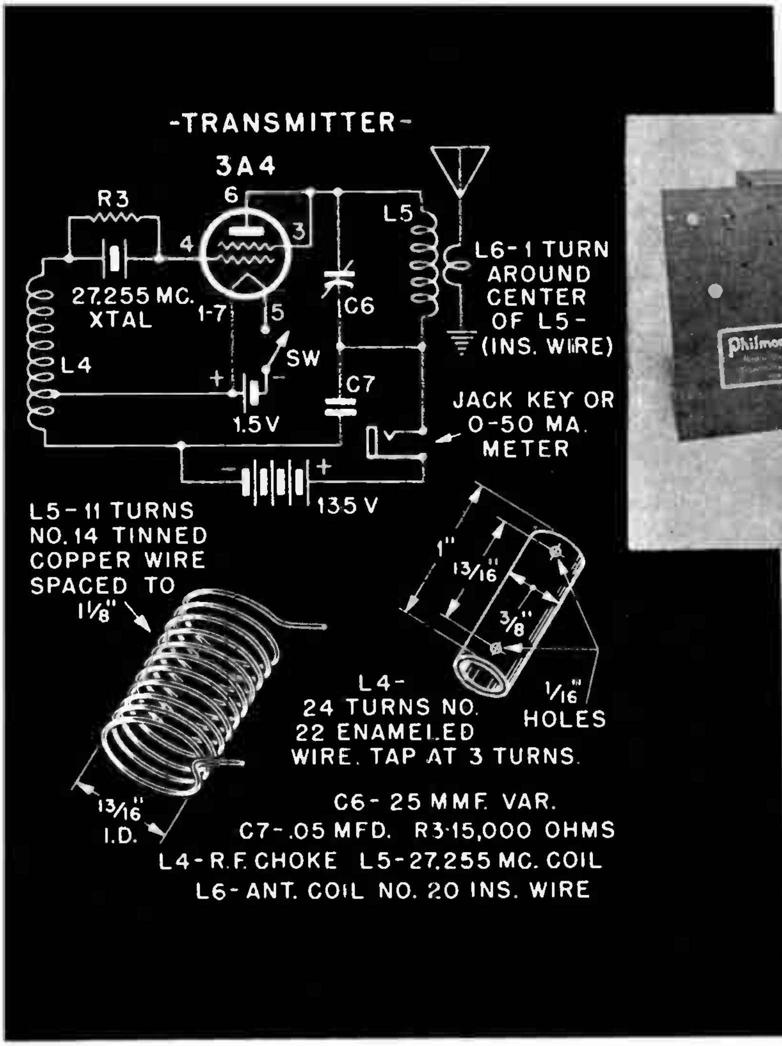

Above is the R/C transmitter in kit form. At right (in hand), is quartz crystal that holds the frequency to 27.255 mcs.

At left is wiring diagram of Philmore transmitter. See top left photo on opposite page.

lookers. The clockwork needs winding only about once an afternoon.

The boat receiver is a homemade affair. It is very small and simple, and uses only one Raytheon RK-61 thyratron, a tube designed specifically for radio-control purposes, and a CK-722 transistor. The schematic diagram and the parts list are given herewith. The physical arrangement is not critical. The parts are mounted on small aluminum panels which in turn are supported on balsa blocks, between the drive motor and the storage battery. Receiver energy is provided by a single "D" size flashlight battery and two 22½-volt miniature hearing-aid-type batteries. Receivers in packaged kit form are available.

The ship's antenna is a 24-inch length of stiff piano wire, taped to a gunwale adjacent to the storage battery.

The transmitter shown in the pictures is a Philmore Model RC222T, assembled from a kit. It operates on 27.255 megacycles, one of the "Citizen's Band" frequencies. As in the case of radio garage-door openers, a license from the Federal Communications Commission is required. This is a mere mail formality, and no technical examination is involved. The model and hobby stores that sell R/C equipment have the necessary application forms.

The transmitter is completely self-contained in an aluminum case measuring 9x6x5 inches. It uses one tube and is dry-battery powered. With a telescoping rod antenna mounted directly on the carrying case, it gives reliable control over any distance at which the boat is still visible to the operator. Experimentally, it has been used in a car up to a mile away, with the receiver still clacking away strongly.

It should be mentioned in passing that

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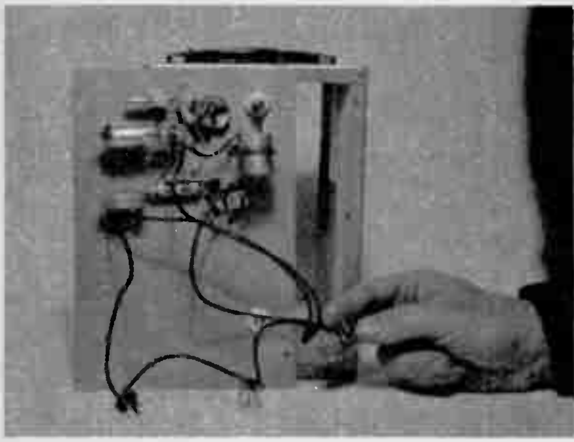
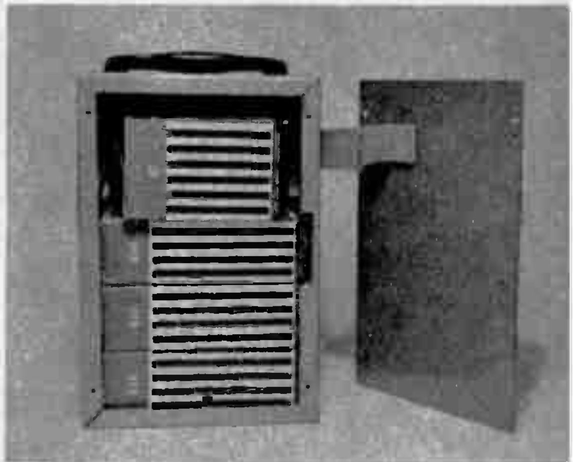


Here is a back view of transmitter panel, assembled and wired. Small connectors are for batteries.

Three "B" batteries (left) and one "A" battery are required to power the Philmore transmitter.



The four batteries occupy most of the space in the transmitter case. The back of case screws on.

Push-switch plugs into transmitter next to vertical antenna. Once tuned up, the Philmore R/C transmitter will not require further adjustment.

27.255 megacycles is outside the amateur "10-meter" band and that a ham license is not valid for this R/C frequency.

An electronic technician can readily see that much more elaborate and spectacular operations than mere rudder control are possible. If the transmitter is tone modulated at several different frequencies, and the receiver is fitted with selective filters that respond individually to these frequencies, the boat can be made to start, stop and even back up, lights can be made to blink on and off, and guns can be made to fire. The circuitry then presents a fine challenge to student engineers.

Some model builders are no longer satisfied with boats and are known to be working on radio-controlled *submarines* that surface and submerge as directed. The big headache with these vessels is making them watertight. •

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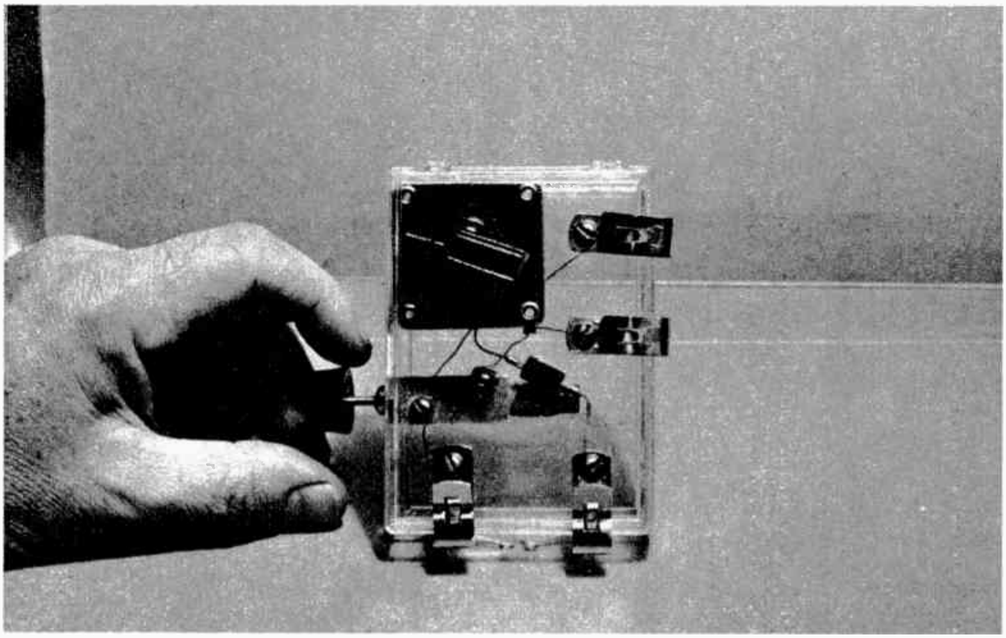
Simplest Radio Receiver



It uses a crystal detector and earphones, requires no batteries or other current and will produce excellent results with a good aerial.

"FOR A WORKSHOP project for boys in the 10 to 13 year age bracket, design the simplest possible radio receiver that works, but doesn't use batteries or connect to the house power line."

This was the assignment given to an industrial arts teacher in one of New York City's biggest junior high schools. The set that evolved from a series of experiments is shown on these two pages.

The parts required, all obtainable from radio parts jobbers, are as follows:

Loopstick, with round knob to fit shaft.

Flat style midget variable capacitor, 365 micromicrofarads, with pointer knob to fit shaft.

1N64 diode.

4—Fahnstock clip type binding posts.

6—Round head machine screws, iron or brass, 6-32, ¼ or $\frac{5}{16}$ inch long, with nuts.

Clear plastic box, hinged, 2¾x3¾x1¼ inches.

Single high-impedance earphone, or pair.

All the parts are mounted on one section of the box. See the full size drilling layout. The variable capacitor mounts by its own threaded center stud. Screws hold the binding posts. Run the nuts on loosely; they are not tightened until after connecting wires have been placed under them. A small mounting bracket comes with the loopstick. Bend this L shaped, and fasten with two screws. Push the threaded rod end of the loopstick through the hole from the inside of the box, and the neck of the coil form will lock into place.

A crystal receiver depends on an aerial and a ground for good signals. The longer the aerial wire, the better the results, usually. In New York and other cities served by numerous stations, a piece of any copper wire as short as eight or ten feet, merely stretched out on the floor, produces fine signals. For a "ground," touch a wire to a clean spot on a water pipe or radiator. A ground is not always necessary; do a little experimenting. Generally, signals are louder with a ground, but tuning is sharper without one.

