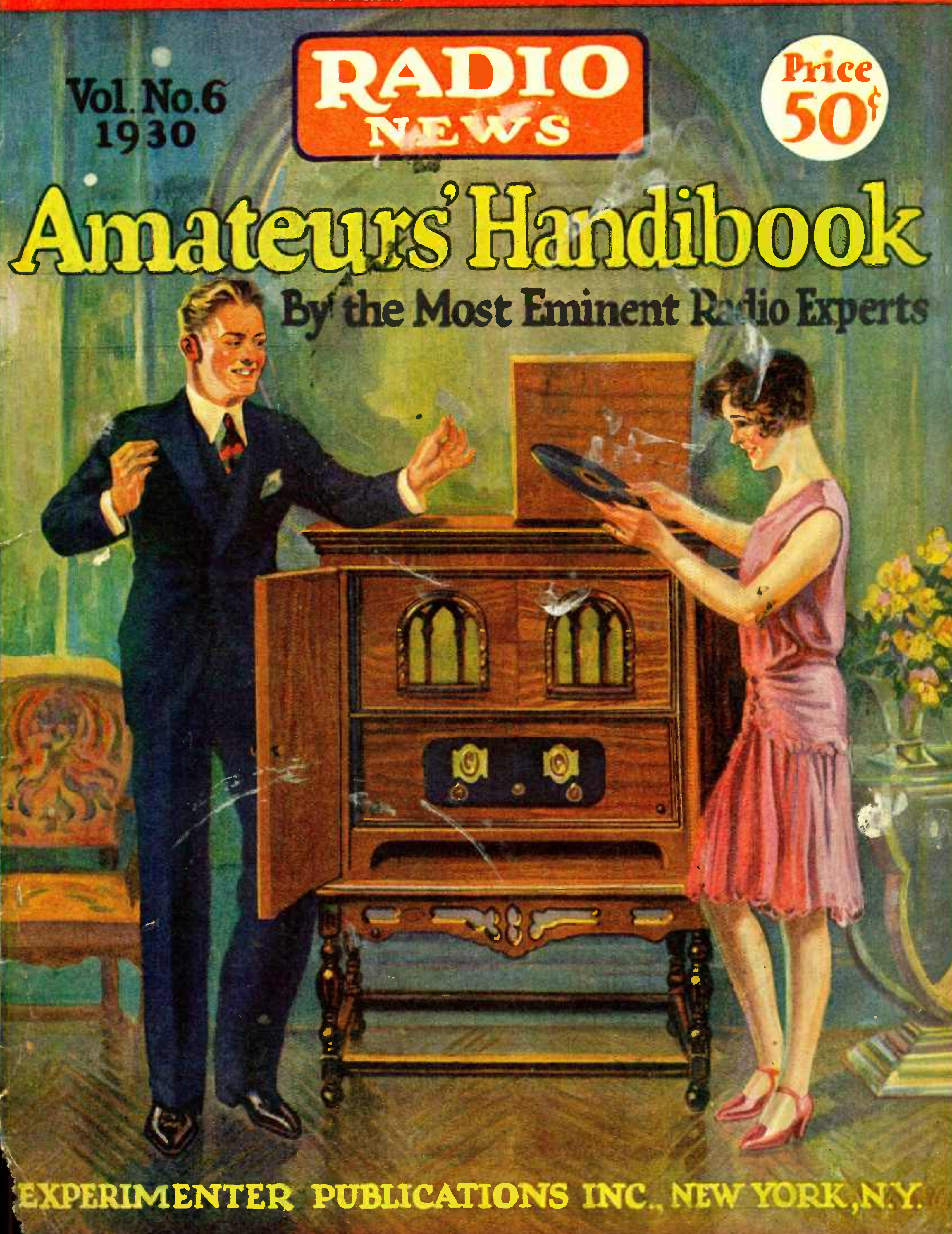

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Amateurs' Handibook
By the Most Eminent Radio Experts
EXPERIMENTER PUBLICATIONS INC., NEW YORK, N.Y.

RADIO NEWS

Amateurs' Handibook

By the

Foremost Radio Authorities

A Selected Series of Practical and Instructive Articles for the Radio Set Owner, the Set Builder and the Experimenter

Volume No. 6.

Experimenter Publications, Inc.
381 Fourth Avenue, New York, N. Y.

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EXPERIMENTER PUBLICATIONS, INC.,

381 Fourth Avenue, New York City

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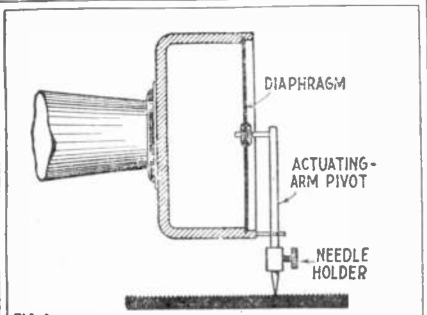
ELECTRIC PHONOGRAPH PICK-UPS

How to Make Your Radio a Phonograph

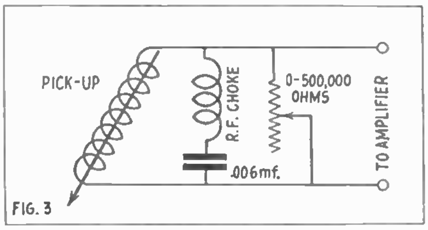
MANY of our older readers would remember the debates which were waged in the pages of radio magazines during the years 1922 and 1923, with reference to the increasing vigor of the competition between radio and the phonograph as means of public entertainment. One article in particular (which appeared in the June, 1922, issue of RADIO NEWS) explained that, although radio was growing fast and was certain to become a great industry, it could never supplant the phonograph in public favor. One reason assigned was that the radio receiver cannot be called upon to reproduce any desired selection, chosen arbitrarily, at any time, but is governed by the station programs which are actually being broadcast at the moment within its range. Of course, we must recognize the truth of this statement, so far as the receiver alone is concerned.

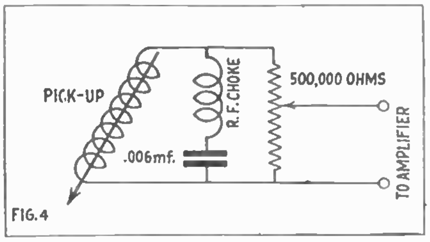


The old-fashioned phonograph unit depended upon mechanical leverage to produce sounds.

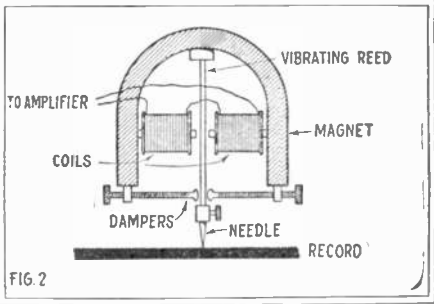
The same article voiced also some opinions as to the comparative fidelity of the tones reproduced by the radio and the phonograph, and evidenced some doubt as to whether radio reproduction could ever reach the perfection of phonograph quality.

What a surprise a radio "Rip Van Winkle" of 1922 would receive if, after sleeping peacefully for seven years, he were awakened to be confronted by a modern phonograph equipped with an amplifier of the type used so extensively for radio reception! Who would have thought, a few years ago, that radio would not only soon reach the perfection of the phonograph, but pass it and even cause the phonograph to be modified to obtain radio's degree of "perfection"? Yet, this is just what has happened. The same article discussed the outcome of the conflict between radio and the theater—and, of course, we all know that the vacuum-tube amplifier (the same, fundamentally, as that used in the new phonographs) is now being used in the new popular "talkies." The tables have certainly been turned; for the question now appears to be "Can the phonograph compare with radio in quality and fidelity of tone?" The best way to answer this question is to compare the two, draw your own conclusions. It is not very costly, nowadays, and not at all difficult to construct a really good electric phonograph.





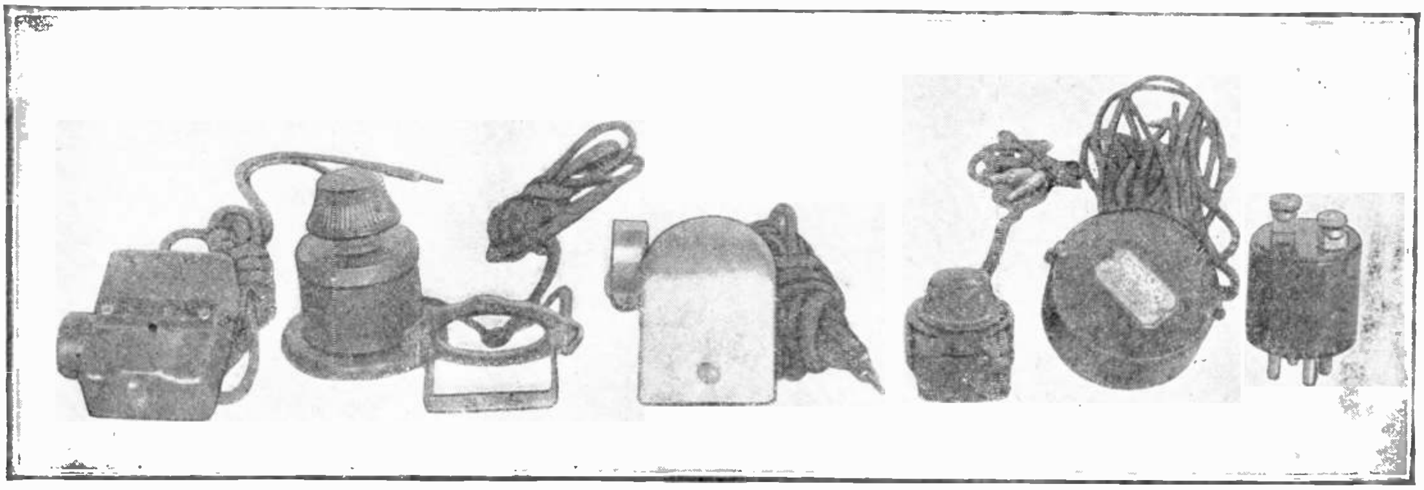
Optional connections for a volume control.



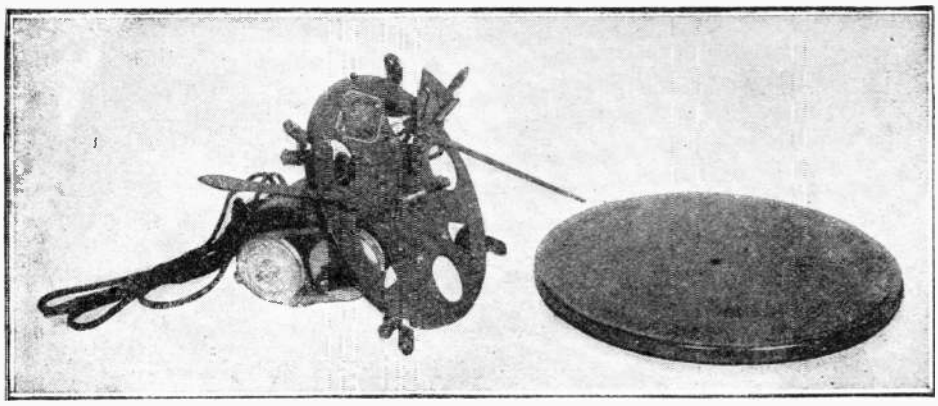
The electric pick-up vibrates more freely than the older unit; but its output may be amplified to any volume desired.

RADIO IN PHONOGRAPH PRACTICE

The question has been brought up, just what differences are there between the old and new methods of phonograph reproduction? The grooves in a phonograph record are so cut that the needle vibrates from side to side, as the record turns. In the old system, these vibrations are carried to a diaphragm by the mechanical motion of a lever and a suitable hinge. The vibration of the needle causes a corresponding motion of the diaphragm, which in turn sets up a vibration of the air in the horn. In this way the sound is transmitted to the ears of the listener. This system is both low in cost and reliable but, unfortunately, it causes a considerable amount of distortion. Both the



Commercial apparatus for converting a receiver to phonograph use. Left to right, a pick-up with control, an adapter making a detector the first A.F. stage, a pick-up, a remote-control device, a pick-up of a third type, and an adapter which replaces the detector tube in its socket. The latter is less used because of the greater advantages obtained by rewiring the receiver.

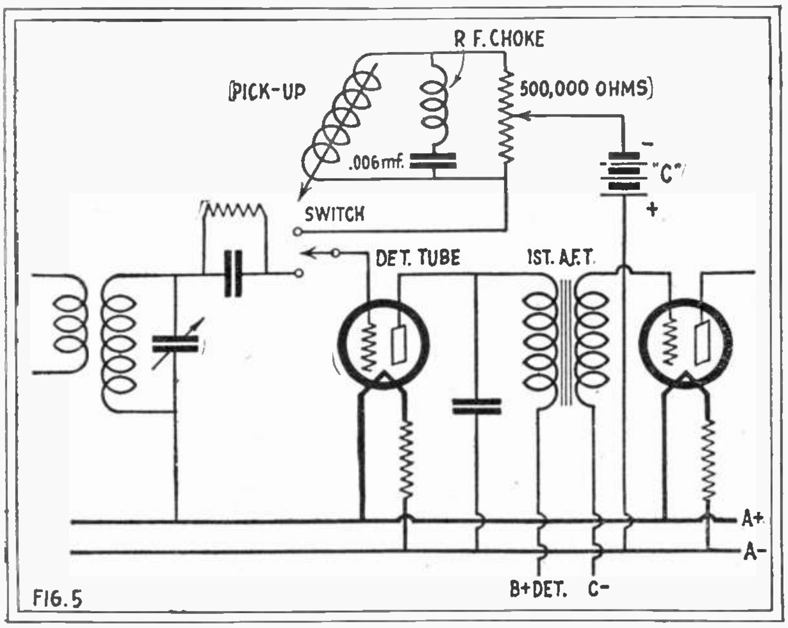


The owner of a radio receiver may convert its A.F. amplifier for phonograph reproduction, by building an electric motor and turntable like the above into the console.

horn and the moving mechanism have "points of resonance" and, of course, notes corresponding to these in pitch are brought out much louder than the others. The construction of the old-fashioned short horn, moreover, destroys some of the low notes.

The new system depends on changing the energy created by the vibrations of the needle into pulsating electric currents in a "pick-up" coil; this will be described more fully, later. The currents set up in the coil are transferred to an audio amplifier, a device well-known to all radio enthusiasts, and, finally, a loud speaker coupled to the amplifier brings out the notes which were originally impressed on the record.

"Pick-up" units of this type were introduced to the radio public about the middle of 1926 and, since that time, a dozen or more of good quality have been placed on the market. (The term "pick-up" is almost a misnomer, since the unit really does not pick up anything. The word "reproducer" or "converter" would be better; since the "pick-up" merely converts a mechanical motion into an electric current.) The difference between the two units is shown in Figs. 1 and 2; the first, the old phonograph "sound box"; the second, the magnetic pick-up for electrical reproduction, which gives also amplification.

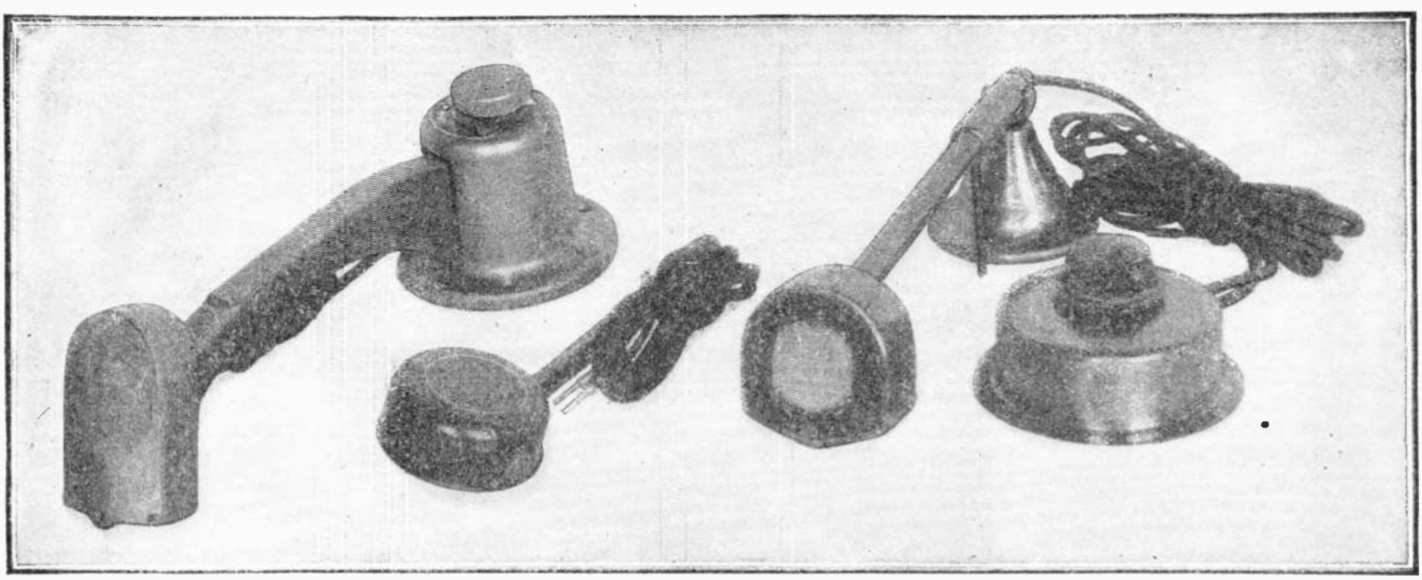


DEVELOPMENT OF SOUND DEVICES

The history of the electric pick-up (to adopt the common term) can be carried back as far as 1875, when Alexander Graham Bell first developed the telephone; the operation of the pick-up device is almost identical with that of the early microphones used by Dr. Bell. The first microphone consisted of a permanent magnet, around which was placed a coil of wire; a thin piece of *magnetic* metal (iron), placed in front of the magnet, was suspended by its edge so that the center could vibrate. By speaking directly in front of the diaphragm, it was caused to vibrate; and this caused to be generated in the coil a weak current, due to changes in the magnetic field around the permanent magnet. The fluctuating current in the coil was found to be almost identical in its "wave form," with the motion of the diaphragm and, in this way, an electrical equivalent of the sound was obtained. A similar magnet, coil and diaphragm were placed at the other end of the wire and the electric currents were re-converted into sound in just the reverse manner.