Tuning is done by turning both the variable capacitor and loopstick knobs. •

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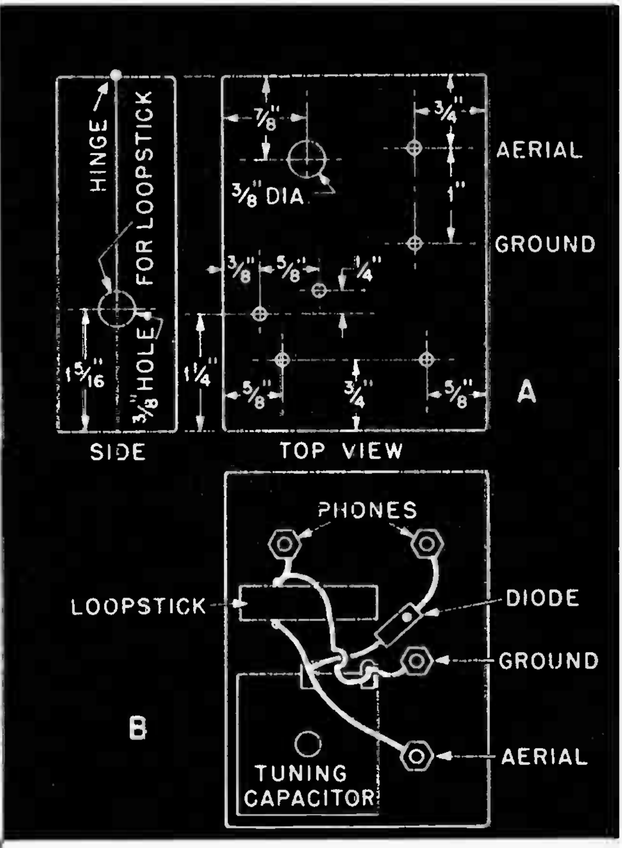
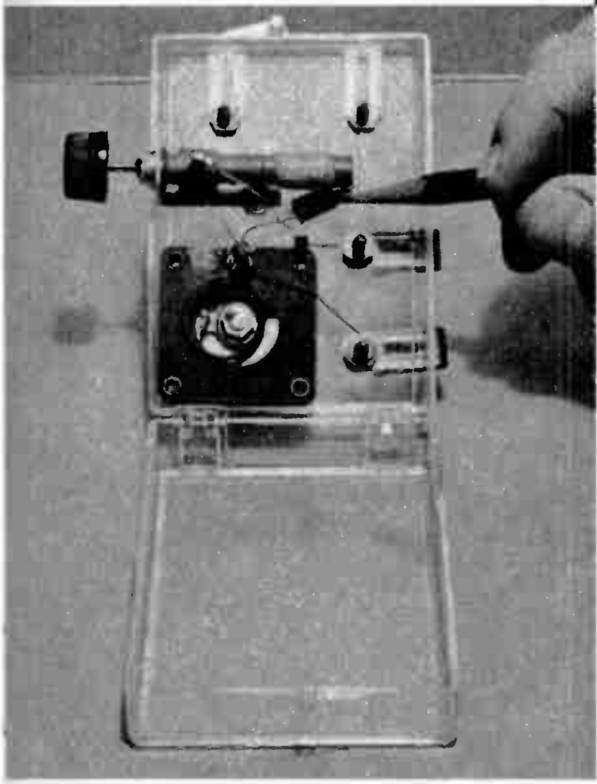
Opposite, finished set in plastic box looks impressive. Aerial and ground wires connect to upper right binding posts, the earphones to the lower ones.

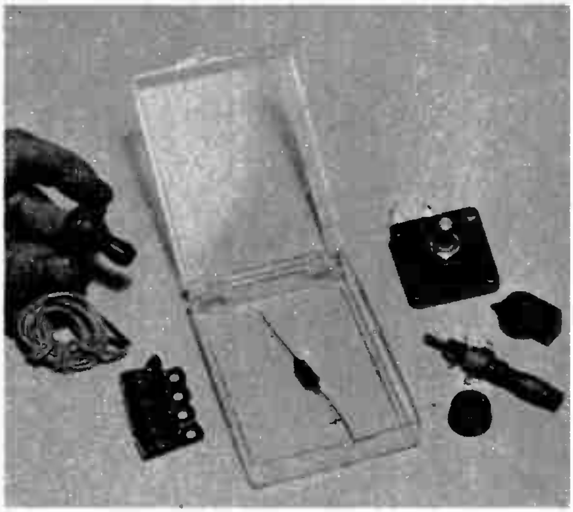
Diagram A represents the drilling layout. Placement of parts is not critical. In following the wiring diagram B, use any thin wire, bare or insulated.

Below, this is an inside view of the receiver. Pencil points to crystal diode, mounted by its own pigtail wires between an earphone binding post and the center lug of the tuning capacitor.





Below, these are the parts for the simplest radio set. Single hearing-aid type earphone is at left, above binding posts. Diode is in box. Top right is tuning capacitor; loopstick is at bottom right.



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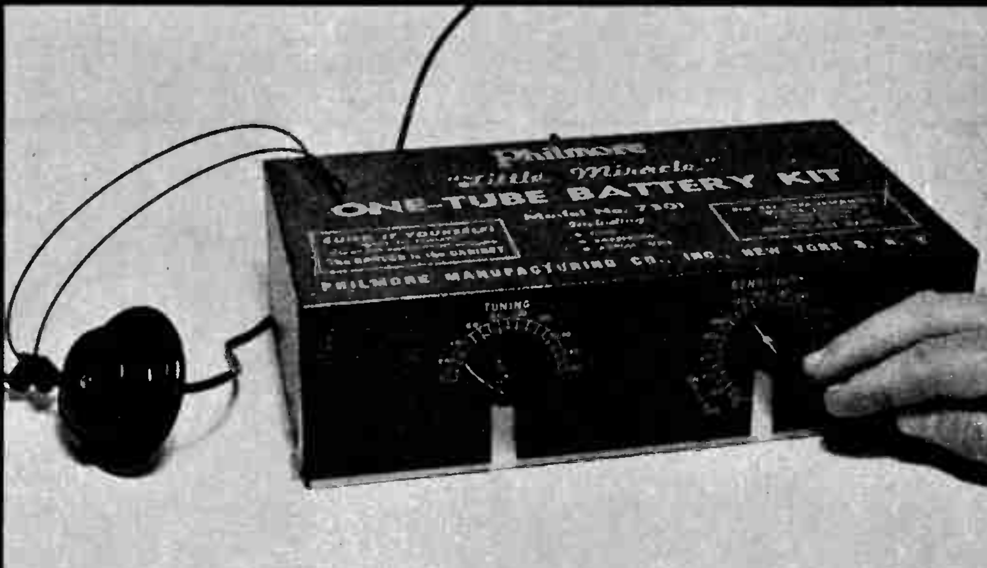

One-Tube Battery Set

Use the kit's box as a cabinet for the finished set.

Above, here is the completed set mounted in the original box. Earphone, aerial and ground are connected to the chassis through holes in rear.

Left, a full-size layout template simplifies job of placing and mounting parts on the plywood base.

AN ingenious packaging job has been done on the Philmore one-tube battery set, which is furnished in kit form: the cardboard box in which the parts are packed does double duty as a protective "cabinet" for the completed instrument.

The set itself uses a single tube in a reliable, time-tested regenerative circuit. This combines high sensitivity and good selectivity. With an outside aerial about fifty feet long, broadcast stations several hundred miles away can often be heard at night. On local stations the volume is almost too much for comfortable listening with the earphone, although not quite enough for satisfactory operation of a loud-speaker.

A single 1½-volt flashlight cell and a

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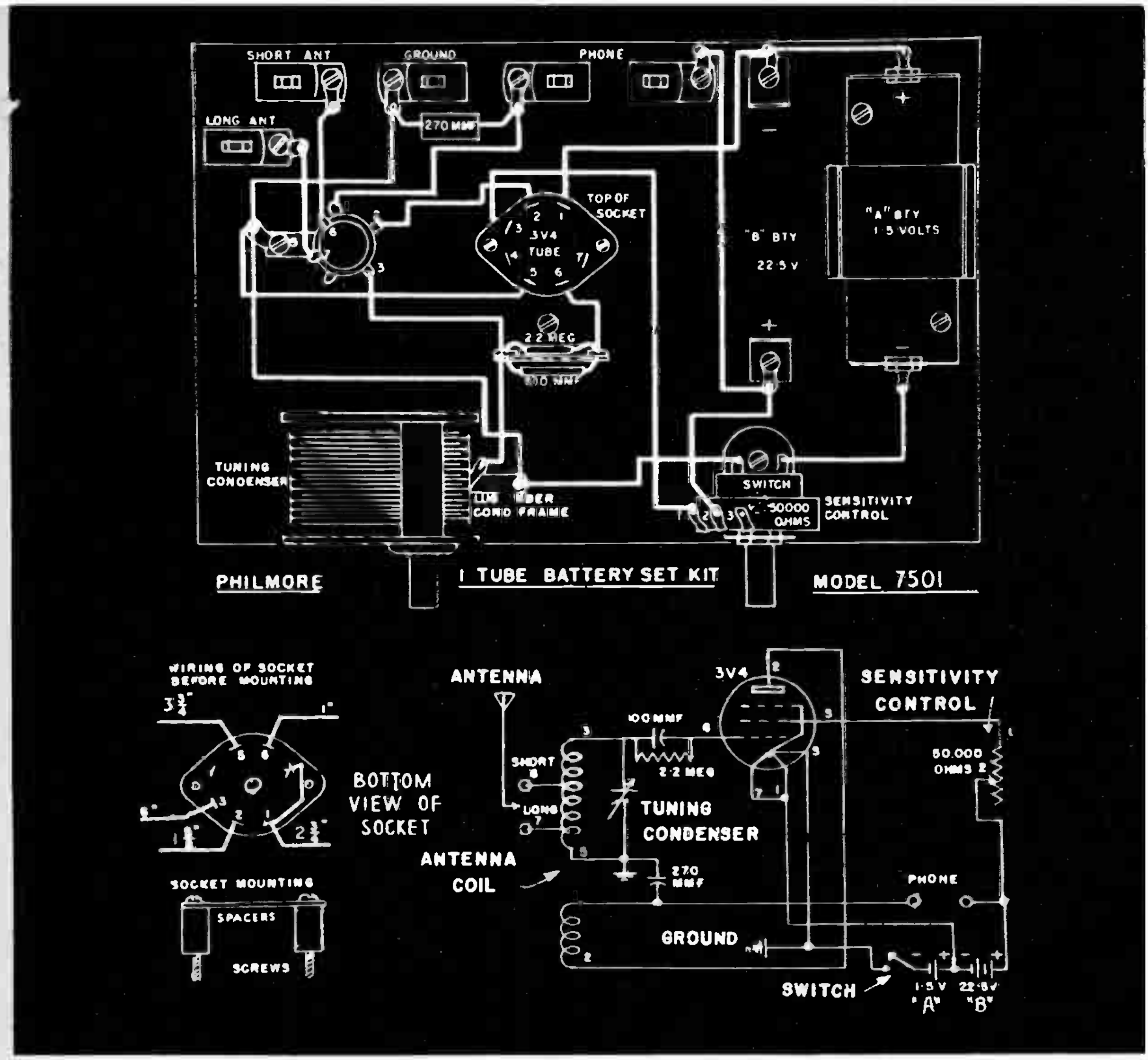

At top is the wiring of one-tube set. At bottom is schematic diagram, details of socket connections.

miniature 22½-volt hearing aid battery supply the necessary power for the tube. Since no connection is made to the house power line, there is absolutely no shock danger. The set is therefore a fine project for youngsters who have already passed through the crystal receiver stage.