The circuit shown in Fig. 5 gives the largest possible amount of volume from a given pick-up and amplifier, for it utilizes the detector tube of the set as an additional A.F. stage. The switch may be inside or outside of cabinet, as convenience dictates.

In the electric phonograph pick-up, a permanent magnet is also used, a coil, or several coils, is placed near the magnet and a thin bar of metal or "armature" is used instead of the diaphragm. The metallic bar is fastened to a phonograph needle with a suitable clamp, and the complete unit is placed over the record in place of the usual needle and sound-box assembly.



The pick-up devices illustrated opposite are designed to be used with a phonograph already in use, and to slip over its tone-arm. Those pictured above are complete in themselves, with the aid of a motorboard, to construct an electric phonograph suitable for incorporation in a radio set. The pick-up at the left incorporates its own volume control in the base.

The original phonograph was developed soon after the telephone; the first commercial record was a wax cylinder upon which the mechanical vibrations engraved grooves by means of a sharp needle. (The needle was connected to a metallic diaphragm, similar to the telephone's, and the selection was played directly in front of the diaphragm.) In reproducing the music from the wax cylinder, a needle was again connected to a diaphragm and the cylinder was revolved by a suitable spring mechanism. The needle passing over the surface of the cylinder, in the grooves, was forced from side to side and this made the diaphragm vibrate, thus reproducing the sound. Later, the cylinder was replaced by a more compact disc, and the diaphragm was placed in the small end of a conical horn, in order to direct the sound more effectively.

MODERN DESIGN

The design of the electric pick-up required much research in order to overcome the usual difficulties from distortion. The amplifiers, with their new power tubes, could be made sufficiently perfect for the purpose; but there were several difficulties inherent in the design of the pick-up device, which caused trouble at first. The vibrating reed, or armature, was found to have a "resonant point," and distortion was caused through this. By careful design, it was found, a suitable magnetic reed could be made with its resonant point above the audible band and this source of distortion was eliminated. The magnet, case and support of the pick-up also had to be considered from the standpoint of resonant frequencies, but these problems were comparatively simple.

The rigidly-mounted vibrating reed was too stiff in motion at first and caused an excessive amount of wear on the record; so, in order to prevent this wear, the reed was supported in bearings and allowed to vibrate freely. By using small pads of rubber or other suitable material, the reed was prevented from vibrating too far.

The weight of the complete unit and the way in which it was mounted also had a great deal to do with the wear on the records and, with most of the units, it was found necessary to use a balanced type of mounting in order to prevent the records from being scratched too much.

The actual difficulties encountered in the design of a pick-up are comparatively small, and most of them can be overcome by carefully balancing the parts and the weight.

VOLUME CONTROL AND "NEEDLE SCRATCH"

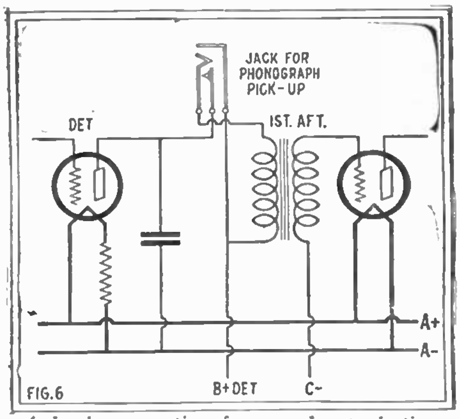
Another point which had to be considered was the method of controlling the volume of the reproduced currents. A large amount of distortion could be introduced in this way, if the volume were incorrectly controlled. The use of either a resistor connected fully across the pick-up (Fig. 3) or a potentiometer connected as shown in Fig. 4, is the most common method; although other systems are also suitable. A resistor connected in the audio amplifier, across the secondary of one of the A.F. transformers, or across the speaker may be used. Many of the commercial pick-ups are already equipped with volume-control systems; usually of the simple resistor or potentiometer type. These resistors are placed either in the pick-up mounting base or in a separate case, connected in the leads to the amplifier.

Music from the old type of phonograph reproducer was accompanied, in most cases, by an annoying scratchy noise known as the "surface noise" or "friction noise." In reproduction of the old type, it was not possible to eliminate this; but, fortunately, the new electric reproducer allows a great reduction of these noises, and in many cases the scratch is almost inaudible. The reduction of these noises involves the use of a filter which is tuned to a frequency near to that of the undesirable tone. These noises are rather high-pitched and the absence of harmonics of the music, which are cut on at the same time, do not affect the quality sufficiently to cause any trouble. In fact most listeners could not discern most of them anyway; since the average person can hear only up to 9,000 or 10,000 cycles. Broadcast stations carry signals only up to 5,000 cycles, because of the interference problem; and the loss of the higher frequencies is hardly noticeable even by musically-trained hearers, when the transmission and reception are otherwise perfect.

The filter used for reducing these noises is very simple in construction; it consists of a choke coil of suitable design and a fixed condenser in series. The complete filter is connected directly across the terminals of the pick-up. Most commercial pick-ups are already equipped with a suitable filter and, in case one is not incorporated in the device, it can be improvised very easily by using a radio-frequency choke coil of approximately 200 millihenries and a fixed condenser of .006-mf. The connections of such a filter are shown in Figs. 3 and 4.

ber of amplifiers of this type have been described in back issues of RADIO NEWS; that in the February, 1929, issue is designed for high quality and great volume, and a special phonograph amplifier was published in the January, 1928, issue.

The pick-up may be coupled to the set in several ways; to either the primary of the first audio-frequency transformer, the grid circuit of the detector tube, or the grid circuit of the first audio-frequency tube. These methods are shown in Figs. 5, 6, and 7, respectively. The method of Fig. 5 will probably supply the greatest volume, since

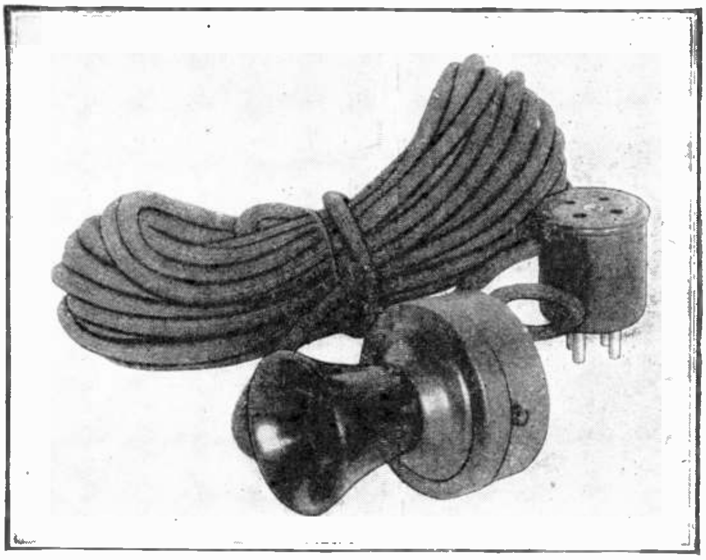


A handy connection for record reproduction.

A handy connection for record reproduction.

it converts the detector into an amplifier tube; although this is a matter for experimentation. It is necessary to connect a "C" battery in the circuit in order to obtain the best quality. The battery would need only a small potential; probably several flashlight batteries connected *in series* will be the easiest way of obtaining this bias.

The second method (shown in Fig. 6) uses the pick-up in the plate circuit of the



With a small microphone connected to the detector socket by a plug, speech is clearly reproduced through the A.F. amplifier of a receiver.

CONNECTING THE PICK-UP

Almost all commercial units are equipped with plug-in devices, so that the experimenter can use the regular audio amplifier in his radio set for phonograph reproduction. Ambitious fans can build separate amplifiers for the purpose by using power tubes and suitable power supplies. A num-

detector tube, across the *primary* of the first audio-frequency transformer, thus using the amplification of this instrument. The final method connects the pick-up across the *secondary* of the audio transformer. Although this system supplies the least volume of the three methods, it is

(*Continued on page* 83)

The "Home-Builder's Seven"—A "Super" Set

A Receiver Meeting All Requirements and Which May be Built by the Constructor Himself in Largest Measure

By B. B. Bryant

RADIO NEWS BLUE PRINT ★ No. 78

"THE HOME-BUILDER'S SEVEN" is a superheterodyne set which has been designed especially for those who like to build their own receivers, as completely as possible. Its intermediate amplifier is a single screen-grid stage which, however, utilizes a new arrangement to increase its amplification until it equals that of nearly three general-purpose tubes; while an additional tuned R.F. stage before the modulator gives added selectivity now much needed. The quality also will be found eminently satisfactory to the most critical listener. In addition to the battery-operated set described here, an alternative circuit is provided, carefully worked out to give equal results with the convenience of A.C.-operation. In either model, this set will be found attractive by the custom builder as a receiver worthy of selection by discriminating purchasers who are willing to pay for quality, yet which can be produced by him with a low outlay for components. It presents also to the home builder a circuit giving high amplification, with excellent appearance and worthy of being housed in an attractive cabinet; but which will not be a task requiring more than a moderate amount of experience and constructive ability. Blueprints of large size have been prepared for the "Home-Builder's Seven," and may be had for the customary price of 25 cents, postpaid.

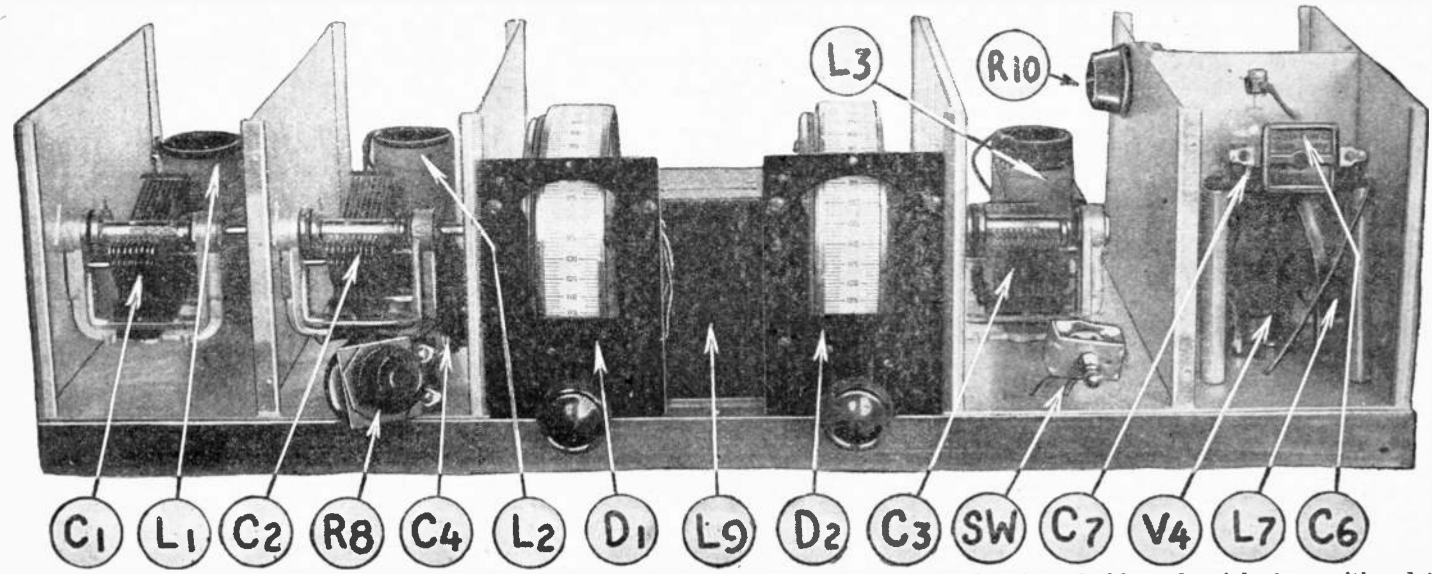
THE development of modern radio receivers has been steadily toward a greater degree of complexity; and this, no doubt, has led many builders who are not in the veteran class to approach gingerly the job of constructing larger sets. The necessity of a high degree of selectivity, the desire for increased fidelity of reproduction and larger output, the vogue of all-electric operation, and the problem of producing a set to rival the appearance and performance of the commercial receiver—all these things have caused too many radio fans to forsake their hobby. Many still have the itch for distant reception but, while ready enough to undertake a four- or even five-tube job, are cautious about tackling the job of building a larger and more complicated receiver, even though the above desirable qualities are assured. Others find in ready-made, elaborate kits the possibility of building a powerful and finished-looking set in which the work of assembly has been reduced to a routine, but miss the pleasure of actually preparing the essential parts of the apparatus with their own hands.

With a view to the needs of several classes of both custom set builders and fans, the writer set about the task of designing a receiver of moderate cost (its merits considered) which should embody the desirable requirements listed above, be comparatively simple to build, and in which as large as possible a number of parts should be within the resources and skill of the home constructor to make for himself. After the construction of a series of five successful receivers, the somewhat simplified model described here was determined upon. While, if the directions are followed, it should equal in appearance and performance the finest of commercial receivers, only a few tools are required for the work—pliers, a wire-cutter, a hacksaw, a hand drill with a suitable selection of sizes, a hammer, screwdriver and soldering iron are sufficient.

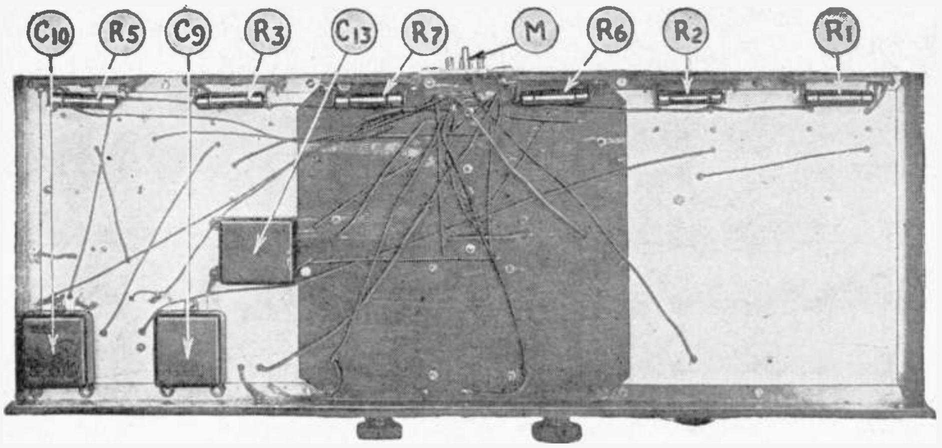
THE CIRCUIT

An inspection of the schematic diagram (Fig. 1) will show that three elements have been adopted in the system of radio-frequency amplification. The well-known and efficient Ultradyne frequency-converter, preceded by a tuned radio-frequency stage which is controlled by a plate resistor, is followed by a single stage of intermediate frequency (1,400 meters, or 214 kilocycles) in which, however, the use of a screen-grid tube gives a high degree of amplification. The regenerative detector following is used (with the peculiar arrangement which will be noted), not so much for the sake of added amplification as for the purpose of affording a suitable high-impedance load, required by the 222-type tube. A conventional two-stage transformer-coupled amplifier, with a 171A in the power stage, completes the hook-up, and provides sufficient amplification for any reproducer adapted to the home. The result thus obtained is great sensitivity, with selectivity enhanced by the additional tuned R.F. stage, and quality which does not suffer in the inductively-coupled intermediate band-filter. It will be found that more amplification is thus obtained than from the conventional superheterodyne circuit, in which a first-detector stage coupled to the antenna is followed by 201A tubes in three I.F. stages and a non-regenerative detector.

After some consideration, it was decided to feature here the circuit using direct-current (storage-battery) tubes; while, in order that those who prefer alternating-current operation may be able to proceed with that type of construction, an alternative circuit is given in Fig. 1A. The latter uses throughout heated-cathode or 227-type tubes, except an A.C. 22 in the I.F. stage and the power tube; the necessary alterations in the



A front view of "Home Builder's Seven," with its panel removed and the shield cans partially disassembled, to show the simplicity of its construction. The first shield at the right is partitioned to screen the detector circuit from the intermediate-amplifier stage.



The central sub-panel, of insulating material, and the bottoms of the shield cans on either side, carry the limited apparatus shown on the under side. The wiring which comes through should be carried direct from point to point, and be well insulated.

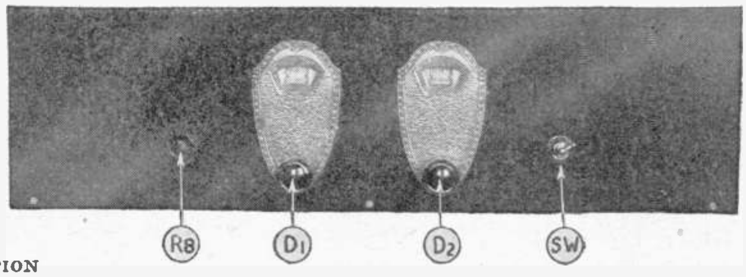
circuit and the values of the additional parts required are indicated in the diagram. On the other hand, those who adhere to D.C. set operation, whether from choice or necessity, will find the receiver first described highly satisfactory; while a good "A" unit will give equally convenient lamp-socket service with these tubes, and a "B and C" unit presents exactly the same features with either A.C. or D.C. tubes in the similar circuits shown.

MECHANICAL CONSTRUCTION

The use of a chassis, or metal frame, to support a receiver's parts, marks the third and latest stage of design in radio sets. The original "breadboard," used for convenience by the experimenter, was long kept in use even when hook-ups had become both more permanent and more elaborate. Yet it was in many ways inconvenient and inefficient because of the great lengths of wire required by the fact that all components were in one plane and it was necessary to loop and dodge the wiring about them.

Complete insulating sub-panel mounting, the second stage, presented a great improvement in neatness, as well as in operation; because it made wiring more direct and gave greater freedom in the arrangement of components. It is, however, more costly, and requires much strengthening to present a good appearance and rigid construction.

The metallic chassis enhances at once appearance, firmness of assembly and, owing to its conductivity, ease of wiring. With the vogue of shielding all high-frequency stages, it has become almost necessary. As used in this set, the chassis may be made by the constructor with slight expense and labor, and will lend a professional touch to the assembly. The metallic shielding cans, needed by every receiver of high sensitivity under present-day conditions, add to the ease of wiring and form an integral part of the construction. The audio stages are supported by a small sub-panel, just sufficient in size to accommodate the necessary parts, which may be of metal or insulating material as preferred.

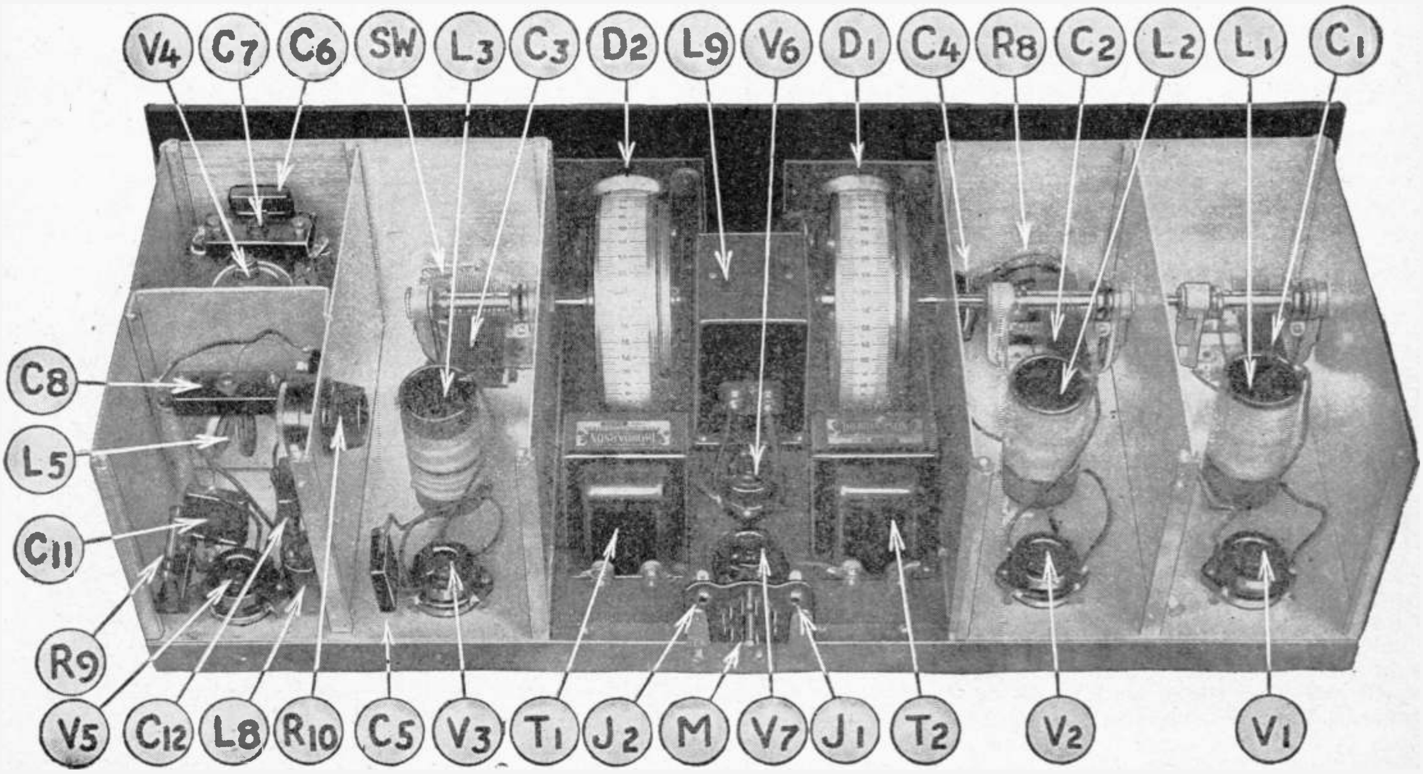


The neatly balanced panel with its two illuminated vernier tuning dials, the volume control R8, and the switch.

COMPONENTS NEEDED

Any equivalent components may be substituted in this circuit, with the exception of the four special coils used in the I.F. stage, detector circuit and the oscillator. The symbols appearing below and in the schematic diagrams, in connection with the respective components, correspond with those used throughout the text and illustrations. Those required are:

Two variable condensers, removable-shaft type, .00035-mf. (C1 and C2);
One variable condenser, .0005-mf. (C3);
Two semi-variable condensers, mica type, .0001 to .0005-mf. (C7 and C8);
Two mica fixed condensers, .001-mf. (C4 and C5);



The detector-intermediate amplifier compartments at the left contain the "heart" of the circuit. In the rear compartment are the detector components; in the front one, the intermediate transformer, L5, its compensating capacitor C8, the regeneration control R10, R.F. choke coil L8, and grid leak R9. The top terminal of the screen-grid tube V4 may be seen above the shielding.

Two mica fixed condensers, .0005-mf. (C6 and C12);
One mica fixed condenser, .00025-mf. (C11);
Two by-pass condensers, paper type, 0.5-mf. (C9 and C10);
One by-pass condenser, paper type, 1-mf. (C13);
One antenna coupler (commercial or home-made) to tune over broadcast band with .00035-mf. condenser (L1);
One R.F. transformer (commercial or home-made) to tune over broadcast band with .00035-mf. condenser (L2);
One oscillator coil, home-made (L3);
Four intermediate coils, home-made (L4 and L5);
Three R.F. chokes, 80-millihenry or more (must not be of smaller value) (L6-L7-L8);
One 30-henry iron-core choke coil (L9);
Five 1A amperites (R1-R2-R3-R5-R6);
One power-tube amperite (R7);
One 25-ohm fixed resistor tapped at 10 ohms for shield-grid bias (R4);
One 0- to 500,000-ohm variable resistor for volume and R.F. oscillation control (R8);
One 2-megohm grid-leak resistance and mounting (R9);
One 0-to 2,000-ohm variable resistor for regeneration control (R10);
Two audio transformers 2:1 ratio (T1 and T2);
Seven UX sockets—not more than ¾-inch high (V1 to V7);
One 12-wire cable and terminal (M);
One filament snap switch (SW);
One bakelite panel, 7 x 24 x 3/16-inch;
Two aluminum double cans, size 8¾ inches long, 7¾ inches wide and 5¾ inches high, with two equal compartments (S1, S2);
One piece of sheet aluminum 4½x5¼ inches;
Two drum dials, with knob immediately under scale (D1-D2);
Two cord-tip jacks (J1 and J2);
Two binding posts, aerial and ground;
Six feet angle brass, 1x½x1/32-inch, for chassis;
One piece of 1/32-inch aluminum (or 3/16-inch wooden board, hard rubber or bakelite) 8¾x9 inches, to form a sub-panel support.
Ten-inch ¼-inch brass shaft for condensers;
Two 25-foot rolls hook-up wire, single-strand push-back type;
Two lengths spaghetti tubing;
Four ½-inch wooden dowels, 3¾ inches long;
Screws, nuts and other small hardware.

CONSTRUCTING THE I.F. COILS

Most receivers of the superheterodyne type offer difficulty to the home builder in the construction of the intermediate transformers or coils. The construction of the coils L4 and L5 used in this receiver is simple and offers no difficulty. They are efficient and, while reasonable care is necessary, they need not be exactly the same. Exact matching of their inductance is not necessary; as two are adjustably tuned.

For their construction, a small form is required; this is made of three wooden discs held together by a screw as shown in Fig. 4. The wire is wound in the resulting slot. The central disc is 1 inch in diameter and 3/16-inch wide; the side discs are 1½ inches in diameter and of such thickness as to be rigid. The central disc may be sawed from a broom handle. The side discs may be made from a cigar box and need not be round; three slots are sawed in them, at equal distances around their circumference; these slots should be ¼-inch deep. A hole is drilled through the center of each disc. They are then assembled with the 1-inch disc in the center, and held securely together with a long 6/32 or 8/32 bolt and nut. After assembly the slots are aligned and a length of strong linen thread placed in each slot across the surface of the central disc; these are tie strings to hold the winding in shape when the form is taken apart.

Three coils are now wound, each with 200 turns of No. 32 D.S.C. or D.C.C. wire in the large slot. The ends of each tie string are then tied around the winding, after which the nut and bolt are removed. The side discs will now fall aside, leaving the tied winding with the central disc in the center. The latter is now pushed out, taking care to preserve the shape of the coil.

The fourth coil is made in the same manner, but with 75 turns of No. 28 D.S.C. or D.C.C. wire.

No particular care in winding the wire in the slot is used; as a matter of fact the greater the "scrambling" the better, as this will result in lessened distributed capacity. Highly distributed capacity would result in high resistance and broad tuning. When all the slot-wound coils are finished they are soaked in airplane dope or celluloid

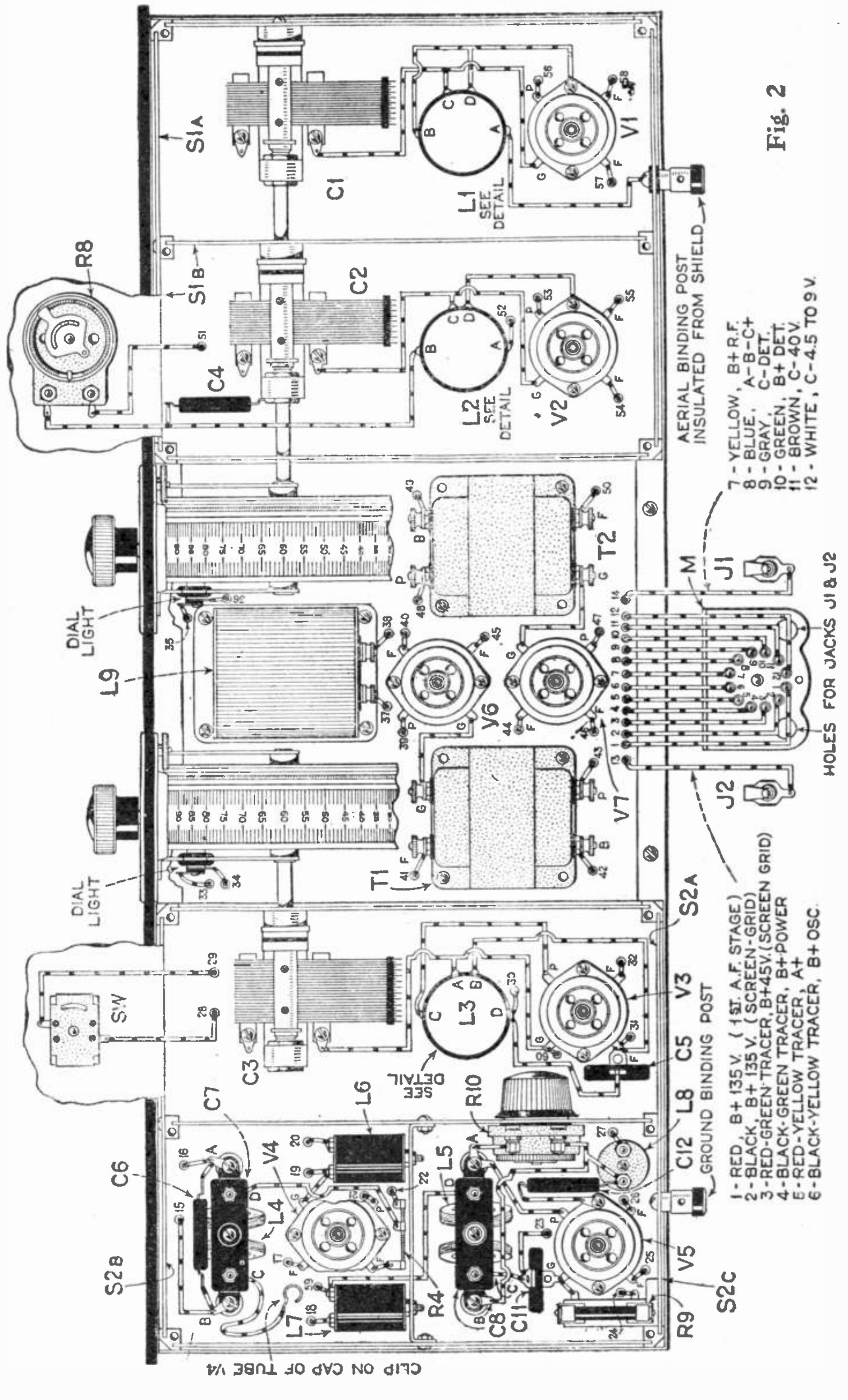


Fig. 2

cement; after removal they are pressed between two boards to remove the excess dope and to make them flat. They are then put aside until hard and dry.

ANTENNA, R.F. AND OSCILLATOR COILS

While commercial coils may be used for the antenna and R.F. couplers, they are easy to make. The secondary windings of L1 and L2 consist of 100 turns of No. 28 D.S.C. wire wound on pieces of 1½-inch tubing 3¼ inches long. The primary of L1 consists of 20 turns of No. 28 D.S.C. wire wound at the filament end of the secondary with a separation of ⅛-inch. The primary of L2 is wound in the same manner as the antenna primary, but consists of 30 turns of No. 32 D.C.S. wire. (See Fig. 5.)

A thick coating of airplane dope or celluloid cement is applied to these windings, and immediately wiped off with a clean cloth. When it is applied and removed in this manner, sufficient dope remains for protection and adhesion of the windings.

Terminals for connection are provided by drilling small holes around the base for anchoring the beginning and end of each winding. The insulation is scraped from the free ends of the windings, which should be left about 5 inches long, and looped several times through the small hole near the base. If done properly, this will provide a soldering contact ¼-inch long and 1/16-inch wide.

The oscillator coil L3 is made in the same manner. The secondary or grid coil consists of 48 turns of No. 28 D.S.C. wire wound on 1½-inch tubing; the plate or primary coil consists of 35 turns of No. 28 D.S.C. wire wound at the filament end of the grid coil. The windings are spaced ¼-inch; soldering terminals are provided as for the antenna and R.F. coils.

All the various windings are wound in the same direction.

MAKING THE CHASSIS

Six feet of angle brass 1 inch by ½-inch by 1/32-inch thick, is obtained. Measuring on one side from the center, points are marked at 11¾ inches, 20½ inches, 32¼ inches and 33¾ inches. On the other side from the center, points are marked at 11¾ inches, 20½ inches, 32¼ inches. The length is sawed off at the ends (at the 32¼-inch point and 33¾-inch point). The 1½-inch section next the 33¾-inch mark is sawed off on the ½-inch side, leaving on the 1-inch side a tongue 1½ inches long, for a lap joint. Right-angle wedges are now sawed out at the 11¾- and 20½-inch marks, also on the ½-inch side of the angle brass. The apex of each right angle should be directly on the points marked at the edge of the 1-inch width.