The kit includes a small plywood baseboard and a full-size template. Mounting the parts should take about a half hour, wiring them another half hour. All the connections are on the top of the baseboard.

Two antenna connections, marked "Short Ant" and "Long Ant," are provided. Use whichever gives the best results.

The two-handed tuning is simple. Stations are selected with the tuning condenser, and volume is adjusted with the sensitivity control. The latter is somewhat critical. If it is turned up too far, the set breaks into oscillation and whistling is heard. The clearest and loudest signals are usually heard at the setting just before the point of oscillation.

The 22½-volt "B" battery will probably last for six or more months, as the current drain on it is very slight. The "A" battery life will be shorter. Fortunately, this battery is cheap. If the set is left on for more than about thirty minutes at a time it will die off to an extent depending on the condition of the "A" battery. However, if it is turned off for about five minutes, the battery will restore itself. This action is common to all dry cells. ■

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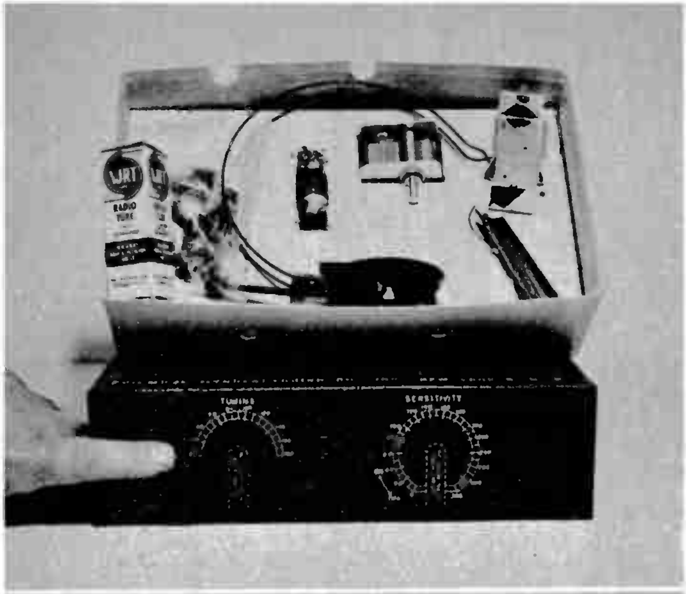
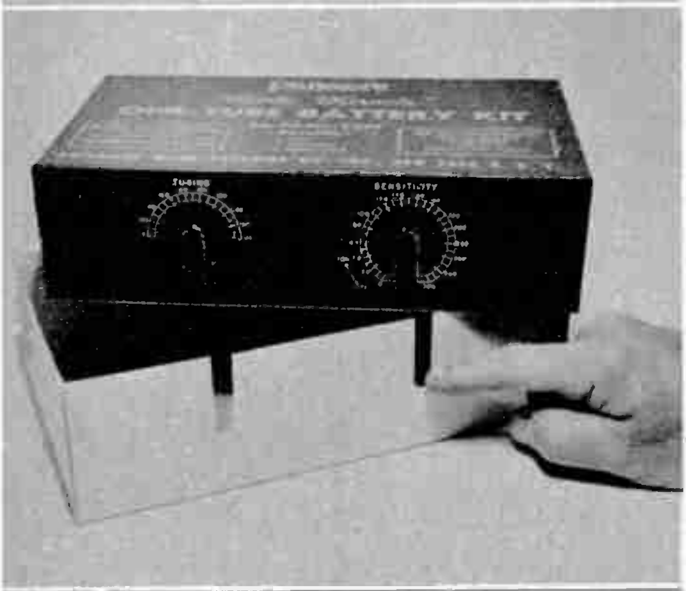
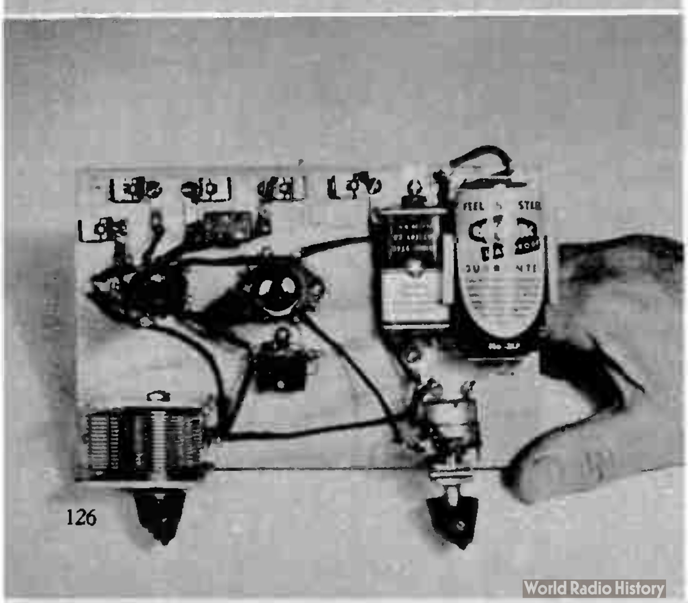


Components for one-tube battery set are in the upper box section. Finger points to scales printed on the outer section of the box.



Matching slots are cut into front edges of box sections. Shafts of tuning and sensitivity controls are enclosed in slots when chassis is in position and box is closed.



This is completed "chassis" ready to operate. Batteries fit in the spring clips on baseboard. Battery "B" should last 6 months.

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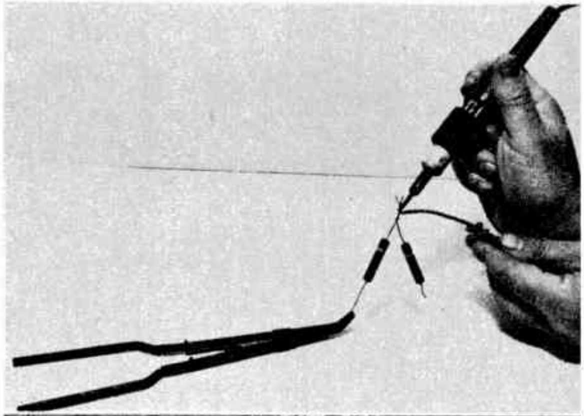
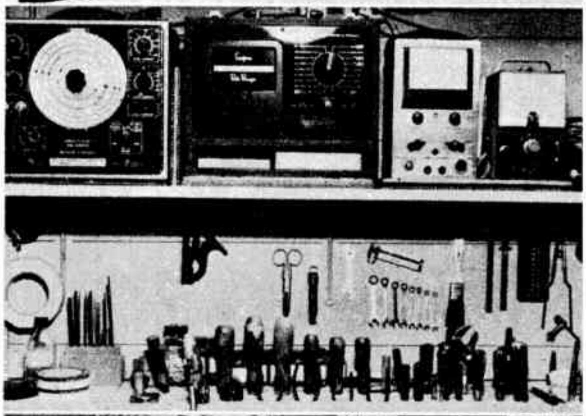
Handy Kinks

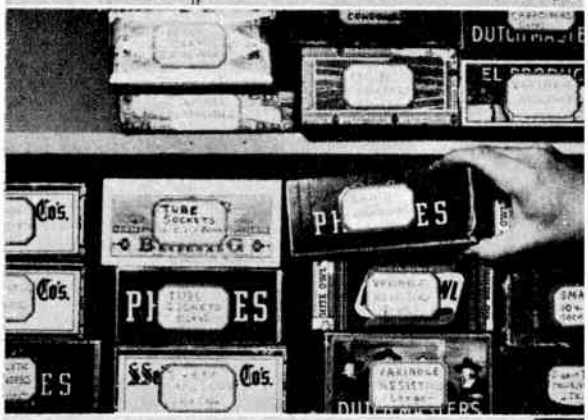
Do you wish you had a third hand when soldering small parts? You'll find that a pair of clamping type tweezers or forceps does the trick. Rest tool on workbench or secure it in a vise.



This is a very convenient arrangement of electronic test equipment and the small hand tools used in electronic construction and repair. Equipment is on shelf, at eye level, and is mounted there permanently. Standard test leads are long enough to reach to bench top. Typical set-up is (left to right) Precision Model E200C signal generator, Simpson Roto-Meter, RCA vacuum-tube voltmeter, Heathkit capacitance meter. Small tools are below.



For holding the various small parts used in electronic construction, there is nothing as good as old-fashioned cigar boxes. Stores that sell cigars usually throw the boxes away, so you can get all you want by asking. Stick on red-bordered labels and mark contents of cigar boxes in ink.



Smooth, shiny recording tape does not take an ordinary pen or pencil marking. When editing tape, use a "negative pencil," which is sold in most photo stores. It leaves a thick black mark.