After the angle brass strip is prepared as explained above, it is shaped into a rectangular frame, 8¾x23½ inches, by bending at the apex of the "V" shaped notches made by the removal of the wedges. The tongue prepared for the lap is placed on the inside. The top of the frame, which is formed by the ½-inch side of the angle, is made to butt closely. While it is in this position, holes are drilled through the top angle and through the tongue. Screws are then inserted into the holes, nuts placed on the inside and tightened. The chassis is thus formed.

ASSEMBLY OF CANS

The bottom plates of the cans are now placed flat on top of the brass frame, with their sides even with ends of chassis frame. With a pencil, the positions of the holes in the can bottom are marked on the chassis. The points indicated are then drilled through to pass 6/32 screws, ½-inch long. The screws should extend through the can bottoms and should turn into the corner and center pillars of the cans.

The sides and front of the cans are slipped into their grooves temporarily; the 8¾x9-inch strip of aluminum, wood or bakelite is now placed in position in the open space of the chassis between the cans, fitted underneath the ½-inch flange, and fastened in position by 6/32 screws and nuts.

MOUNTING CONDENSERS AND DIALS

For mounting the variable condensers, four of the side pieces of the cans are drilled for ⅝-inch holes, at proper places. The condensers are now fastened to these plates with the large bushings provided, and the sides are now replaced in their regular positions.

The 10-inch shaft is placed through the two .00035-mf. condensers C1 and C2; it should protrude about two inches for the drum dial D1. The shaft of the .0005-mf. oscillator condenser C3 is made to extend out to the same length. After loosening the set screws of the hollow shafts of the drum dials, D1 and D2, they are slipped

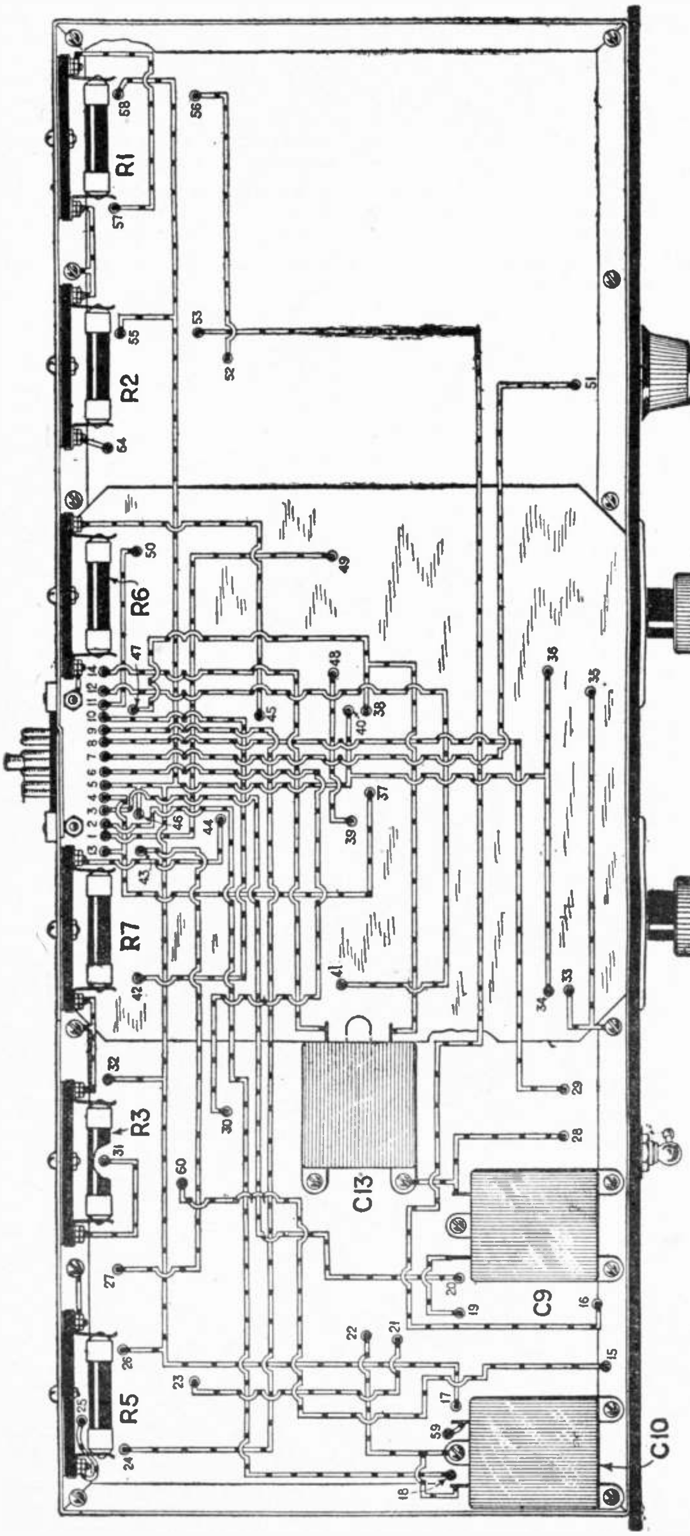


Fig. 3

The layout of all parts, and all wiring connections of the "Home-Builder's Seven," are shown in these two views, of the upper and the lower sides of the sub-panel and the two shields which support the apparatus. The wiring, though shown quite square here, is actually run in the most direct lines between its terminals. Holes are numbered correspondingly in both upper and lower views. The constructor who follows the usual precaution of crossing out each lead on these diagrams after its connections are soldered will avoid any possible error in constructing this receiver.

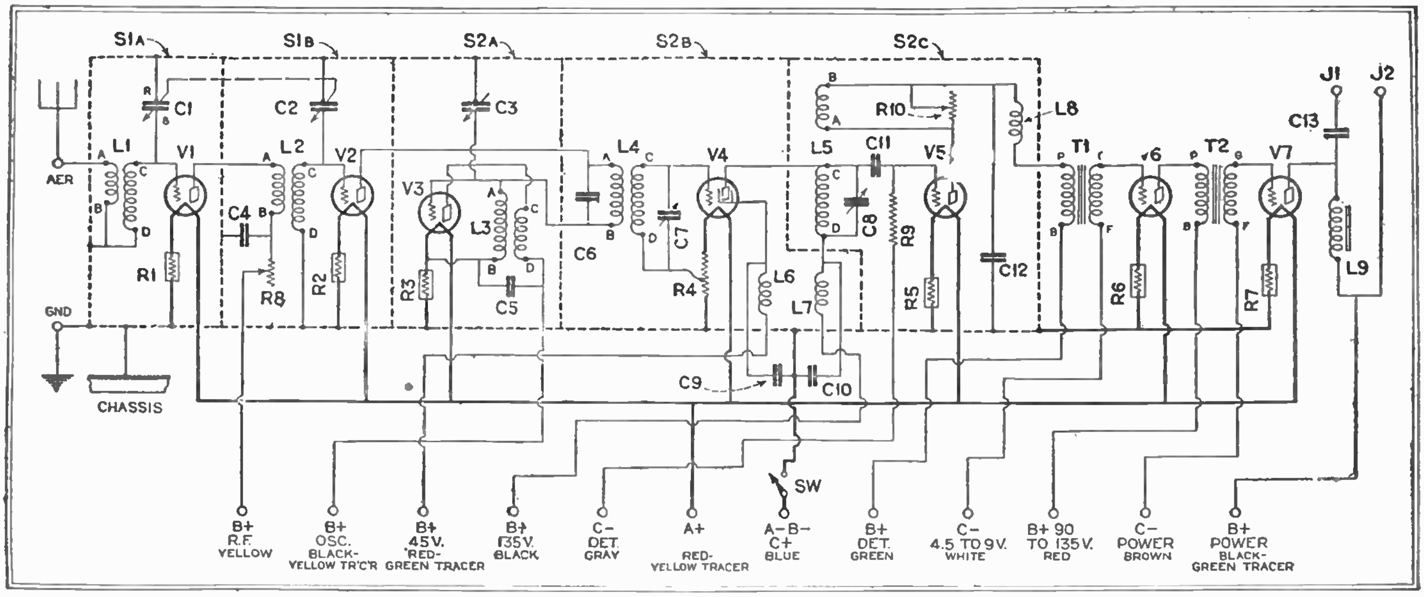


Fig. 1

The circuit diagram of the "Home Builder's Seven" for use with D.C. tubes. The changes necessary to adapt it to A.C. tubes can be determined readily from the corresponding diagram, Fig. 1A, on page 968. The shielding used saves much of the wiring.

over the extended shafts of the condensers. The edge of the drum-support frames should be flush and against the edges of the cans. Mark on the chassis positions of the holes in the turned-over edge of the drum-support frame, and drill holes for 6/32 screws. Pass the screws through holes of the chassis and fasten the frames of the drums rigidly to the chassis; after which all set screws of the condensers and drums are tightened.

The choke L9 is now placed in position at the front edge of the chassis between the drums, and the audio transformers T1 and T2 are fastened in position back of the drums, close to the sides of the cans. This leaves a rectangular space in which the two audio sockets, V6 and V7, are equally spaced and fastened to the sub-panel. In the exact center of the rear edge of the chassis frame, the cable-plug receptacle is mounted. The cord tip jacks J1 and J2 are then put in the holes provided on the cable terminal.

MOUNTING THE COILS

L-shaped brackets, 1¾ inches long, are used to mount the antenna coil L1, the R.F. coil L2 and the oscillator coupler L3. After the brackets have been fastened to the coil forms as shown in Fig. 5, the coils are mounted in their respective shield cans; L1 in S1A, L2 in S1B, and L3 in S2A. When mounting the coils, sufficient space must be left for the socket and tube at the rear of each compartment; the sockets in these three compartments may be mounted at this time.

Mounting of the I.F. coils is equally simple, although care is required. The ½-inch dowel is now cut into 3¾-inch lengths. Small holes are drilled, ½-inch in depth, in the exact centers of their ends. These are for the wood-screws used in mounting the semi-variable condensers.

Most small semi-variable mica condensers have two holes, provided for fastening to the baseboard. On the under surface of the molded bases are seen the flat heads of the condenser's terminal screws. To these heads are soldered the flat heads of 6/32 brass screws, 1-inch long. Four bakelite strips ⅛-inch thick and ½-inch wide, are cut to such lengths that, when holes are drilled near their ends, they will slip loosely over the screws. These pieces serve as clamps for the special coils already described.

To assemble, one strip is placed over the screws and the coil is held in position while another strip is passed through its center and slipped into place over the screws; nuts are then screwed down over the clamping strips and tightened until the coils are held firmly in position. Care should be taken that the windings are placed so that they run in the same direction.

The entire assembly as shown in Fig. 5 is fastened to the bottom of its respective can compartment (S2B and S2C) by passing wood-screws through the metal bottom and screwing them into the lower ends of the wooden dowels.

FINAL ASSEMBLY

The sockets are placed in compartments S2B and S2C as shown in Fig. 2; after which the partition is placed in position and the positions of holes for mounting the chokes are marked. One hole for the "B+135" lead to the I.F. plates is drilled above the choke L7; the partition is re-

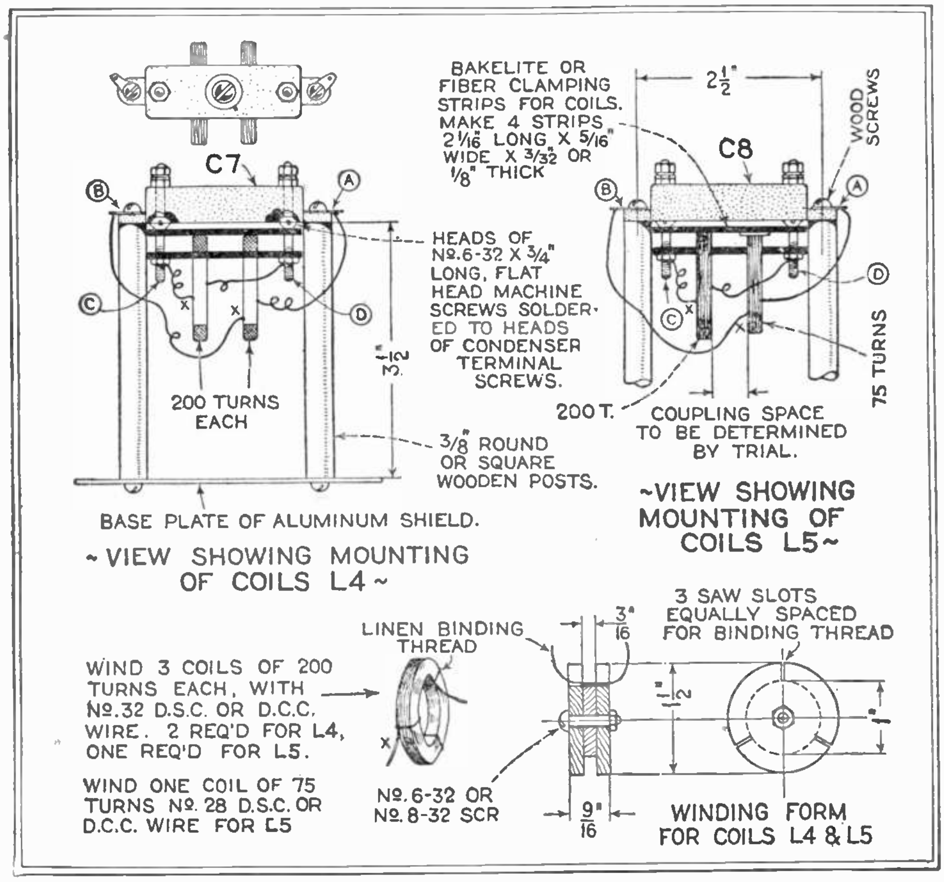


Fig. 4

The details for making and mounting the 214-kc. intermediate transformers required.

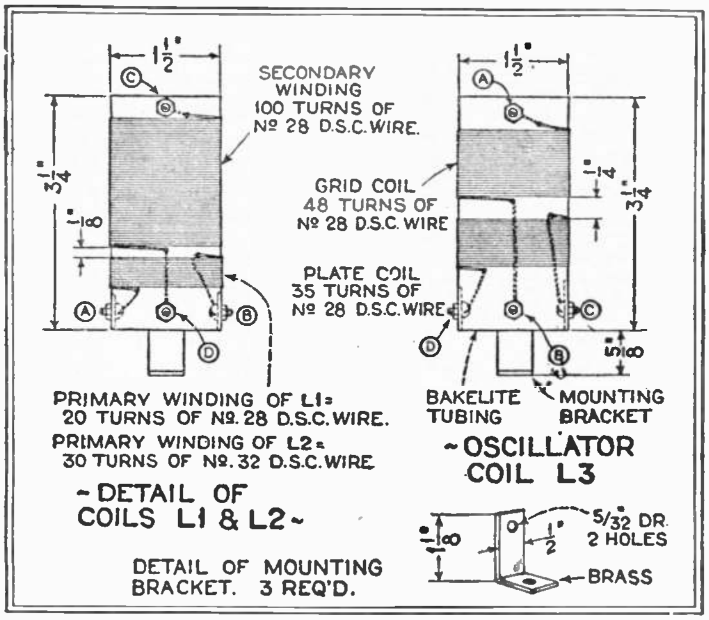


Fig. 5

Data for construction of the two R.F. coils and the oscillator coil of the "Home-Builder's Seven."

moved and the chokes L6, L7 and L8 are mounted in their respective positions.

The holes for mounting the volume control R8; the regeneration control R10, and filament switch SW are marked and drilled in the can fronts and the central partition of the S2 can (the latter for R10). The can fronts and partition are again placed in position, and the respective parts are mounted; care should be taken that R8 and R10 are insulated from the cans, as otherwise a short will result.

The by-pass and output condensers C9, C10 and C13 are fastened into the positions as shown in Fig. 3. At this time the amperite holders are mounted on the inside of the vertical section of the chassis frame as shown. The element R4 is soldered to the "A—" prong of the socket in compartment S2B, as shown in Fig. 2. The vertical grid leak mounting is fastened to the back of S2 in compartment C; conveniently close to the detector socket. The grid condenser C11 is soldered to the socket "G" terminal of V5 at the same time the lead of the mounting is soldered.

WIRING AND ADJUSTMENT

Wiring of the receiver is simple. The method recommended is that of "point-to-point," marking out the lead on the wiring diagram when the connection on the set is completed. When passing each lead through the hole drilled in the bottom of the cans for that purpose, a ¾-inch length of spaghetti tubing is slipped over the wire and through the hole. This procedure will prevent abrasion of the wire by the cans and possible short circuits.

For those who prefer to wire from the schematic diagram (as the writer does) it is recommended that all grid leads, plate leads, grid returns, plate returns, "A+," "A—," and the remainder of the connecting leads be wired in the order given.

After the builder has tested the various circuits for shorts and is sure that everything is in perfect order, the various tubes are placed in their proper sockets. A tube of almost any type may be used at V5 as a special bias lead is provided; in a great many cases, locals will be of such strength that overloading the detector can be prevented only by the use of a negative bias, resulting in plate rectification. Otherwise, on distant stations greater sensitivity and volume will be obtained by the grid-leak-and-condenser, or grid-rectification, method.

When the tubes are in their sockets, the cable M, which previously should be connected to the "A," "B," and "C" supply, is now plugged in. The aerial lead-in and the ground wire are connected to their binding posts, and the speaker cord tips to J1 and J2.

The filament switch SW is turned on and, while rotating the drum D1 slowly over the scale, the drum D2 is worked back and forth over its scale until a signal is heard. If possible, a signal should be selected at a condenser setting that will allow the builder access to the set screws C1 and C2, which may now be loosened. Slowly turn the rotor of condenser C1 until the signal is loudest. Keeping this preliminary adjustment, the adjusting screws of condensers C6 and C8 are adjusted in turn for loudest signal strength. After this adjustment, regeneration in the detector circuit may be too great. Regeneration control is obtained by adjusting R10 to a point just under sustained oscillation of the tube, or until the audio beat-note disappears and the signal becomes loud and clear. The controls D1 and D2 are now readjusted. When tuned to a station, the R. F. stage V1 should oscillate; if it does not, readjust the rotor of C1. Should the aerial be too long, or if the signal is from a powerful local, it may prove difficult to make the R.F. stage oscillate. In this case, the aerial should be shortened or a weaker station selected. Oscillations of the R.F. stage are controlled by the panel knob of R8 which serves also as a volume control.

At this time the oscillator tube V3 should be removed from its socket; upon which the signal should immediately disappear. If it does not, the coupling between the primary and the secondary of L4 is too great. The normal separation of the coils should be about one inch, where medium selectivity is desired. Great selectivity may be obtained by greater separation, or by placing the coils in right-angle relation. It should be remembered that, as selectivity increases, signal strength decreases. A compromise must be struck for the peculiarities of the location and the aerial which is used.

In rare cases, it may be difficult to cause V3 to oscillate. A simple test is to place a pair of phones in series with the plate return of this tube and its lead "B+Osc." with battery connected. With the tube in its socket, upon touching the grid and plate socket terminals with a wet finger tip loud and distinct "plops" should be heard. In some cases the turns of the plate coil of L3 must be increased, to ob-

(*Continued on page* 84)

Characteristics of Two New Tubes

IN recognition of the tendency to standardize on 2.5 volt a.c. tubes, the Arcturus Radio Company of Newark, N. J., announces two important additions to their line in the development of the type 145 and 124, respectively power and screen-grid tubes.

The power tube has an undistorted power output of 1.7 watts under the following normal operating conditions:

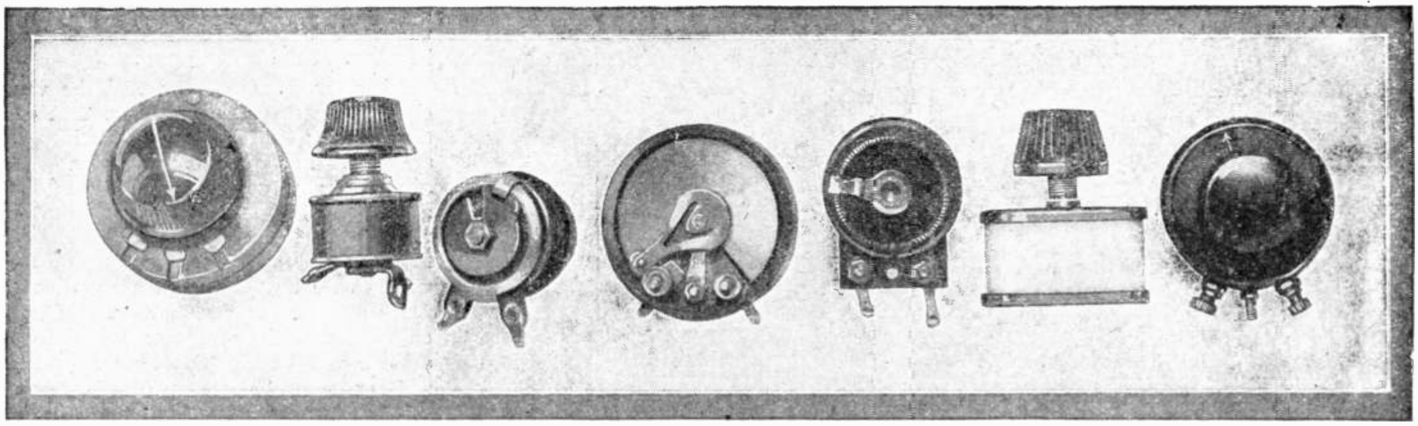
Plate potential	250 volts
Grid bias	—50 volts
Filament voltage	2.5 volts
Filament current	1.5 volts
Amplification constant	3.5
Mutual conductance	1,900 micromhos
Plate resistance	1850

The undistorted power output of this new tube is equal to that of the 210 type of tube and is secured at much lower plate voltages. Also, the low plate impedance improves the tone quality when outputting into readily available load circuits.

The characteristics of the screen-grid tube are as follows:

Heater potential	2.5 volts
Heater current	1.75 amperes
Plate potential	180 volts
Shield-grid potential	75 volts
Control grid bias	1.5 volts
Amplification constant	400
Plate resistance	400,000 ohms
Mutual conductance	1,000 micromhos

The 124 tube is of the heater cathode type and is mounted in the UY five-prong base. The control grid is brought out to a cap on the top of the tube.



The variable resistors above, suitable for volume controls, are (left to right) a Centralab wire-wound potentiometer; Clarostat (carbon-compression); Carter carbon-strip resistor; Centralab carbon-strip potentiometer; Electrad high-resistor; Bradleyohm (carbon-compression); and an old-style potentiometer which will adorn many junk-boxes. The potentiometer may be used either as voltage divider or plain variable resistor.

Choosing Between Volume-Control Methods

By *Ashur van A. Sommers*

It has been said that the method of controlling volume in a radio set can either "make" or "break" the set. At first glance, this appears to be a rather broad statement; but, on further consideration, it will be found that this is at least partly correct and, in many cases, entirely correct. For instance, if we refer to the methods used for controlling the volume in the average set several years ago, we find that they are considered entirely inadequate for present-day receivers, because the radio public has been educated to understand some of the causes of distortion in a set.

In Figs. 1 and 2 we find two common methods of volume control, most generally used in sets a few years ago. Fig. 1 shows the use of filament rheostats for controlling the filament temperature; this in itself is quite satisfactory, if care is taken to keep the tubes from being overloaded. If this reduction of the filament voltage is used for a volume control, however, there is a very great possibility of causing distortion; because the tubes will not carry as much plate current when the filaments are turned down, as when they are kept at the correct temperature. This effect is most evident when the radio-frequency and detector tubes are controlled by one rheostat.

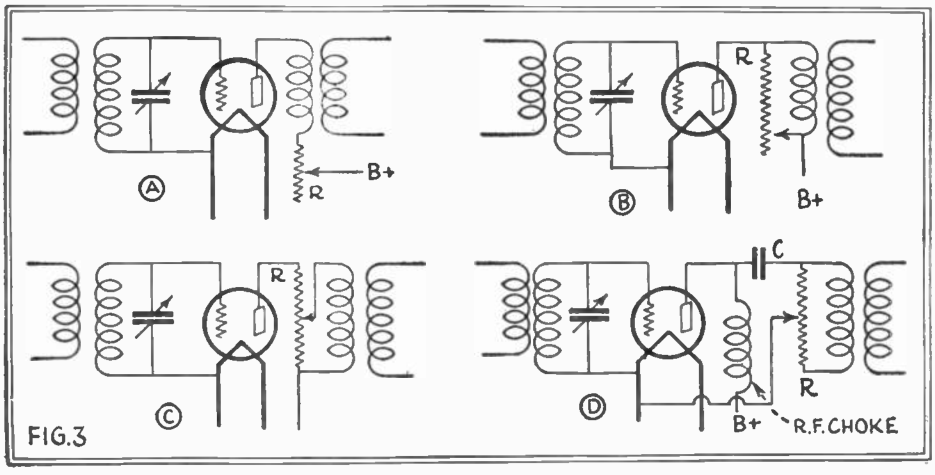
Fig. 2 shows the use of a potentiometer R for oscillation control as well as volume control. As an *oscillation* control, the use of a potentiometer is satisfactory; providing the adjustable arm is kept on the side of the resistance wire which is connected to the negative filament terminal. Of course, the use of resistors in the grid wiring of sets is not to be advocated, unless correctly employed, and for this reason the use of the potentiometer in tuned-R.F. sets has been practically discontinued. Another drawback in using the potentiometer, either as a volume or oscillation control, is the large increase in the plate current caused when the movable arm of the potentiometer is moved to the positive side. A third reason is that broad tuning results from a positive bias on the grid.

OTHER DEVICES EMPLOYED

Both of the methods mentioned above have been largely discontinued, because of their inherent weaknesses; but inefficient volume controls are still being employed, and unbiased discussion of the various methods should help to straighten out this matter in the minds of radio builders. Probably the best way to show the relative advantages and disadvantages is to divide the different types of receivers into groups: we will refer first to direct-current (battery) sets using the standard tubes; secondly, to alternating-current sets; and thirdly, to the new screen-grid sets.

We may define the ideal volume control as that which will allow a gradual control of the receiver's volume from a whisper to the greatest possible amount of sound that the receiver can produce, without affecting the fidelity of reproduction. In controlling the volume, also, the tuning of the set must not be disturbed; since this would cause trouble in single-control sets. There are a number of otherwise suitable methods which cannot be used for this reason.

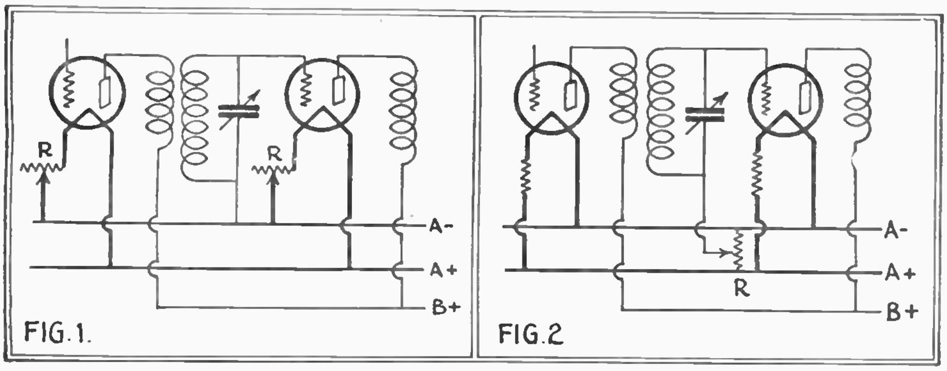
Practically, the volume control should be capable of reducing tube distortion when the set is turned down; since distortion is much more apparent on soft signals than on loud ones. Also, the set is often turned down solely to reduce the distortion, and, if the volume-control method used does not reduce the distortion more than the volume of music, it is not entirely suitable. By a method which will lower the input to the tubes which are most likely to be overloaded, distortion will be reduced considerably when the set is not operated at its greatest volume. The volume control must not introduce any distortion or noises of its own, and it must not change the characteristics of any of the apparatus in the set. There is one exception to this rule, which will be described later with the systems which are incorporated in the audio-frequency amplifier.



The first method (A) controls plate voltage and incidentally oscillation; the second (B) the voltage of the signal passed on. This and (C) are better adapted to small sets; that at (D) for the larger models of receivers, using power units, although it requires more components to construct the circuit.

VOLUME CONTROL IN BATTERY SETS

Two methods which have fallen into disuse have been mentioned above; there are also several others which, though more in favor, are for one reason or another not quite satisfactory. A very common way to reduce the volume in a set is to place across the loud speaker a variable resistor of high value. The volume is controlled very satisfactorily in this manner; but, unfortunately, the *load on the tubes in the set is not lessened* when reduced volume is used and, because of this, the distortion is just as bad at a whisper as at a thunderous roar. This is not desirable, and a method of reducing the load on the tubes will permit the set to give better quality when the volume is reduced. This is particularly advantageous when local stations are being received, because of the overpowering signal strength.



Two old methods: Fig. 1, reducing filament emission by turning down the rheostats. Fig. 2, controlling bias of R.F. grid circuits by a potentiometer across the "A" battery. Neither is entirely satisfactory.

Another common method is to place a variable resistor across the primary of one of the audio-frequency transformers, usually the first. This method is slightly better than control at the speaker; but the detector and radio-frequency tubes are still operated at full load regardless of the volume. The use of a resistor across the transformer may also change its characteristics; although the change is often an advantageous one, especially with transformers which are "peaked" rather sharply, such as those designed some years ago. With more modern transformers, the change in the transformer characteristics may be a detriment rather than an asset; since it may change a good "characteristic" curve to a rather poor one. However other methods which will give control over the first tubes in the set, are more suitable.

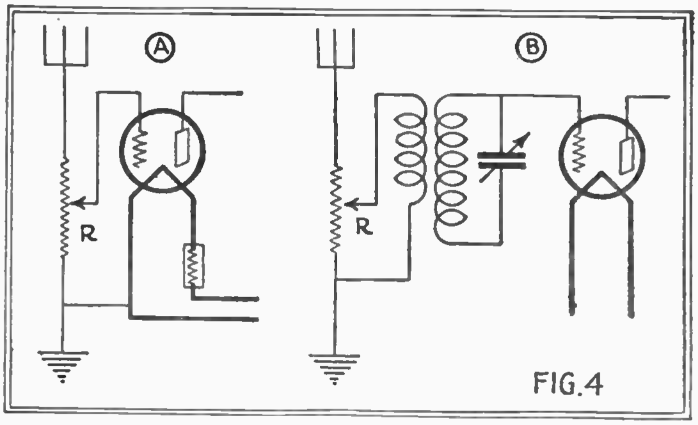
CATCH 'EM EARLY

Since the speaker and audio-amplifier methods of control are both applied too late, the logical conclusion is that a control either in the radio-frequency amplifier or in the aerial would be best. This leaves several methods, some of which are quite satisfactory and others less so. A variable resistor in series with the plate supply ("B"-battery lead) to the radio-frequency tubes is very often used and, in most sets, is quite satisfactory. This resistor serves also as an oscillation control and, in sets of only one or two stages, very good results can be obtained. This method is shown at A in Fig. 3, in which several other plate-voltage control methods are also illustrated; at B we have a high resistor in parallel with the primary of one of the radio-frequency transformers. This method is slightly better than the first for larger sets, but may cause a change in the tuning when its resistance is low. This is due to the fact that it practically short-circuits the tuned coil when the resistance is reduced; which reduces the primary's effective inductance, and causes also a change in the inductance of the tuned secondary. Such a result makes this method unsuitable for single-control sets, unless "trimming" condensers are used for matching the tuning condensers.

In the system shown at C this difficulty is avoided, but another encountered. If a "B" power unit is used, a variation in the setting will change the voltage applied to the plate; and this will also cause a difference in the voltages on the other tubes with corresponding complications. This is also true of using the series resistor as at A and, for that reason, this method is suitable only for small sets.

The method shown at D (Fig. 3) is the most suitable of the plate-circuit control methods, because it does not have any of the defects of the others. The choke coil maintains a constant potential, and the resistor reduces the volume without any alteration of the inductance in the primary coil.

When a set is used which is shielded, or for other reasons will not pick up signals without an aerial, the volume may be controlled in the aerial circuit; two methods are



shown in Fig. 4. The first (at A) is a potentiometer, of about 10,000 ohms, directly across the grid circuit of the first radio frequency tube. This method reduces the number of tuning controls required in the set; but it also reduces the amplification, and for this reason is only suitable for large sets. The second (at B) allows the use of all tuning controls and is applicable to most sets; a resistor of about 25,000 ohms is used as shown. As mentioned above, a difficulty often encountered with controls of this type is due to the pick-up of strong signals in the coils and wiring of the amplifier and detector.

GRID RESISTOR CONTROLS

The final method of control in the radio-frequency amplifier is the grid circuit. Two methods of using this method of volume control are shown in Fig. 5; the first (A) is quite satisfactory if single-dial tuning is not used. However, it is not entirely suitable if the tuning controls are ganged together, because of the detuning effect; but this detuning can be overcome by using the system shown at B. The disadvantage of this method is the effect on the selectivity; when the resistance is reduced, the selectivity is ruined.

The resistor used in the grid control must have a very high maximum value, so that the amplification is not reduced on the maximum setting; one of about 500,000 to 1,000,000 ohms is required for this purpose. If the grid control is placed in the last stage of radio-frequency amplification, the detector will not be overloaded and the volume will be controlled even though the set may operate with the aerial disconnected.

To sum up the best methods of controlling volume in a battery-operated set, we find that the radio-frequency and aerial control methods afford the most advantages and fewest disadvantages. Of these, the ones shown as 3D, 4B and 5A are applicable to most sets.