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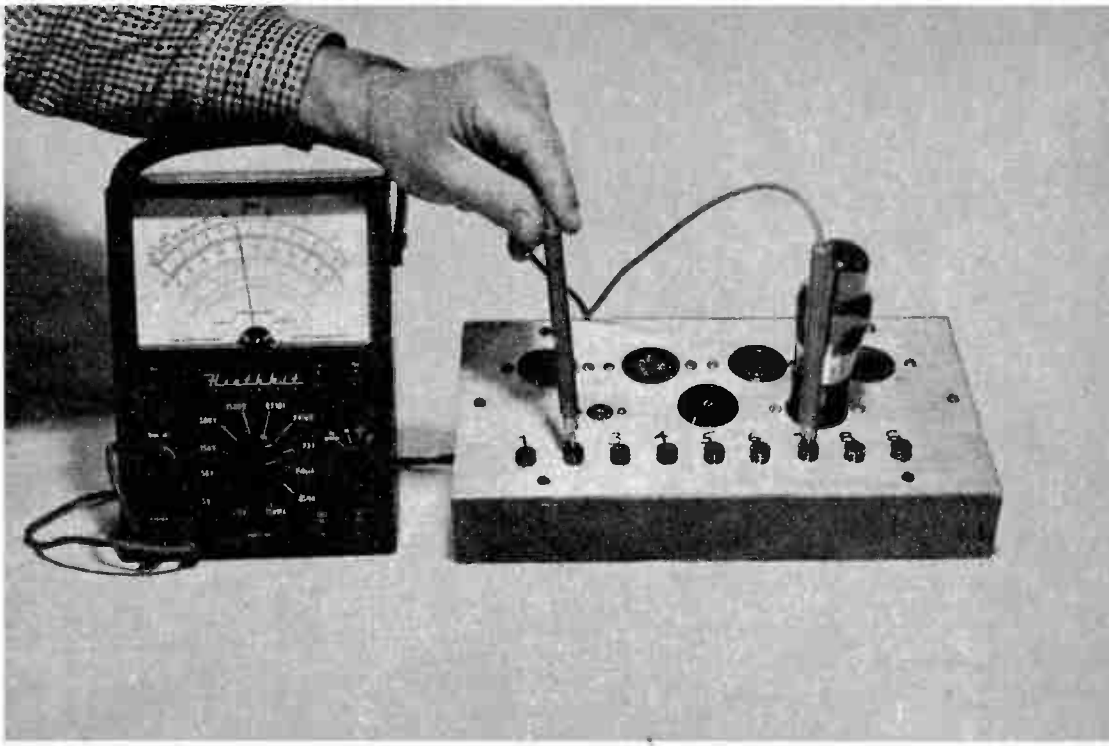

Tube Testing Made Easier

Save time and insure accurate readings by building this simple socket box to use as an adjunct to your multimeter.

THE most important thing you need to know about an electron tube is the condition of its filament, sometimes also called "heater." In normal operation this runs at either a cherry red or at full white heat, and eventually it will burn itself out. You can check the continuity of the filament wire very positively with any standard circuit tester or "multimeter." From the physical standpoint, what should be a very simple job is often an awkward one because the base pins of many tubes are very close together.

You save a lot of fumbling and wasted time by making the extremely simple socket box illustrated on these pages. This consists merely of a double row of sockets, one of each standard type, and a row of nine small pin jacks. All the No. 1 pins of all sockets are wired to the No. 1 pin jack; all the No. 2 pins to the No. 2 pin jack, and so on. To run a filament check on any tube, insert it in the proper socket, look up the filament pins in a tube manual or chart, and insert the test prods of the multimeter in the proper tip jacks. The connections thus made are very positive. There is no chance of obtaining a false reading, as is often the case when the test prods are placed directly against the tube pins.

Depending on what kind of hole cutters you have available, use aluminum, plywood or press board for the panel. The author used aluminum for the tester illustrated, because he has a set of radio chassis punches. With these, accurate holes of the correct sizes for standard sockets can be made in about a minute apiece.

You need sockets of the following types: four-pin, five-pin, six-pin, seven-pin, eight-pin octal, seven-pin miniature and nine-pin miniature. You can buy these new for as little as a nickel apiece, or you can salvage them from your junk box. You also need nine pin jacks of the insulated type for an aluminum panel or plain for a wooden one.

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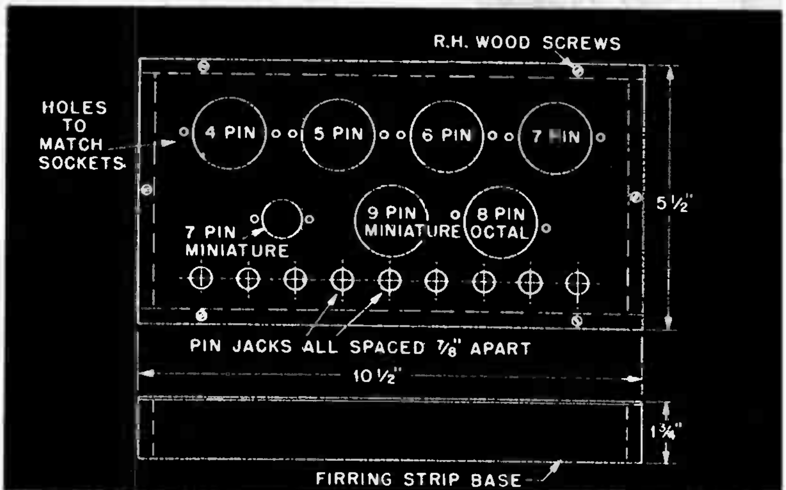
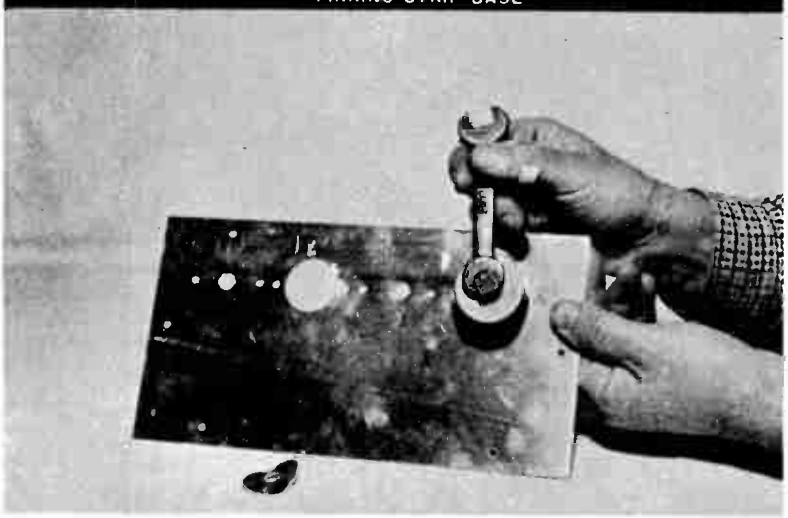
Opposite, the tester box in use. A tube is in the octal socket and test prods of the multimeter are in the No. 2 and No. 7 jacks. Meter reading, on low-ohm scale, shows that the filament is OK.

This type of chassis punch is convenient for making clean holes in metal chassis. Bolt draws cutter section (center) through the metal and into the body (right).



Layout of the tester panel is simple. Placement of sockets is not critical. Hole diameters depend on which sockets are used.



Chassis punch in use. Bolt fits through small pilot hole drilled in panel. A few turns with a wrench and the punch cuts out a perfect hole. Metal removed by the punch resembles bent washer.

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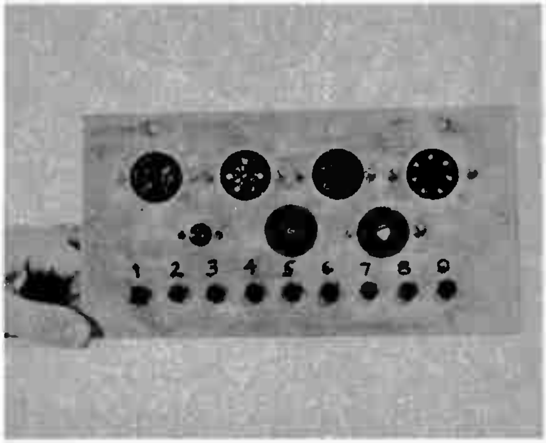
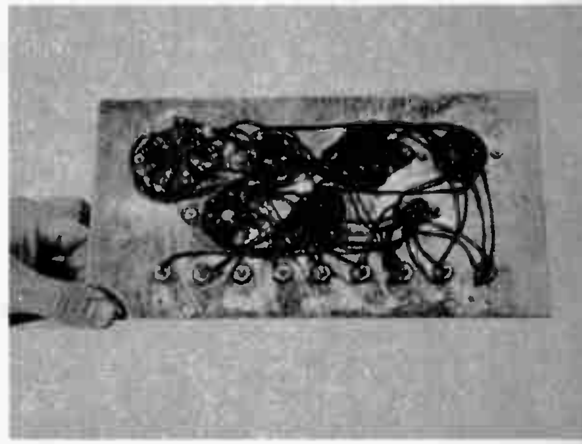
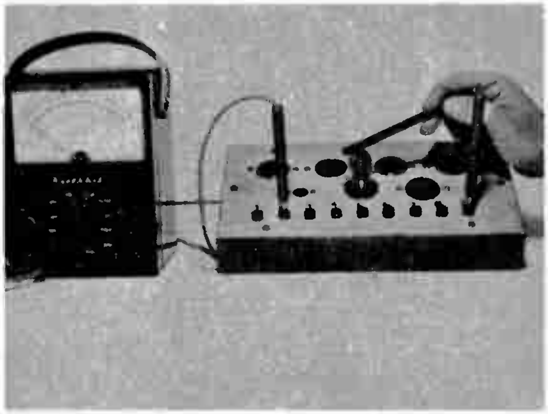
From the front, the panel presents a neat appearance with all sockets and pin jacks in position.



Wiring of panel is simpler than it looks. No. 1 pins of sockets go to the No. 1 pin jack, etc.



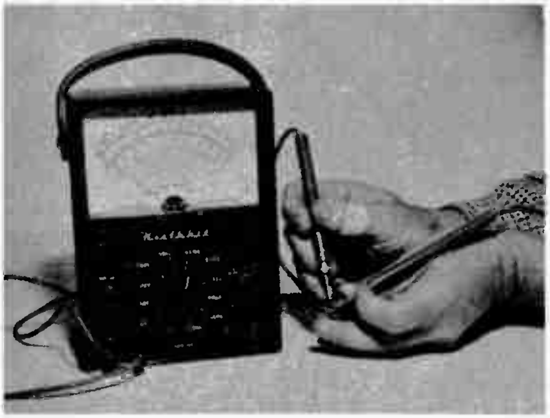


Are internal elements of a tube touching where they shouldn't? An easy way to find out is to connect multimeter between suspected elements and tap tube with pencil. If needle flickers (on high-ohm resistance scale) the tube is bad.

The dimensions of the panel and the spacing of the sockets and the pin jacks are not critical. In laying out the holes, make allowance for a base consisting of pieces of firring strip (common wood measuring about 1¾ inches wide and ¾ inch thick). The pieces are merely butted and nailed, and the panel is screwed to the edges. Assemble and wire the sockets and pin jacks and then mount the panel to the base.

Mark the pin jacks from left to right with large, legible letters. Ordinary drawing ink will stick to aluminum if the surface is "matted" by rubbing lightly with fine emery cloth. Or cut out numbers from a newspaper or magazine and cement or tape them down.

The tester is not limited to filament checking. With the multitester connected between various other tube elements, intermittent internal short circuits can often be located. Altogether, the unit will prove highly useful in a ham "shack," a basement "lab" or a school shop. •



Photo, left, shows awkward method of tube testing that often gives misleading results. Small tubes are hard to hold and pins are too close for comfort. The socket box eliminates this nuisance.