The aerial resistor is highly satisfactory, from the standpoint of quality solely.

VOLUME CONTROL IN A.C. SETS

The problem of controlling volume in alternating-current operated sets using their special tubes, is quite different from that encountered in battery sets. In order to simplify the discussion, it is best to divide the sets into two classes; first, those using the "heater-" (227-, etc.) type tubes and, secondly, those using the direct-to-"filament- (226-, etc.) type" tubes in the amplifier sockets. In sets using the heater tubes in all stages (except the last audio-frequency or "power") most of the systems of volume control above outlined for battery sets are satisfactory. In order to keep the hum at a minimum, however, it is advisable to use some system which will not disturb the plate and grid voltages.

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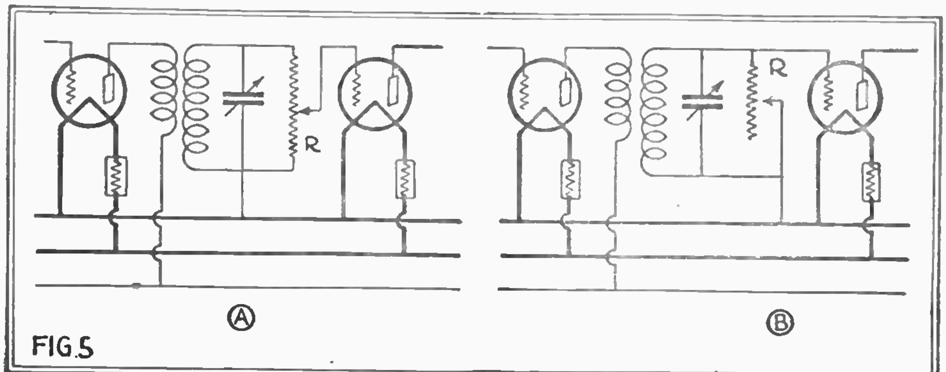


The methods of controlling volume shown above, while efficient in some ways, affect tuning in the circuit shown at A, and selectivity in that at B. High resistance is necessary here.

The Hammarlund-Roberts "Junior Hi-Q 29"

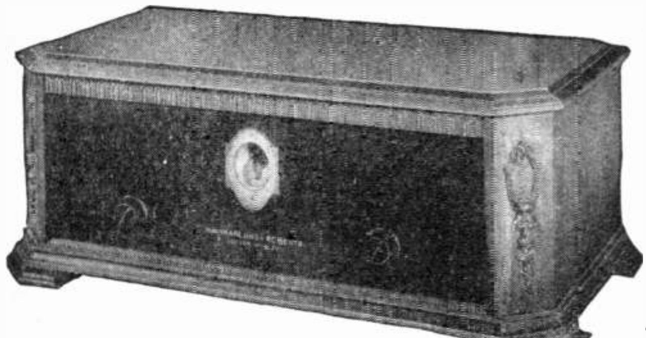


Fig. A

D. C. Model

A Product of Radio Engineers Who Have Designed It for the Custom and Home Builder's Convenience

By Leslie G. Biles

Shown here in a table cabinet, this panel will grace any console.

"WHAT is a good receiver?" is the question which has been presented to the public jury innumerable times. At first glance, one would naturally consider the answer to this question to be of necessity weighted down with intricate details. No idea is more distant from the truth; because a few words based upon public opinion constitutes the reply. To be exact, *a good receiver is one which is scientifically designed and will perform in an admirable manner, when placed in the hands of any user, even though he is not possessed of a technical education.* The criterion of a receiver's performance is in the results secured, not by one who is sufficiently versed in radio lore to be able to secure the "Nth" degree of efficiency, but by the man who can simply assemble and wire a receiver and then manipulate the controls in conventional fashion.

Much may be said and written about the performance of a radio receiver but, since the background and basis for good performance is scientific design, we believe that an analytical discussion of the factors involved in the design of the highly-successful "Junior Hi-Q 29" receiver (direct-current model) will undoubtedly be of interest to the myriad enthusiasts who are interested in the "why" of a receiver. An analysis of the design makes it easy to understand the entire receiver, and gives one an insight into the fundamentals of its performance. It is the performance of a receiver which determines whether the investment has been wise. Hence, design details are not mere technical items but the road to "your money's worth."

BATTERY operation is still the favorite of the fan who wants distance. In this powerful receiver we find the same screen-grid tubes as in the larger A.C. model; though not the elaborate filter circuits, nor the push-pull output. However, this receiver, considerably easier and less costly to build, is capable of excellent DX work in any fair location, has selectivity sufficient under the usual conditions, and gives high quality with volume suitable for the home.

SELECTIVITY AND AMPLIFICATION

True, radio engineering, during the past few years, showed a steady tendency towards the use of 7-, 8- and 9-tube radio sets; but with new wavelength allocations and the production of the D.C. 222-tube screen-grid tube at the advent of the 1929 radio season, a decided change in receiver design set in. What with the allotment of station frequencies uniformly 10 kilocycles apart, thus improving the status of the broadcasting and increasing consequent selectivity, and the gain per stage obtained with the screen-grid tube, greater economy in stages were made possible in receiver design, particularly in radio-frequency amplifying systems.

In this respect, the screen-grid tube played the paramount role. The reasons were numerous: first, it made possible greater gain per stage and effected a consequent reduction in the number of tubes required to impress a certain voltage upon the detector grid. Secondly, the reduction in tube capacity, accomplished in the design of the screen-grid tube, made possible the realization of enormously high gain in the radio-frequency amplifier without fear of uncontrollable regeneration. Hence, the devices previously necessary to curb this annoying force can now be eliminated, thus reducing the cost of the receiver.

The possibility of high gain per stage, in the radio-frequency amplifier, however, introduced associated problems. Atmospheric disturbance, the ban of the radio pioneers, has now been supplemented by man-made static which greatly decreases the ratio between signal and noise; and the high gain available with the screen-grid tube makes necessary careful consideration of the number of stages to be used in the R.F. system, because ultra-sensitivity greatly increases the effect of man-made static. The abundance of broadcast stations adjacent to the larger cities, and the increased power employed by the stations, introduce additional factors. The public demand for high-quality reception of local stations during the period of their operation augments the items which must be considered when the number of R.F. stages is determined.

Investigation of the maximum gain available from a screen-grid tube and its radio-frequency transformer, consistent with satisfactory selectivity between local stations and the ability to tune in DX stations after the locals have signed off (plus the radio-frequency "response curve" for each individual stage which produced minimum side-band-suppression) as well as detailed consideration of the items previously mentioned, showed that two stages of screen-grid radio-frequency amplification constitute an amplifying system which is conductive to high-calibre performance in every respect. The use of individual stage shielding, whereby all inductive coupling between the radio-frequency transformers, and electrostatic coupling between the condensers, is eliminated, has made possible the attainment of a high amplification level with perfect stability; so those DX stations can be received with excellent volume after the locals have signed off the air. The elimination of such interstage couplings displayed its effect upon the regeneration present in the system, by improving the shape of the resonance curve of each stage, and greatly minimized side-band suppression. The minimization of regeneration, together with the total radio-

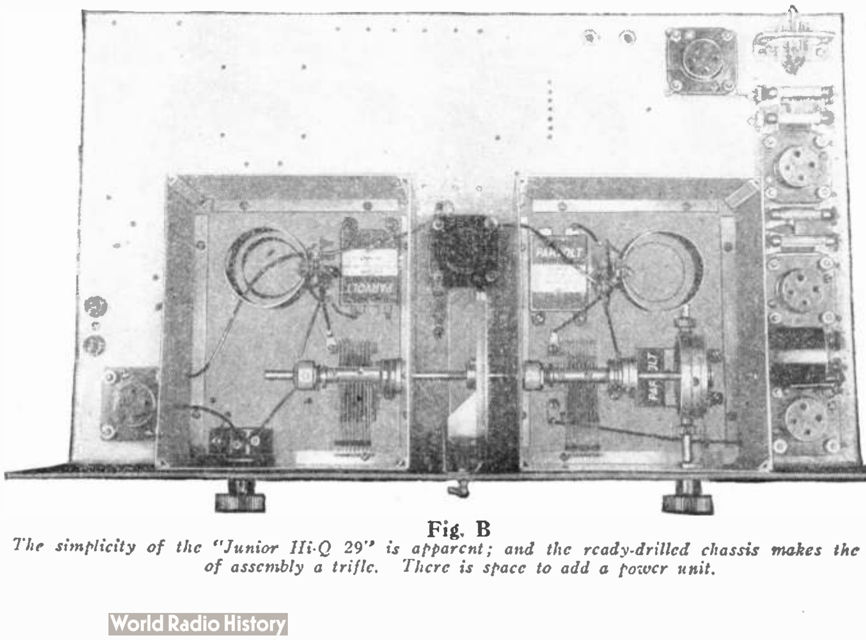


Fig. B
The simplicity of the "Junior Hi-Q 29" is apparent; and the ready-drilled chassis makes the work of assembly a trifle. There is space to add a power unit.

frequency shielding, made it possible to obtain a certain co-efficient of coupling between primary and secondary inductances of the tuned radio frequency transformers. This, again, permits a high gain per stage without a sacrifice in selectivity.

The proof of the high gain available in the radio-frequency amplifier is evident from the use of a "C"-bias detector in place of the normal grid leak-and-condenser system. The former is used in the receiver here described, despite the fact that the latter method of detection is many times more sensitive. However, the use here of the grid-bias system of detection is not solely to prove the gain obtained in the R.F. system. The true reasons are numerous: first, the fact that it permits full realization of the gain present in the radio-frequency amplifier. Secondly, it reduces distortion in the detector system because the input that may be applied to a grid-bias detector is several times that which may be applied to a grid leak-and-condenser detector system. (See RADIO NEWS for April, page 916.) Third, it improves the selective powers of the detector's input circuit.

AUDIO AMPLIFIER

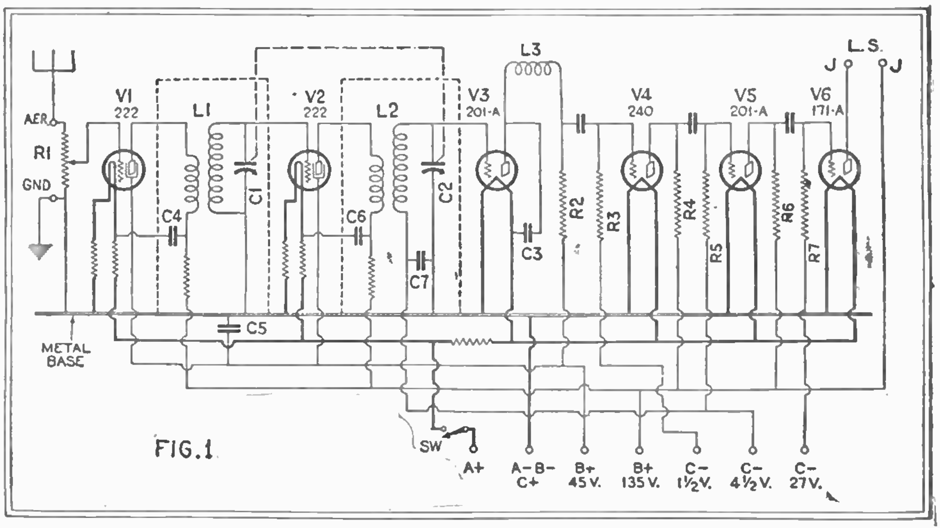
The audio amplifier was likewise a subject of investigation. Of the many systems available, three stages of resistance coupling was decided upon as being the best to follow the radio-frequency and detector systems employed. The smallness of the usual gain in such an amplifier, due to the lack of step-up in the audio coupling units, is counteracted here by the use of a "high-mu" tube in the first stage. The reason for the use of this tube only in the first stage is that the permissible input voltage to any tube decreases as the amplification constant is increased. Under the circumstances, the voltage output of the detector tube is not sufficient to overload the first stage but, if this tube were used in the second-stage, its margin of "grid swing" would not permit the application of the voltage output obtained from the first stage when the receiver is tuned to a local station.

Although this factor is seldom discussed, the combination of values, of the coupling capacity and the grid leak, displays a large effect upon the audio-frequency response available from an amplifier. In this receiver, the value selected for each is such that the cumulative effect of the R.F., detector and A.F. systems provides the desired characteristics required for best performance with the average loud speaker. The use of a single 171 as the output tube was decided upon only after acoustic measurements had been made and the 700-milliwatt output available from the 171 had been found to be quite satisfactory for the average home and apartment.

LIST OF PARTS

The parts required for this receiver are as follows; those which are not lettered on the circuit are those included in the foundation unit, which obviates all drilling and saves the constructor a great deal of drudgery.

One Sangamo .001-mf. fixed mica condenser (C3);
One Carter TP-3M tapered volume control, 3000 ohms, (R1);
One Carter No. 2 battery switch (SW);
Four Acme "Parvolt" 0.5-mf. Series 200 by-pass condensers (C4, C5, C6, C7);
Two Durham metallized resistors, ¼-megohm (R3, R5);
One Durham metallized resistor, 1/10-megohm (R7);
Two Durham "Powerohms," 1-watt, 100,000-ohm (R2, R4);
One Durham "Powerohm," 1-watt, 50,000-ohm (R6);
One pair Yaxley No. 422 insulated phone tip jacks (J, J);
One Yaxley No. 660 cable connector and cable;



The schematic diagram of the "Junior Hi-Q 29" is easily followed; its untuned antenna stage gives distortionless volume control; and its non-regenerative, plate-rectifying detector and resistance-coupling in the A.F. end show that quality as well as amplification has been a paramount consideration.

Two Hammarlund No. ML-17 .00035 mfd. "Midline" condensers (C1, C2);
Two Hammarlund No. SGT-17 shield-grid R.F. transformers (L1, L2);
One Hammarlund No. RFC-95 radio-frequency choke, L3;
One Hammarlund No. SDW knob-control drum dial, walnut finish;
Six Benjamin "Cle-Ra-Tone" sockets No. 9040, for V1 to V6;
Two Eby engraved binding posts ("Aer.," "Gnd.");
One Hammarlund "Junior Hi-Q29" foundation un·· (containing drilled and engraved Westinghouse micarta panel, two complete aluminum shields, drilled steel chassis, shafts, coupling condensers, resistor mounts, binding-post strips, fixed resistance units, clips, wire, screws, nuts, washers, solder and all special hardware required to complete receiver).

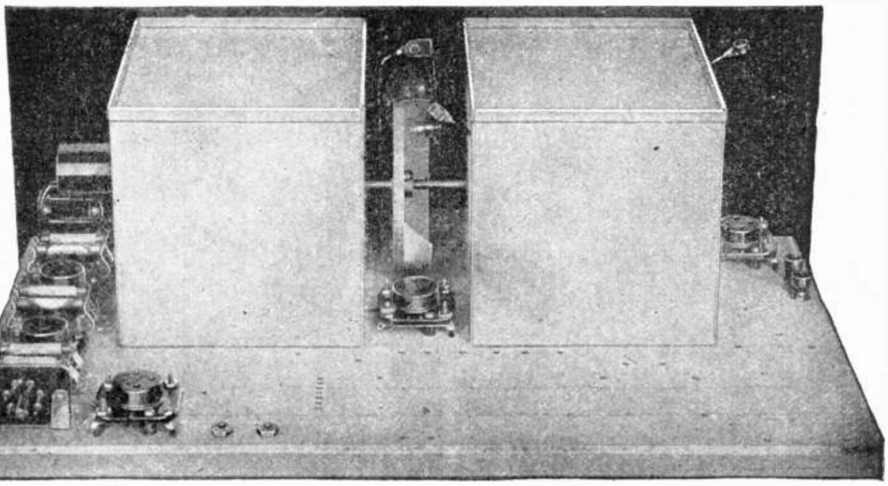


Fig. C

A rear view of the completed receiver, showing the finish of its appearance, as well as its strong mechanical construction. The compactness of the audio amplifier and the shortness of its connections is noteworthy.

GENERAL DISCUSSION

Referring again to the wiring diagram, we cannot help finding a few interesting details. Since the "Junior Hi-Q 29" in this model is designed for battery operation, low plate-current consumption is imperative; this is secured by the use of a *distinct grid-bias voltage for every tube* in the receiver. That for the screen grid tubes is secured by means of the voltage drop across a resistor in the filament circuit of each tube. The volume control is located in the most advantageous position—in the aerial circuit where it cannot diminish the selective qualities of the radio-frequency transformers and where it precludes all distortion by providing control of the signal input. Its use in this position accomplishes two other effects: first, isolation of the tuned circuits; and, secondly, single-dial tuning control of all tuned circuits independent of the aerial system. Since this control is in the form of a voltage divider, the characteristics of the antenna system remain un-changed during the manipulation of the control.

The need for proper by-passing of the radio-frequency currents in the plate circuits of the screen-grid tube is secured by means of individual filters, interposed between the battery terminals of the plate coils and the source of plate potential. The elimination of radio-frequency currents from the audio amplifier is secured by means of a filter in the form of a radio-frequency choke and a by-pass condenser in the plate circuit of the biased detector tube. Individual filament control is supplied for the screen-grid tubes, and one major control governs the supply to the detector and the three audio stages.