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the *smoother* the tape, the greater the *fidelity*

...because of better head-to-tape contact

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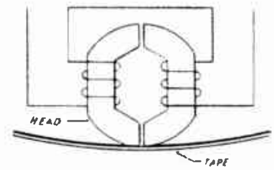
BRAND
FERRO-SHEEN TAPE
has the *smoothest surface* of them all!*



The oxide coating of recording tape must make close contact with the head for accurate reproduction of the upper frequencies. The high frequencies correspond to such small physical dimensions in the magnetic recording process that the minutest discontinuities in the oxide coating will interfere with the magnetic influence of the head on the oxide. Hence, the coating should have as little "grain" in it as possible. The ***FERRO-SHEEN*** process results in the smoothest and most homogeneous magnetic surface ever produced on tape, improving high-frequency reproduction and overall total fidelity on any tape recorder.

****Make Your Own Test in 20 Seconds!***

Place a sample of *FERRO-SHEEN* tape side by side with strips of the other leading brands of recording tape. You will see at a glance the obvious difference in surface between *FERRO-SHEEN* and all the others. And . . . the difference you can SEE is responsible for the improvement you will HEAR!

FIVE Great irish *FERRO-SHEEN* Tapes:

SHAMROCK #300: The ultimate in premium, professional tape for broadcast and studio use. 1.5 mil plastic base. Comes with 5' Mylar leader in dust-proof polyethylene bag.

LONG PLAY #600: Extends playing time 50% over conventional tapes of same size reel, on Dupont's miracle film Mylar.

DOUBLE-PLAY #7-2400: Now 2400' on a standard 7" reel. Twice as much playing time on all speeds. Mylar base.

GREEN BAND #211: The only premium tape available for the same price as ordinary coated tapes.

SOUND PLATE #220: Super-tough tape for masters and recording under adverse climate conditions.

ORRADIO INDUSTRIES, INC., Opelika, Alabama

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If not available at your favorite dealer, write to manufacturer.

World Radio History

Tips on Tapes

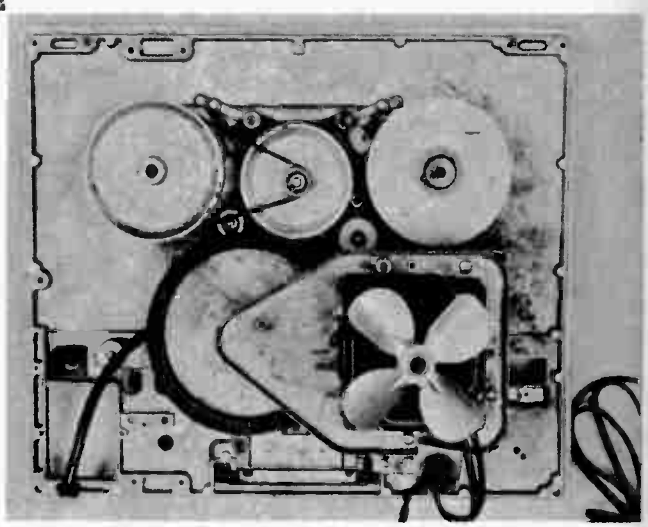
If you've never owned a tape recorder, you'll be surprised by the simplicity of its operation and the durability of the tape itself.

THE feature of tape recorders that new buyers have the greatest difficulty understanding is their utter simplicity of operation. This sounds a bit odd, but take the word of salesmen in electronic supply stores: it's true.

What causes the initial confusion is the fact that the paper recording tape itself looks and feels exactly like 8-millimeter movie film, and further, it is spooled on the very same reels made for the latter. People then jump immediately to the conclusion that the tape must be "processed" or "developed" just as photographic film is. They look sort of blank when told, "No processing is necessary. You can play back the recording right after you rewind it. Also, you can reuse the same tape over and over, without wearing it out." The deal sounds almost too good . . . as if something were being given away. It usually takes a couple of demonstrations to convince some buyers that the tape is as magical as it appears.

Tape recording works on a magnetic principle. The paper or plastic tape is merely the base for a very thin layer of finely divided iron dust. In the recording process, the tape passes over an electromagnetic "head," which is actuated by

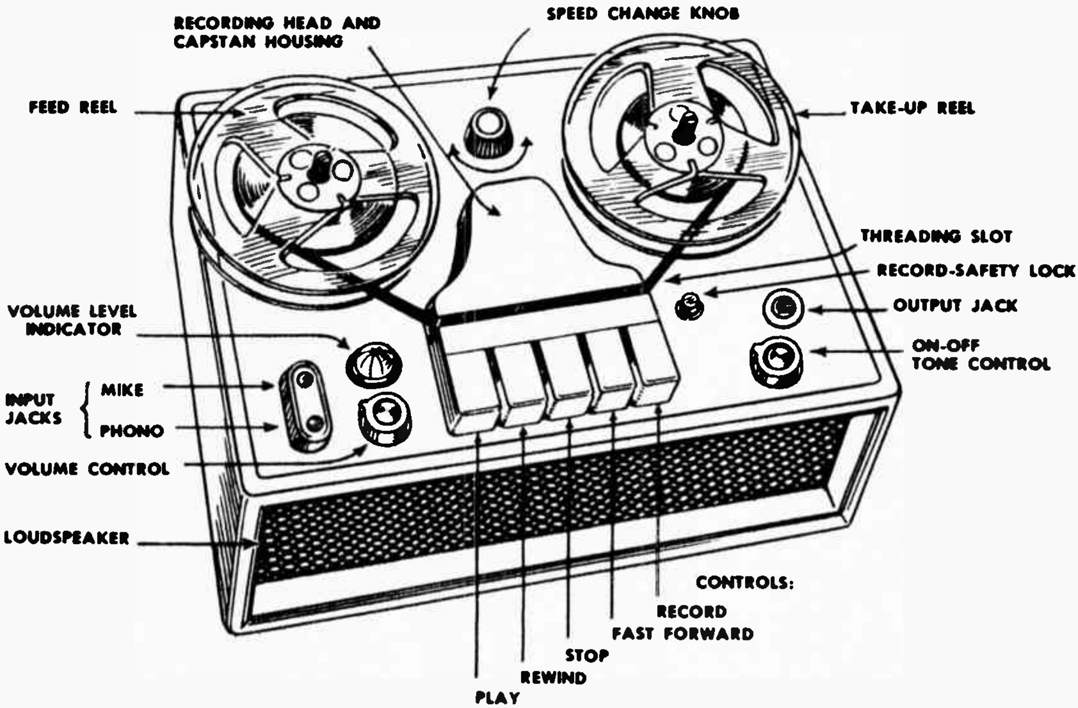
RCA Victor Congressional Model 7TR2 is portable, comes in a smart, luggage-type case. It has 5 push buttons and runs on 2 speeds. Speaker measures 5x7 inches.



Inside view of RCA Victor Judicial Model 7TR3 tape transport featured on cover of this book. It has 3 speakers: one 6½-inch for low and mid-range frequencies and two 3½-inch ones for high. Price is $199.95.

World Radio History

TYPICAL TWO-SPEED TAPE RECORDER WITH PUSH-KEY CONTROLS



Minnesota Mining and Mfg. Co.

a microphone-and-amplifier combination. The iron layer is magnetized by the head, in accordance with the variations of tone of the speech or music being recorded. During playback, the tape passes over the same head, but this time the latter's role is reversed. The faint magnetic lines of force surrounding the tape induce voltages in the head, and these are strengthened by the same amplifier and reproduced as sound.

Only strong, close-by magnetic fields can disturb the magnetic images impressed on tape by the head. Although modern homes, offices and factories are filled with magnetically-operated machines (motors in hundreds of shapes and sizes, radio and television receivers, fluorescent lights, etc.), fortunately their *outside* magnetic effects are very weak. Stored in a desk drawer or on a bookshelf, tapes retain their recordings indefinitely.

If a particular recording no longer has

By using an inverter, you can now power your tape recorder with your car battery and use the machine for recording and playback while on the road.

World Radio History

any value, the tape can be run through the machine and used for a new impression. In all machines the tape passes over an "erase" element, actually a powerful electromagnet actuated by alternating current. The erasing process breaks up the previous magnetization of the tape and substitutes for it a random magnetization that represents an inaudible image. The test of whether the erase feature of a recorder is working is to run a previously-recorded tape through with the controls in the "record" position, but with the microphone turned off or disconnected. When the tape is rewound and the machine set to "play," nothing should be heard from the loudspeaker.

If a tape is not erased before re-recording, the new recording is usually just a jumble of sounds.

Several "head" arrangements are in use. In the most popular one, found in carryable machines for home and office applications, a single head contains an erase coil and a combination record-playback coil. In professional-type machines, completely separate record, playback and erase heads are employed.

The ¼-inch-wide tape is available in lengths from 150 to 7,200 feet per roll, in reels from 3 to 14 inches in diameter. Practically all the standard carryable recorders operate on two "speeds," expressed in terms of inches of tape moving by the head in one second: 3¾ inches-per-second and 7½ ips. Also, "dual track" recording is used in these machines. Only the upper edge of the tape is used on the first run-through; then the tape is flip-flopped and the other edge is recorded too. This has the effect of doubling the useful length of the tape. At 3¾ ips, dual tracked, an inexpensive 3-inch reel of tape is good for 15 minutes of speech or music: a 5-inch reel for an hour.

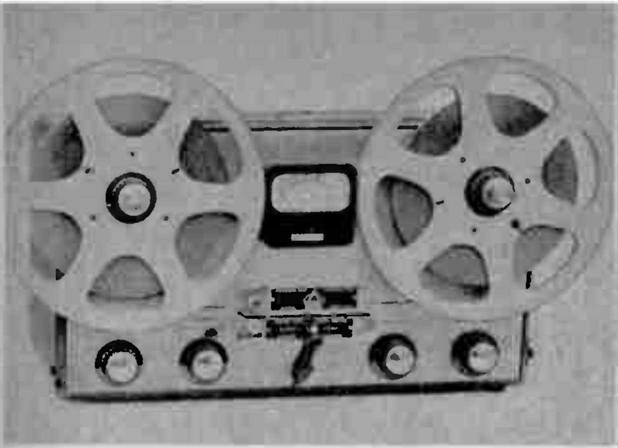
Professional equipment (also used by many "amateurs"!) generally operates at speeds of 7½ and 15 ips and uses the en-

Revere T-11 high fidelity tape recorder is for professional as well as home use. Balanced tone emphasizes bass and treble even on low volume. Designed for custom installation. List: $284.50.

Revere recorder-radio combos offer top listening reception and taping of favorite programs. Model TR-1200 has 2 speeds; TR-1000 standard speed of 3.75 ips. List: $219.50, $249.50 respectively.

Revere's keyboard control high fidelity recorders are available in three models: T-700D with dual speed, T-700—3.75 ips, and Model T-10—7.5 ips. List prices: $225, $235, and $245 respectively.

World Radio History



Crown 3-motor portable professional recorders feature reel locks, straight line threading, 3 equalized tape speeds of 15, 7.5, and 3.75 ips. Imperial, left, takes 10½-inch reels direct, weighs 50 pounds, lists at $425. Crown Prince, right, measures 19x14x7½", weighs 38 pounds, and costs $349.50, without case.

tire tape area. The advantages are better tone quality (higher "high fidelity") and ease of editing. If you don't like a passage in a single-track recording, you can cut it out and merely tape together the loose ends.

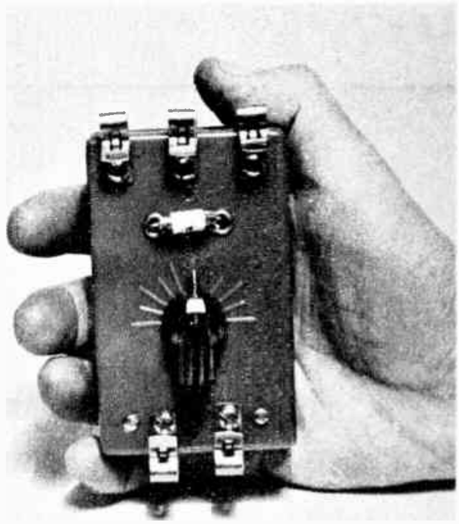
Because of space and weight limitations in carryable recorders, the self-contained loudspeakers are rather small, and often the sound reproduction is about on a par with that of a table model radio set; that is, pretty poor. Most buyers of recorders don't take much notice of this initially, because they are too busy recording everybody and everything within hearing. However, eventually they'll want to hook the recorder into a hi-fi set-up. •

Irish professional recording tape is of red oxide with plastic base, and offers high output, high amplitude constancy and low signal-noise ratio.

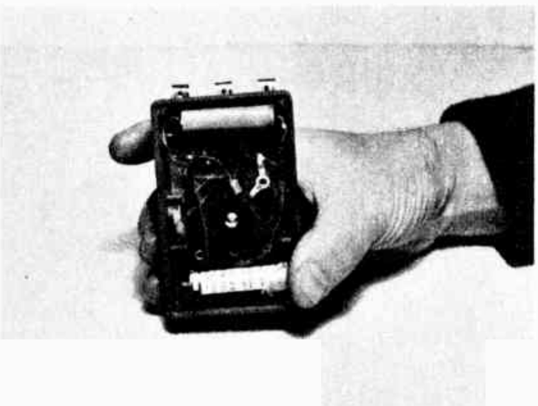
These second-graders at Robert Louis Stevenson School, Melrose Park, Ill., record and play back their favorite stories as part of school's audio-visual program. Recorder is an Ampro Celebrity.

World Radio History

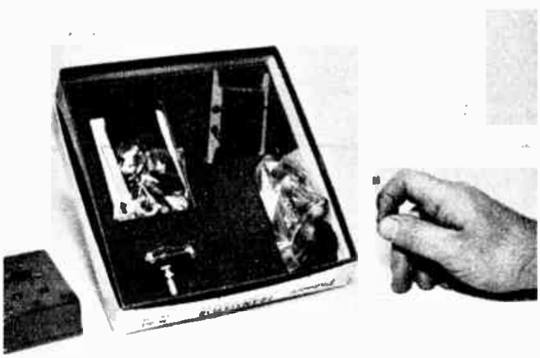
Transistor Radio Set Fits Hand



Space inside the container is well filled. Thumb rests over single penlight battery needed to power transistor amplifier. At top is .05 mfd. condenser.



The receiver in kit form. Tiny transistor is being held in hand at the right. Roll of wire in upper right corner is for aerial. It measures 25 feet.



THE simplicity of the crystal diode detector and the amplification of the transistor are combined in an earphone receiver so small it fits easily in the palm of the hand. This comes as a Philmore kit. and can be put together in twenty minutes. A pencil-type soldering iron with a very thin tip is needed for the job; there is practically no unused space inside the one-piece molded case. The latter has a tendency to melt, so apply and remove the hot iron quickly when working on the lugs for the binding posts and the battery holder.

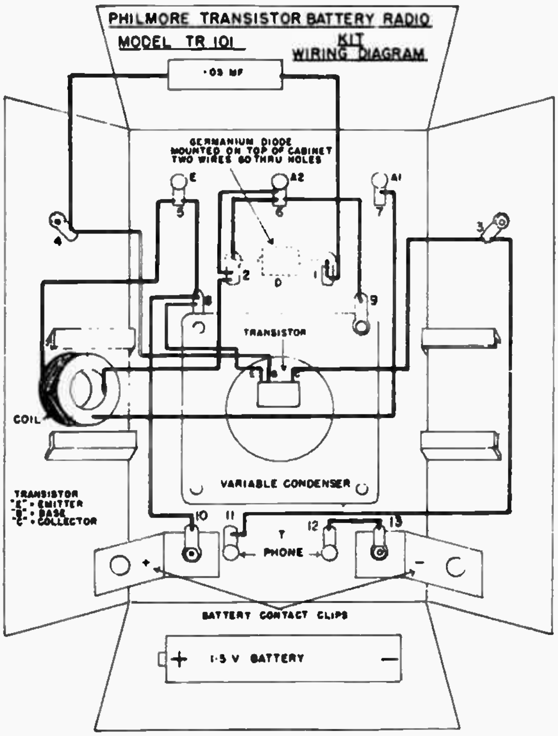
The circuit is simplicity itself. Tuning is done with the midget variable condenser in the center of the case. With the 25-foot "hank" of flexible antenna wire included in the kit, very good local reception is had. Almost any metal surface is effective as an aerial: a window screen, a bed spring, an automobile body, an iron fence, etc. All of these unlikely objects produced signals from the sample set shown in the pictures.

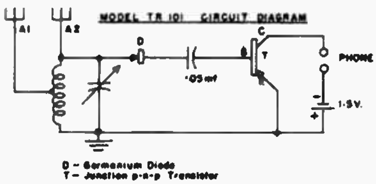
The measured battery drain is only a couple of *millionths* of an ampere. The single battery will last almost as long as if it weren't used at all. When the set is not being operated, disconnect the earphone: this opens the battery circuit entirely. •

Top diagram, right, shows spread-out wiring of the small set. At bottom is schematic diagram.

World Radio History

Although not much larger than a pack of cigarettes, the transistor set at left is a real radio receiver. Crystal diode is under the three binding posts at top.





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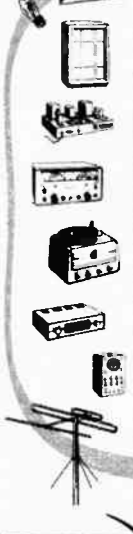

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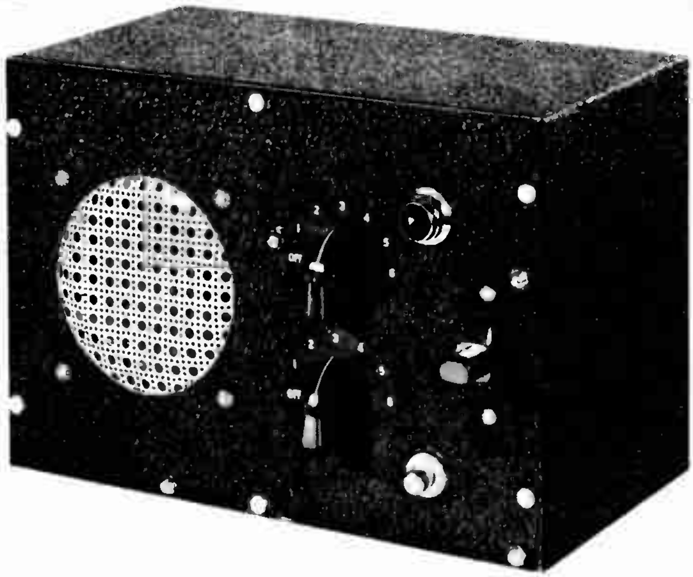
World Radio History

You Can Build This

Remote Control Intercom

It's designed especially for a "hermit" shack and can be constructed in either a rack panel or a compact cabinet.



Here is master unit built into small radio cabinet. The lever switch on the right is spring loaded and normally is in the up or listen position.

WHAT'S SO UNUSUAL about this inter-com system? Its control circuits are designed specifically with the "hermit" type of radio shack in mind—a good nickname for most home stations located in attics, upstairs rooms, cellars, or even an actual shack in the yard. When installed in the radio shack, rapid temper-saving communication is available to the front and rear doors, kitchen, nursery, or what-have-you.

Two types of construction. rack panel and table cabinet, are described.

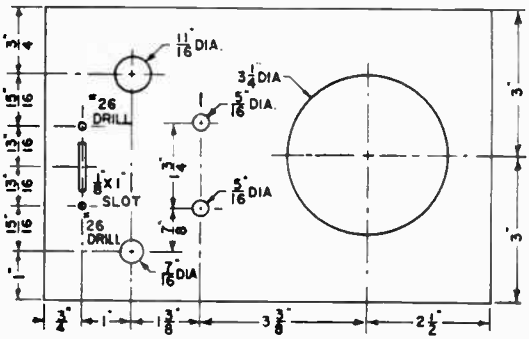
Control Circuits

As shown on page 140, the 3PDT relay RY_1 and the station selector switch, S_2 form the heart of a control system that allows the master station amplifier to be activated from any remote station simply by pressing switch S_4 to the "talk" position. This grounds one side of the heater winding of transformer T_1 and energizes the relay. A ground path provided by one relay contact then acts as a "holding" switch for the relay coil current. Heater and plate power are applied through the other two normally open contacts. The amplifier is turned off by pressing S_5, on the master station, to remove the relay coil power. The heater current must be isolated from the relay-closing circuit, otherwise the extra voltage drop through the external cable would affect the relay operation.

Up to four remote stations can be selected by S_2, the fifth position connecting all stations at once. Any remote station can call into the master station, regardless of the setting of S_2, when S_4 is in the "talk" position. The remote station signal then goes directly to the input of the amplifier whenever S_1 is in the "listen" position.

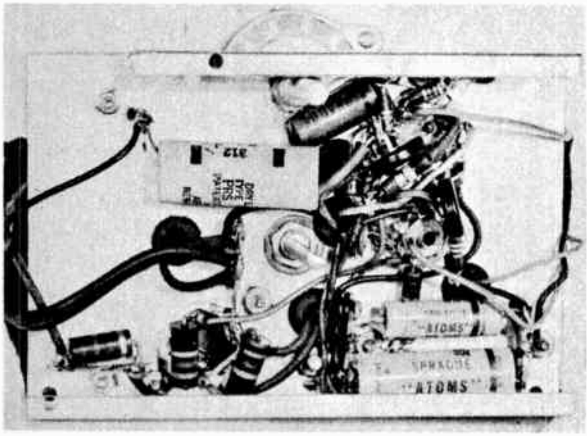
If only the master and one remote station are needed, S_2 and its associated wiring and

World Radio History



Panel drilling layout for cabinet model

This is under view of the master amplifier chassis.



terminal strips enclosed in the dotted lines on the diagram will not be necessary. Further simplification is possible by eliminating the control relay, if the amplifier runs continuously.