Simplicity is the keynote of the entire design in both construction and wiring.

CONSTRUCTIONAL DETAILS

With respect to the constructional details of the receiver, it has been so designed that its assembly is very simple; reference to the wiring diagram will substantiate this statement. However, the constructor should note a few precautionary details—items which, though relatively simple, influence receiver performance. First, the use of the by-pass condensers (C4 and C6), in the screen-grid circuits of the two radio-frequency amplifying tubes. These condensers are indispensable and their positions in the circuit must be correct; because they influence the operation of the vacuum tube and the system. Take particular notice of the fact that they are located between the battery ends of the R.F. transformer primaries and the "A+" terminal, at the filament ends of the voltage-control resistors. The second item is the radio-frequency choke L3, employed in the plate circuit of the detector tube; this component is connected between the plate of the detector tube and the plate end of the first audio coupling resistor, with the by-pass capacity across the combination. This is of particular importance, because it influences the sensitivity of the detector tube. The third item is the detector input; the high-value capacity C7 is *in series* with the regular tuning condenser, C2, as shown. *Do not connect these two condensers in parallel;* if you do so, tuning of this stage will be impossible.

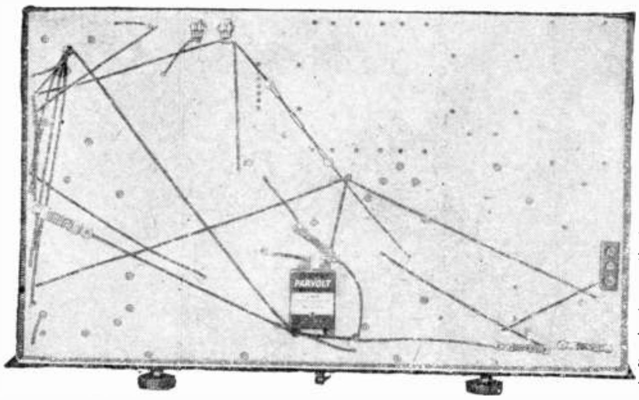


Fig. D

Wiring in the "Junior Hi-Q 29" is almost conspicuous by its absence. The "point-to-point" way is easiest and best. It must be noted that good insulation is needed.

In proceeding with the actual construction, it is best to follow the layout shown in the top view of the completed receiver (Fig. B); as this is the result of extensive experiment and has been determined to be the best for the equipment employed. It provides the simplest wiring and the shortest connections. The equipment enclosed within the individual shields should not be increased beyond the units shown. As may be seen, the two R.F. amplifying tubes are external to the shields; the input tube being at the left of the first shield, while the second stage tube is located between the two shield housings. The volume-control resistor is located within the first shield in order to preclude coupling into the wires connected to this potentiometer. The by-pass condensers associated with the two R.F. tubes are likewise located within the respective shields which house the tuning systems for these stages.

The detector tube and the three audio stages are located outside the R.F. stage shields; the detector is the one nearest to the front panel. Its position is defined (Figs. B and C) by the radio-frequency choke shown between the detector tube socket and the first audio coupling resistor. Referring to the photographs, as reproduced, the sequence of detector and audio-frequency tubes is as follows: Starting at the rear of the front panel, the first is the detector tube, the second the first audio tube. The third (second audio tube) and output tube are located near the battery cable's input plug.

The arrangement shown affords the shortest connections between the audio coupling units and the respective sockets. Wiring of the system is carried out (Fig. D) beneath the sub-panel, with the exception of the two radio-frequency stages. As evident from Fig. B, all wiring of these units is located within their respective shields.

The by-pass condenser connected between the chassis ("A— B—") and the "B+" terminal is located on the underside of the sub-panel, as shown in Fig. D. The input terminals of the receiver are the two binding posts shown in Figs. B and C; the output connections are the two tip jacks visible in the neighborhood of the power tube.

In view of the fact that the chassis is of metal and is a part of both the "A" and "B" systems (since the "A" and "B" minus terminals are connected thereto), it is important that all the wires passing through the holes in the sub-panel have perfect insulation. Care should be exercised, when threading the wires through the holes in the sub-panel, to preclude the possibility of scraping the insulation; for this reason, all sharp right-angle bends in the wiring passing through these holes should be avoided.

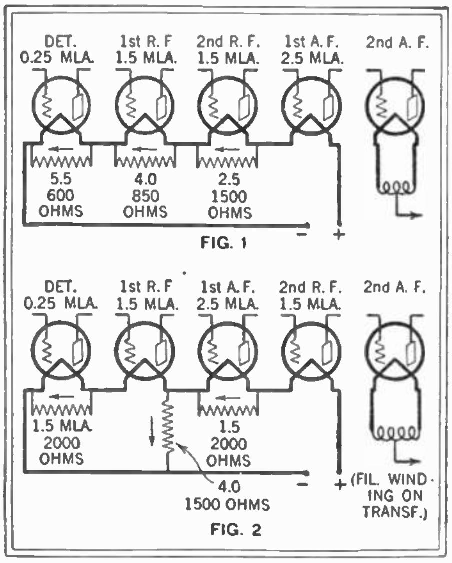
(Continued on page 86)

By-pass Resistors for Series-Filament Operation

By J. H. Arnold

THE use of tubes requiring low filament current (such as the 199 type) with the filaments connected in series and powered by a "B" unit of the usual type, capable of delivering 75 milliamperes or more, has become quite popular as a method of electrification. With such an arrangement, no A.C. is introduced into the circuit at any point—as in the 226-type A.C. tube—and consequently a low cut-off frequency may be used in the audio amplifier without introduction of A.C. hum.

It is necessary to use by-pass resistors across the filaments to keep the current through all tubes at a value of 60 milliamperes; as otherwise the filament current through the last tube in the string will exceed that through the first tube by the sum of the plate currents. The usual resistance values are 600, 850, and 1,500 ohms, shown in Fig. 1. The 600- and 850-ohm resistors are odd sizes, and consequently difficult to obtain from most radio stores. By making use of the revised connections shown connected across each tube filament as in Fig. 2, standard resistors of 2,000, 2,000, and 1,500 ohms may be used. By connecting the 1,500-ohm resistor across two tubes, the 4-milliampere plate current of the other two tubes is by-passed by one resistor instead of two. A higher resistance value may thus be used across the detector tube; namely 2,000 ohms instead of 600.



Series filament wiring with 60-milliampere tubes requires some compensating resistors. Fig. 1 is a usual, and Fig. 2 an improved circuit.

By the application of this idea, sets using more than four 199-type tubes in series may be designed to use resistors of not unusual values, remembering that the resistance in ohms equals three times the number of tubes across resistor, divided by the current in amperes.

By suitable changes in the order of the tubes, as some will draw higher plate currents than others, an arrangement can readily be found which will make use of 500-, 1,000-, 1,500-, and 2,000-ohm resistors rather than of odd sizes.

It is probable that many constructors have feared series wiring overloads filaments, should a tube be taken out of its socket. As the diagram shows, however, the contrary is true; the whole circuit is broken and becomes dead.

The "A. C. Screen-Grid DX-er"

An Old But Efficient Distance-Getting Circuit Brought Up-to-Date with Newly-Developed Tubes

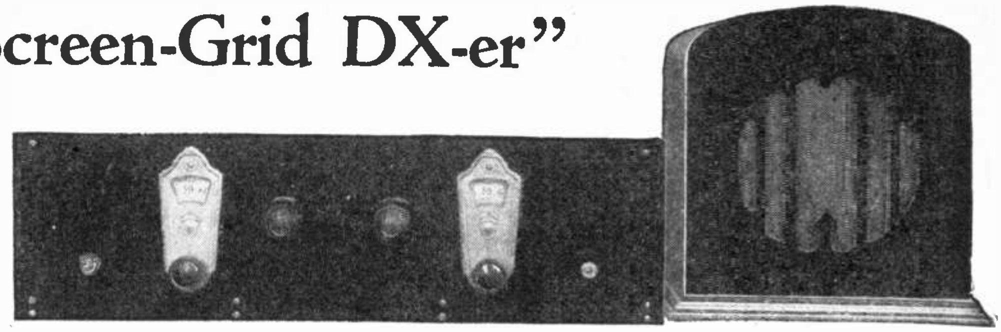


Fig. A
The panel appearance is attractive and, as may be seen, will suit almost any cabinet.

By Robert Hertzberg

IN spite of the many advantages over the normal three-element tube which it possesses, the UX-222 has achieved comparatively little popular application, because of its requirement of a direct-current supply for its filament. Custom set builders, who have been intrigued by its possibilities as a super-sensitive radio-frequency amplifier, have been forced to overlook it almost entirely when building receivers; as the first question of all prospective customers is, "Does this set work off the house current?"

Of course, there are "A" power units which replace the storage battery and work very well over long periods of time; but the luxurious convenience of A.C. operation is a selling point that is acknowledged by all.

The recent marketing of the A.C. screen-grid tube by large tube manufacturers relieves this situation, and opens up a virtually new field for the constructor. The circuits incorporating it are simplified without reduction of sensitivity; the storage battery and the "A" unit may alike be forgotten; the whole power pack is built right into the receiver, while the number of tubes is reduced. The hum introduced is at a minimum; for the new tube has the same filament characteristics as the well-known 227 type, with the advantage of operating from the same filament transformer or winding.

RADIO NEWS, therefore, here introduces to its readers one of the first receivers designed particularly to take advantage of the new tube. It has been called the "A.C. Screen-Grid DX-er" because this name covers its three salient features: the convenience of A.C. operation, the sensitivity by screen-grid high amplification, and the tremendous DX range of the set. The screen-grid R.F. stage is tuned, assuring good selectivity; while the detector is regenerative, assuring maximum sensitivity. For all normal local and middle-distance reception, the detector regeneration control knob is left at minimum; for the screen-grid tube alone is sufficiently sensitive. After the family goes to sleep you can crowd up to the loud speaker, nurse that knob a little, and start logging stations between both coasts.

REGENERATION preceded by a tuned R.F. stage has long been known to offer more distance, tube for tube, than any other circuit. Now the availability of an A.C. screen-grid tube with enormous amplification offers to the constructor an opportunity he has long been waiting for. This is the first set using this new amplifier available to the set-building fraternity, and will be of undoubted interest to all. It is a little giant, as the picture above indicates.

The regeneration control is not the regular volume control of the set, as in most circuits with a single R.F. stage and regenerative detector. Instead, a potentiometer which varies the voltage on the screen-grid of the R.F. tube is employed. This arrangement is highly effective, and prevents distortion by ensuring the detector against overloading. Thus, the quality of the signals from local stations is not destroyed; as it is in many highly sensitive sets designed for the utmost DX.

The set illustrated in the accompanying photographs is a complete receiver; requiring in addition to the speaker only aerial and ground connections and a source of 110-volt alternating-current. It uses five receiving tubes and one rectifier, the latter of the 280 type. While a complete assortment of parts, including drilled and engraved front and sub-panels, can be obtained in kit form (and, when so purchased, saves a great deal of labor) individual parts are widely available; so, if you already have sockets and binding posts and transformers, for instance, you will not have to spend additional money on duplicate parts.

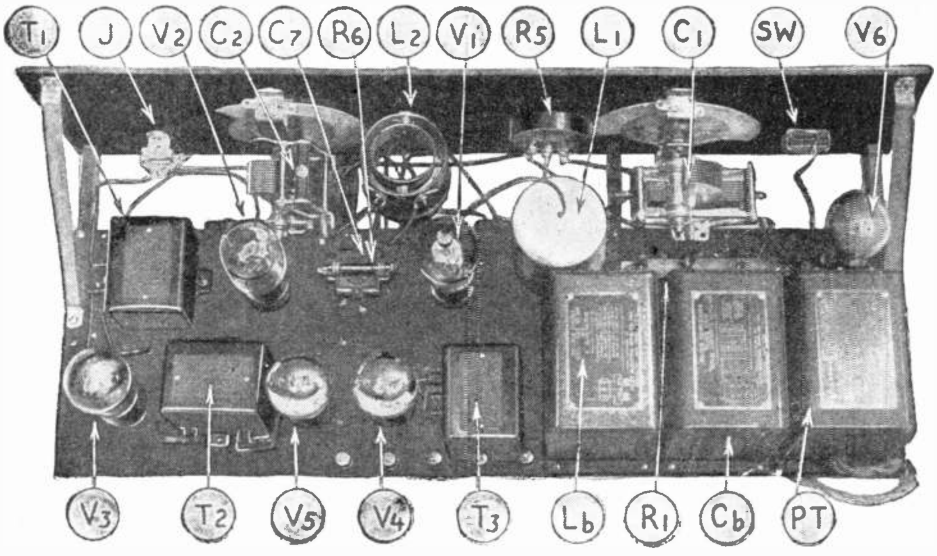


Fig. B
The separated panel and sub-panel assembly, well illustrated in this top view, is very strong, and convenient for the constructor. There is practically no wiring above. The compact power-unit assembly appears at the lower right. Note the shielded, plug-in inductor L1, with its direct connection to the screen-grid amplifier V1.

PARTS REQUIRED

The complete list of parts used in the receiver, as illustrated here, is as follows:

- One Pilot power transformer No. 398 (PT);
- One Pilot filter condenser block No. 396 (Cb);
- One Pilot double choke-coil block No. 395 (Lb);
- One Electrad voltage divider (R1);
- One Pilot 1200-ohm fixed resistor (R2), one Pilot 2250-ohm resistor, (R3), and one Pilot 1200-ohm resistor (R4);
- One Centralab 200,000-ohm potentiometer (R5);
- One Twin Coupler antenna coupler (L1);
- One Twin Coupler interstage R.F. transformer, with tickler (L2);
- One Pilot variable condenser No. 1517, .00035-mf. (C1);
- One Pilot variable condenser No. 1523, .0005-mf. (C2);
- One Silver-Marshall A.F. transformer No. 255 (T1);
- One Silver-Marshall push-pull input transformer No. 257 (T2);
- One Silver-Marshall push-pull output impedance No. 258 (T3);
- Four Pilot fixed condensers No. 59, each .01-mf. (C3, 4, 5 and 6);
- One Pilot grid condenser No. 51M, .00025-mf. (C7);
- One Pilot fixed condenser No. 53, .001-mf. (C8);
- One Tobe Deutschmann by-pass condenser, one-mf. (C9);
- One Pilot single, closed-circuit telephone jack (J);
- Three Pilot UX-type tube sockets No. 214 (for V4, V5, V6);

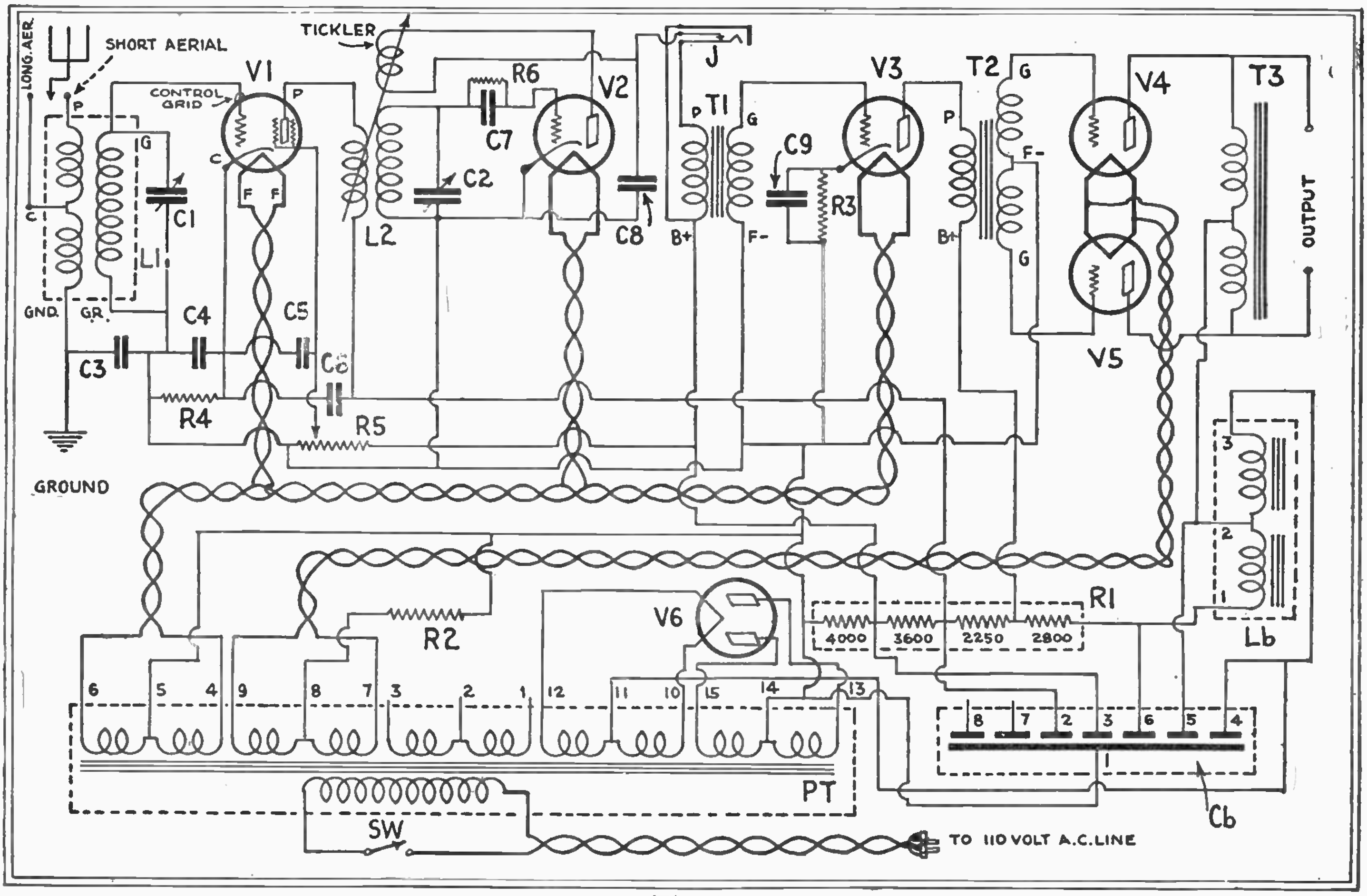


Fig. 1

While the circuit above shown may appear complicated, close examination will show that the units enclosed within dotted lines, representing sealed apparatus, account for a large part of this. The actual connections are quickly made; especially with a panel and a sub-panel drilled ready for use. The use of the same voltage on the first three tubes simplifies the filament circuit; and the push-pull power stage gives tremendous reserve of volume for low-note amplification. The choke provides a filter for the large plate current, protecting the speaker, which has no D.C. voltage across its windings.