Inexpensive four-wire TV antenna rotator control cable is used to connect the master and remote stations when the complete control system is desired. The rotator cable is flat in cross-section and can easily be run around door and window casings, behind moldings and baseboards, under rugs or even fished through walls, if you

Editor's Note: This project was described originally in the "G-E Ham News," a bulletin of technical interest to radio amateurs published bi-monthly by the Tube Department of the General Electric Company. Because of its unusual features, it is being reprinted here as a matter of general information.

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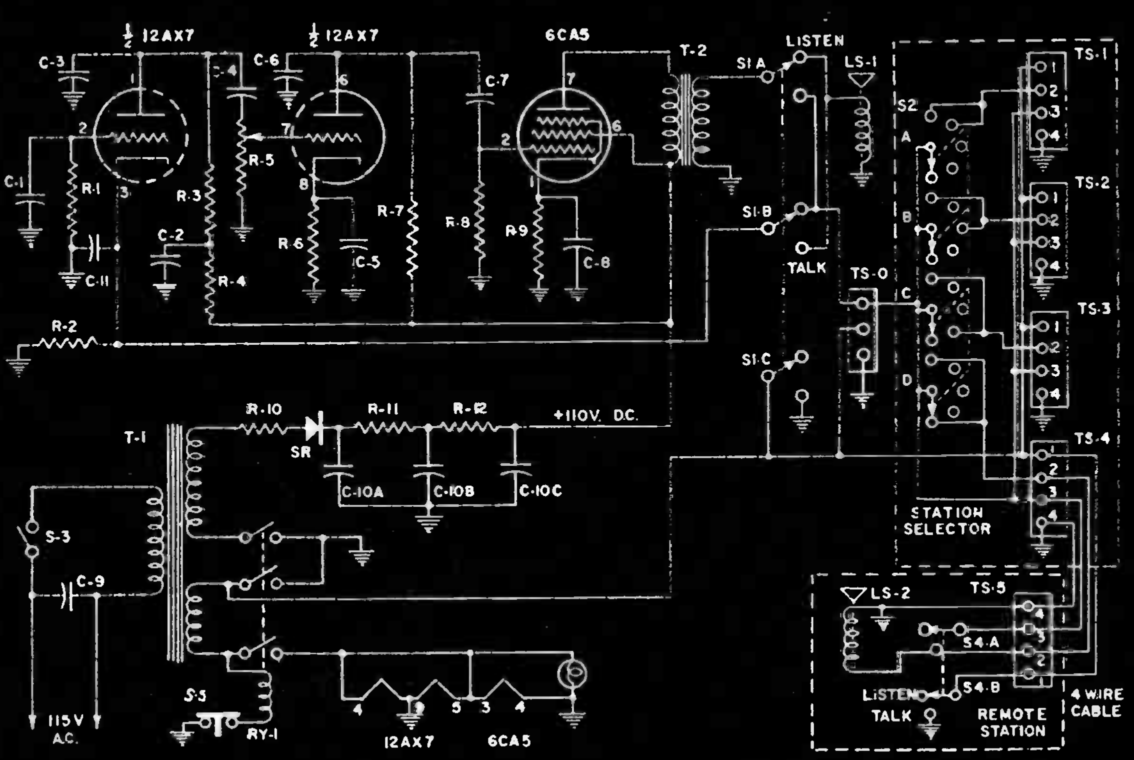

Schematic diagram

PARTS LIST

C_1—0.1-mfd, 200-volt paper.
C_2—10-mfd, 150-volt miniature electrolytic.
C_3, C_6—500-mmf, 500-volt disc ceramic.
C_4, C_7—2000-mmf, 500-volt disc ceramic.
C_5—10-mfd, 50-volt miniature electrolytic.
C_8—50-mfd, 50-volt miniature electrolytic.
C_9—0.05-mfd, 600-volt paper.
$C_{10a,b,c}$—Three-section, 40-mfd, 150-volt electrolytic, "twist-lock" type not over 3 inches high.
C_{11}—5000-mmf, 500-volt disc ceramic.
J_1—½-inch jeweled pilot light and bracket.
LS_1, LS_2—4-inch PM speakers, 45-ohm voice coils (QUAM 4AO7Z45 or similar).
R_1—10-megohm, ½-watt.
R_2—470-ohm, ½-watt.
R_3, R_7—0.1-megohm, ½-watt.
R_4, R_6—2200-ohm, 1-watt.
R_5—0.25-megohm potentiometer with SPST switch.
R_8—0.24-megohm, ½-watt.
R_9—120-ohm, 1-watt.
R_{10}—100-ohm, 2-watt.
R_{11}, R_{12}—180-ohm, 2-watt.
RY_1—3PDT, 6-volt AC coil relay (Potter & Brumfield KR-14A 6-volt AC coil).
S_1—4-pole, 2-position, non-shorting, spring return lever switch.
S_2—4-pole, 5-position, shorting rotary switch.
S_3—SPST switch on back of potentiometer R_5.
S_4—2-pole, 2-position, non-shorting, spring return lever switch.
S_5—SPST, normally closed push-button switch.
SR—130-volt, 75 ma, half-wave selenium rectifier.
T_1—Half-wave power transformer, 125 volts @ 50 ma, 6.3 volts @ 2 amp. secondaries.
T_2—4-watt universal output transformer, connected to match speakers used.
TS_{1-5}—4-terminal and lug phenolic strips.
TS_0—optional strip when S_2 is not needed.
Dial plates: (1) 5-position tap switch plate (Mallory No. 375).
(1) OFF and 10-position volume control plate (Mallory No. 390).
(2) Single gang lever-switch plates (Centralab P-1755).

World Radio History

are the ambitious type of person. Two- or three-wire cable may be used with the simplified circuit.

Amplifier Circuit

A three-stage audio amplifier circuit is used, with the input signal from the speaker-microphones fed into one cathode of a 12AX7 twin-triode. This grounded-grid input circuit has less gain than conventional types, but eliminates the input matching transformer which would otherwise be necessary. Sufficient output at only 110 plate volts is possible with the 6CA5 beam-pentode tube in the power output stage. The coupling, cathode bypass and shunting condensers are tailored to attenuate frequencies outside the normal speech range, reducing any stray hum pickup by the remote station cables.

If the type 6CA5 tube is not obtainable, a type 6BF5 can be used instead, with two changes in socket connections: reverse the wires to pins 1 and 2 on the socket, and shift the lead from the top of the output transformer primary T_2 from pin 7 to pin 5.

Expensive instant-heating type tubes were deemed unnecessary because the amplifier was found to be capable of passing a signal about 8 seconds after the relay was energized.

A transformer-powered, half-wave, selenium-rectifier plate supply with an RC filter is used to minimize the shock hazard always possible with transformerless type supplies. This also simplifies the tube heater and relay power problem. The power transformer, T_1, runs all the time that the power switch, S_3, on the volume control shaft is "on." After running several hours in the stand-by position, the transformer was barely warm.

Standard 3.2-ohm voice-coil PM speakers could be used in place of the 45-ohm types designed especially for inter-com service if each remote station does not require over 25 feet of connecting cable. Savings in original cost would be about fifty cents per speaker.

Construction

The amplifier and power supply is built on a Bud CB-1620 miniature open-end aluminum chassis drilled as shown on page 142. All parts are arranged so that the same chassis can be mounted vertically in either a 6 x 9 x 5-inch metal utility box, or on a 5¼-inch wide relay rack panel. Station selector switch, S_2, and the volume control, R_5, mount with the shafts projecting through the underside of the chassis. Five 3-terminal tie-points are fastened under

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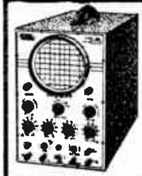
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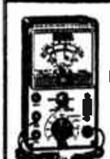
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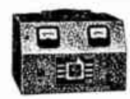
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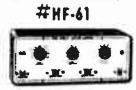
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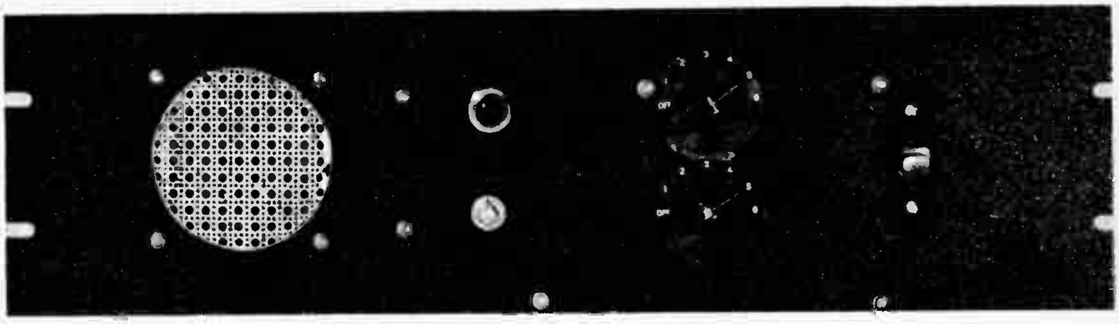
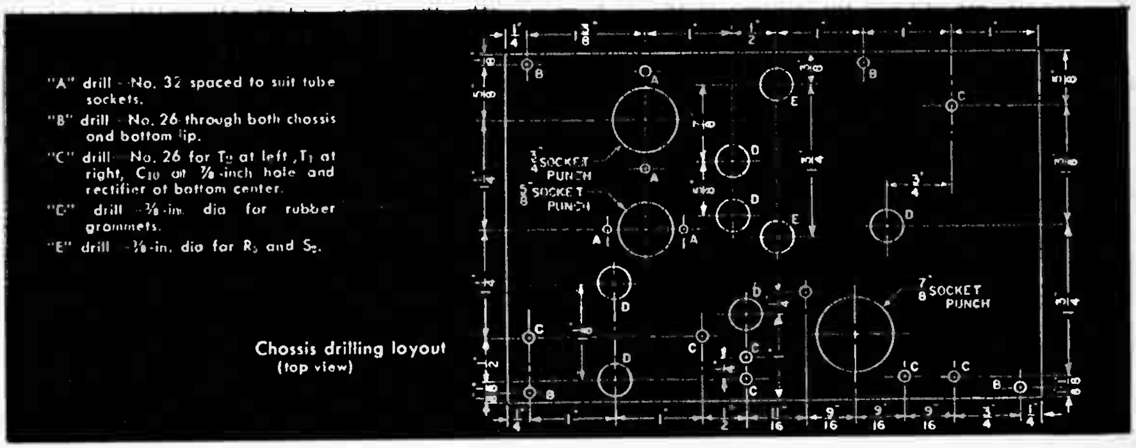


The master unit will spread out for mounting on standard 19-inch relay rack. Note ornamental screws.



Chassis drilling layout (top view)

the chassis at the places shown in the bottom view, page 139, when the transformers and sockets are assembled with 6-32 x ¼-inch and 4-40 x ¼-inch machine screws. Soldering lugs are also placed on these screws for ground tie-points. Rubber grommets are used in the six ⅜-inch diameter holes marked "D" where leads from the transformers, switches and volume control pass through the chassis.

All wiring is done with conventional colored hook-up wire, as no shielded leads were found necessary. The wires to the speaker, S_1, S_5 and the pilot-light bracket are left a few inches longer than necessary. These parts are then fastened to the panel, drilled as shown on page 139 before chassis is assembled with ¾-inch long tubular metal spacers between the bottom lip of the chassis and the panel. Note that blank spaces are left under the chassis where the panel-mounted parts are located. As the power relay mounts on the bottom of the box next to the chassis, connections made to it were left slightly long and then laced together. Small rubber feet, ⅜ inch in diameter, fastened on the bottom of the cabinet, provide clearance for the relay mounting screw-heads. The terminal strips for connecting to the remote stations were mounted directly on the back of the cabinet. Leads from the strips to S_2 and the relay are made long enough to allow the back to be opened with the chassis in place.

The above description also applies if the chassis will be housed in a small table radio cabinet (page 138), except that small blocks of ¾-inch thick white pine are glued to the inside of the panel and 1½-inch long wood screws fasten the chassis to the blocks from the rear. A back cover of ⅛-inch thick tempered hard-board with the terminal strips mounted on it is then fashioned.

The amplifier chassis bolts directly to the rear of the relay rack panel (page 142), with the control shafts located about 2 inches off center. The lower edge of the chassis comes flush with the same edge of the panel. The speaker, S_1, S_5, power relay and pilot-light bracket are fastened to unused portions of the panel either side of the chassis. The speaker is centered about 4 inches from one end of the panel and the

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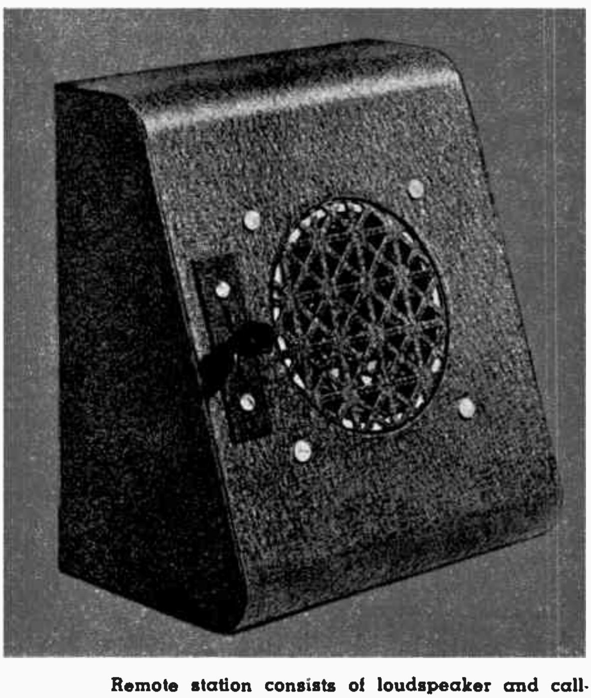

Remote station consists of loudspeaker and calling switch housed in a handsome metal cabinet.

relay positioned next to it. The pilot-light bracket and S_6 are located in line with the control shafts between the chassis and relay. Talk-listen switch, S_1, mounts about 1 inch from the other end of the chassis. Ornamental-head screws are used wherever the heads show on the front of the panel.

A decorative pattern of holes drilled through the panel can be used as a speaker grille, or a small piece of "do-it-yourself" perforated aluminum sheet can be used between the speaker and a 3¼-inch diameter hole bored through the panel. A "dished" effect was obtained by gently tapping the sheet with an object slightly smaller than the hole. Standard lever and rotary switch plates identify the various controls.

The terminal strips were mounted on a small piece of hard-board and fastened to a pair of small angle brackets assembled under the chassis mounting screws.

A Bud CS-1948 4-inch metal speaker cabinet houses each remote speaker and the call-in switch, S_7. A Cinch-Jones No. 17-4 terminal strip for the external cable is mounted on the back of the box with six 32 x ¼-inch machine screws. •

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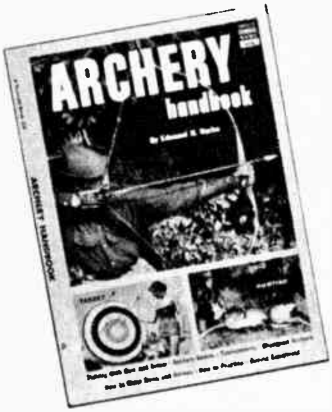

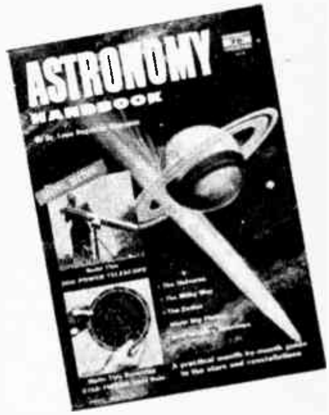

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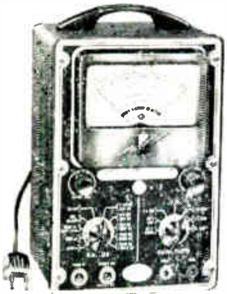
FOR REPAIRING RADIO AND TV

Superior's New Model 670-A

SUPER METER



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PLUS CAPACITY REACTANCE
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ADDED FEATURE:

Built in ISOLATION TRANSFORMER reduces possibility of burning out meter through misuse.

SPECIFICATIONS:

D.C. VOLTS: 0 to 7.5/15/75/150/750/1,500/7,500 Volts
A.C. VOLTS: 0 to 15/30/150/300/1,500/3,000 Volts
OUTPUT VOLTS: 0 to 15/30/150/300/1,500/3,000 Volts
D.C. CURRENT: 0 to 1.5/15/150 Ma. 0 to 1.5/15 Amperes
RESISTANCE: 0 to 1,000/100,000 Ohms 0 to 10 Megohms
CAPACITY: .001 to 1 Mfd. 1 to 50 Mfd. (Good-Bad scale for checking quality of electrolytic condensers.)
REACTANCE: 50 to 2,500 Ohms 2,500 Ohms to 2.5 Megohms
INDUCTANCE: .15 to 7 Henries 7 to 7,000 Henries
DECIBELS: −6 to +18 +14 to +38 +34 to +58

The Model 670-A comes housed, in a rugged crackle-finished steel cabinet complete with test leads and operating instructions.

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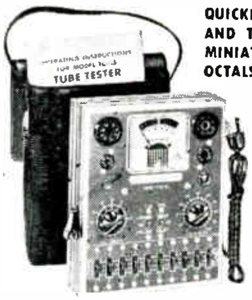
Superior's New Streamlined Model TC-55

TUBE TESTER



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It is impossible to insert the tube in the wrong socket when using the new Model TC-55. Separate sockets are used, one for each type of tube base. If the tube fits in the socket it can be tested.

"FREE-POINT" ELEMENT SWITCHING SYSTEM.
The Model TC-55 incorporates a newly designed element selecter switch system which reduces the possibility of obsolescence to an absolute minimum. Any pin may be used as a filament pin and the voltage applied between that pin and any other pin, or even the "top-cap."

CHECKS FOR SHORTS AND LEAKAGES BETWEEN ALL ELEMENTS.
The Model TC-55 provides a super sensitive method of checking for shorts and leakages up to 5 Megohms between any and all of the terminals.

ELEMENTAL SWITCHES ARE NUMBERED IN STRICT ACCORDANCE WITH R.M.A. SPECIFICATION.
One of the most important improvements, we believe, is the fact that the 4 position fast-action snap switches are all numbered in exact accordance with the standard R.M.A. numbering system. Thus, if the element terminating in pin No. 7 of a tube is under test, button No. 7 is used for that test.

The Model TC-55 comes complete with operating instructions and charts. Use it on the bench—use it for field calls. A streamlined carrying case, included at no extra charge, accommodates the tester and book of instructions.

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- Will measure current consumption while the appliance under test is in operation.
- Incorporates a sensitive direct-reading resistance range which will measure all resistances commonly used in electrical appliances, motors, etc.
- Leakage detecting circuit will indicate continuity from zero ohms to 5 megohms (5,000,000 ohms).
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As an Automotive Tester the Model 70 will test:

● Both 6 Volt and 12 Volt Storage Batteries ● Generators ● Starters ● Distributors ● Ignition Coils ● Regulators ● Relays ● Circuit Breakers ● Cigarette Lighters ● Stop Lights ● Condensers ● Directional Signal Systems ● All Lamps and Bulbs ● Fuses ● Heating Systems ● Horns ● Also will locate poor grounds, breaks in wiring, poor connections, etc.

Handsome round-cornered molded bakelite case, 3⅛"x5⅞"x2¼". Complete with all test leads. Also included is a 64 page book giving detailed instructions for testing all electrical appliances, automotive equipment, etc. Only . . . .

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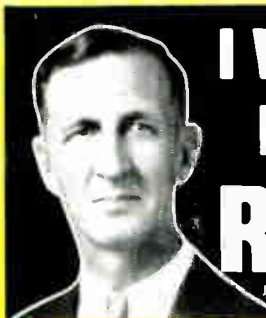

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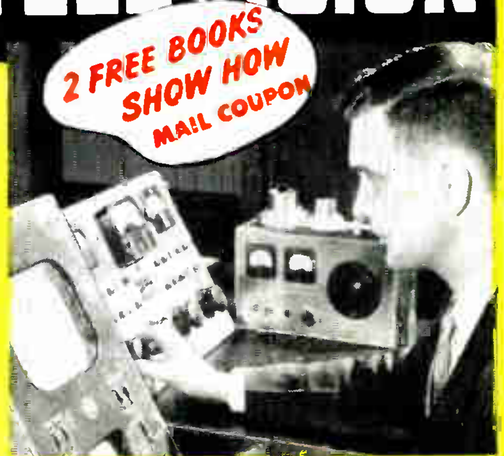

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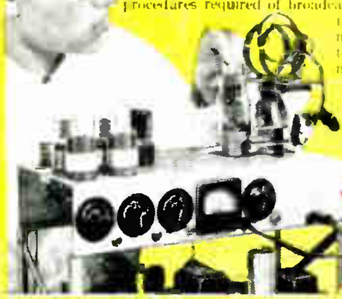

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