Four Pilot UY-type tube sockets No. 215 (for L1, V1, V2, V3);
One front panel, 7x24x¼-inch, and sub-panel, 7x23x¼-inch;
Four Pilot sub-panel brackets No. 3, 8x1-inch;
One Aerovox grid leak, 2-megohm (R6);
Two Pilot vernier dials, No. 1282L (for condensers C1 and C2);
One Carter power switch (SW);
Five X-L binding posts;
One Ceco AC-22 screen-grid tube (V1);
Two Ceco N-27 A.C. (227) tubes (V2, V3);
Two Ceco J-71A (171A) tubes (V4, V5);
One Ceco R-80 (280) tube (V6).

ARRANGEMENT OF PARTS

The placement of the parts on the front and sub-panels is made very clear in the various accompanying illustrations. The front panel, shown in the heading of this article, holds the two vernier dials, to which the variable condensers C1 and C2 are attached; the power switch, at the left; the telephone jack, at the right, and the knobs for the potentiometer R5 and the tickler of the interstage transformer L2 between the dials. The jack, by the way, is not for loud-speaker connection, but for a phonograph pick-up; thus making a very convenient means of connection.

The coil L2 is nothing but our old friend the three-circuit tuner; as it consists merely of a primary and secondary on a bakelite tube, with a tickler rotating in the end of the secondary.

The power transformer PT, the filter-condenser block Cb, and the choke-coil block Lb used in the original model of the "A.C. Screen-Grid DX-er" are all of the same size, and differ only in the appearance of their terminal blocks. They occupy the left section of the sub-panel; with the socket for the rectifier tube in front of the transformer and with the voltage divider in front of the other two units.

The antenna coupler L1 is enclosed in a shielding can, which fits into a regular five-prong socket. The socket for the screen-grid tube V1 is located a little to the right of the latter, and is followed across the sub-panel to the right by the grid condenser and leak C7-R6, the detector socket (V2), and the first-stage audio transformer T1. The first audio tube V3 and the components of the push-pull stage occupy the space along the rear edge of the sub-panel.

The sub-panel is supported by four molded bakelite brackets, which are fastened to the front panel. The mechanical

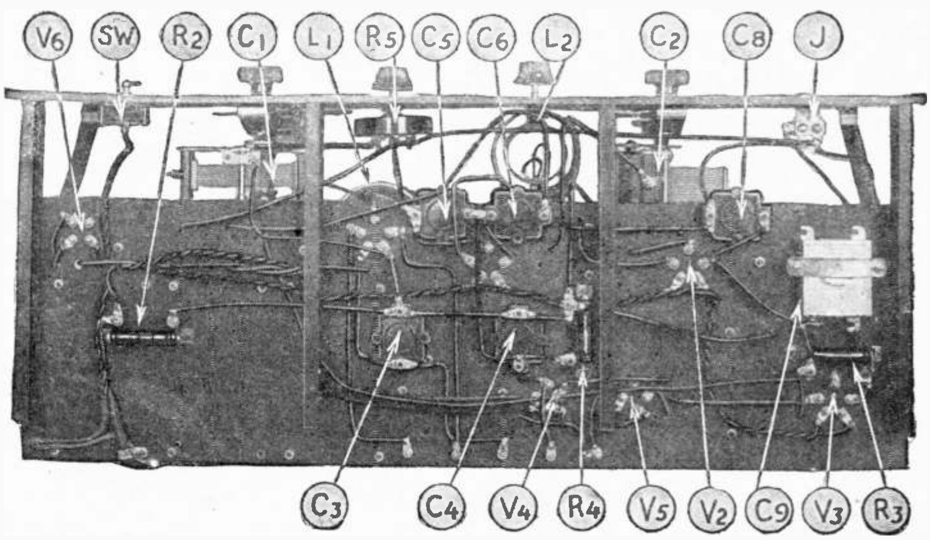


Fig. C

Viewing the under side of the sub-panel, it will be seen how many of the connections are made here directly in the "A.C. Screen-Grid DX-er." The elaborate by-passing provided is essential to quality. The jack J is conveniently placed for connecting a phonograph pick-up.

assembly is rather easy, particularly if prepared panels are used. All the parts may be mounted in about two hours, with the aid of nothing more than a screwdriver and a pair of pliers.

CIRCUIT DESIGN

Electrically, the circuit of the "A.C. Screen-Grid DX-er" will be recognized as one of sound and conservative design, and which can be depended on to give results. The antenna feeds into the screen-grid tube through a coupler comprising a tapped primary and a secondary tuned by the condenser C1. The detector is of the standard regenerative type; the regeneration being provided by the old and reliable rotating-tickler method.

The detector output goes through the jack J to the first-stage transformer T1; from which the signal proceeds through the push-pull stage and out through the center-tapped impedance T3. The jack for the phonograph pick-up is very valuable; as many old-style phonographs, still in use, can be equipped with pick-ups to work through the A.F. amplifier.

The set is thoroughly by-passed by the various fixed condensers shown; these condensers should not be overlooked for, without them, the set is likely to give trouble from uncontrollable oscillation.

The filament current for the first three tubes, which have the same filament characteristics, is supplied by the $2\frac{1}{2}$-volt winding of the power transformer; while the current for the push-pull tubes (171A's) is furnished by one of its 5-volt windings.

The "B" section of the receiver is of standard design; a full-wave rectifier tube of the 280 type, in conjunction with an efficient filter system, provides smooth direct current for the plates of the tubes.

Grid bias for the screen-grid tube is provided by the voltage drop across the resistor R4, in the plate-return lead. Bias for the first audio tube V3 and for the push-pull tubes V4 and V5 is similarly furnished by the resistors R3 and R2, respectively.

The set should be wired with a good grade of flexible insulated wire, preferably of the "push-back" kind, and the filament wires should be twisted, as usual in A.C. sets. Study the schematic diagram (Fig. 1) for the general circuit arrangement, and the pictorial layouts (Figs. 2 and 3) for the

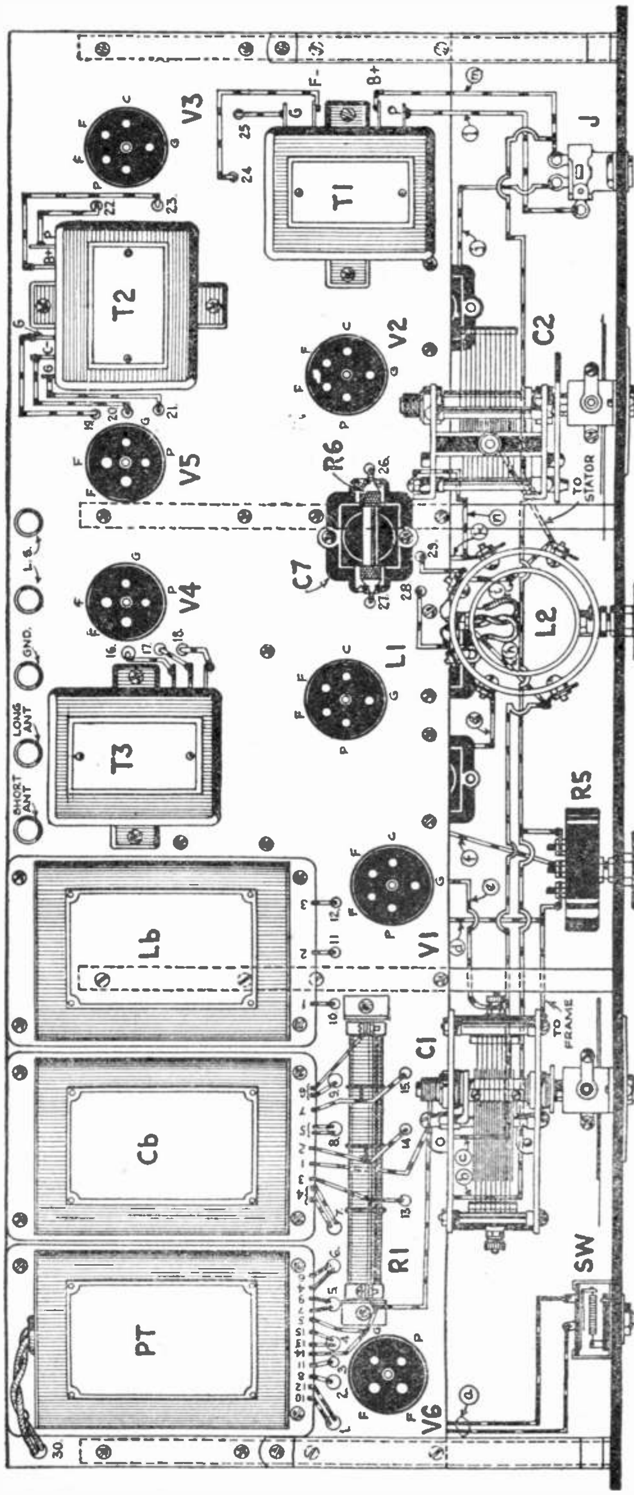


Fig. 2 *Layout and wiring above sub-panel.*

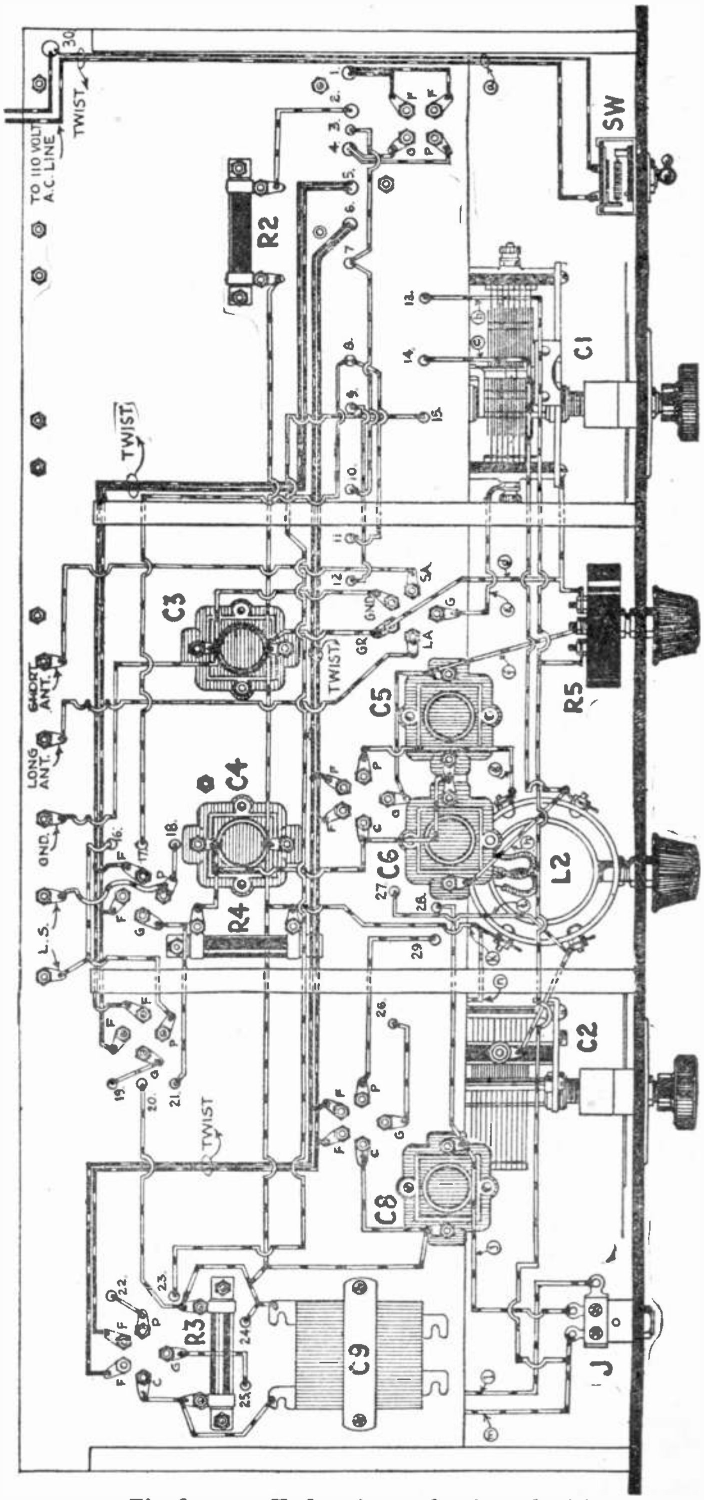


Fig. 3 *Under view and principal wiring.*

actual disposition of the wires. These are illustrated here with numerous right angles, so that the connections may be followed clearly; but, as one photograph shows, the leads may be in some cases run more directly.

OPERATING HINTS

The "A.C. Screen-Grid DX-er" should be handled like the old Browning-Drake and similar sets. For local reception ("local" with this outfit means almost everything within 800 or 1,000 miles), the tickler of L2 is set at its minimum—at right angles to the secondary—and the volume is controlled by means of the potentiometer. The two dials tune more or less alike, and stations are easily located on them.

For real distance work, keep the potentiometer all the way up, and advance the tickler so that the set produces the soft-hushing noise characteristic of regeneration. You can then "spot" weak stations by the squeals they produce; and you can bring them out by first adjusting the tuning condensers carefully, and then turning down the tickler a hair's breadth at a time. You will learn all the tricks in a few evenings, or you can teach them to a customer after one or two visits.

HINTS ON OPERATION

No radio fan will ever be able to boast about transcontinental DX broadcast reception unless he has gone to the trouble of erecting a really good aerial and installing a really good ground. The "A.C. Screen-Grid DX-er" is a highly sensitive receiver; but it will not overcome the initial handicap imposed on it by a leaky aerial or a high-resistance ground.

The best possible aerial for broadcast reception is a single length of bare or enamelled copper wire, rising straight up into the air to a height of about 200 feet. Since 200-foot masts cannot be purchased for $18 in the local radio shop, most set owners will have to struggle along with something less imposing in the way of a pick-up system.

The general rule to follow is to raise the wire as high as possible and to keep it thoroughly insulated from nearby objects by means of pyrex or other good insulators that will not soak up moisture.

The over-all length of the wire, from the point where it enters the house to where it ends finally at the furthest insulator, may be anywhere between 100 and 300 feet. Most people regard the horizontal wire and the vertical lead-in as separate components; actually there is no point at which the lead-in ends and the aerial begins. The whole exposed wire, regardless of the angles which portions of it may take in relation to the surface of the earth, is the aerial. For that matter, the wire running from the aerial binding post on the set to its junction with the lead-in at the window also acts as an aerial. If you don't believe it, try disconnecting the wire at the window, and see how many stations you can tune in.

The necessity for clean, well-soldered joints has often been emphasized. Twisted joints do very well for a few weeks; but, after they have been fanned by the gentle breezes from chimneys and ventilator pipes for a while, you will notice signals do not come in quite as well as they used to. The best way to erect an aerial is to start at the far end and to run the wire in one unbroken stretch down to the window, where you can solder with a fresh, hot iron. It's all very well to talk about soldering joints in the aerial, but, if you've ever dashed up three flights of stairs with a red-hot iron, only to find it lukewarm when you reached the roof, you'll know the advice is not easily applied.

A good ground is more easily obtained. The cold-water pipe is the old stand-by, and

(*Continued on page 86*)

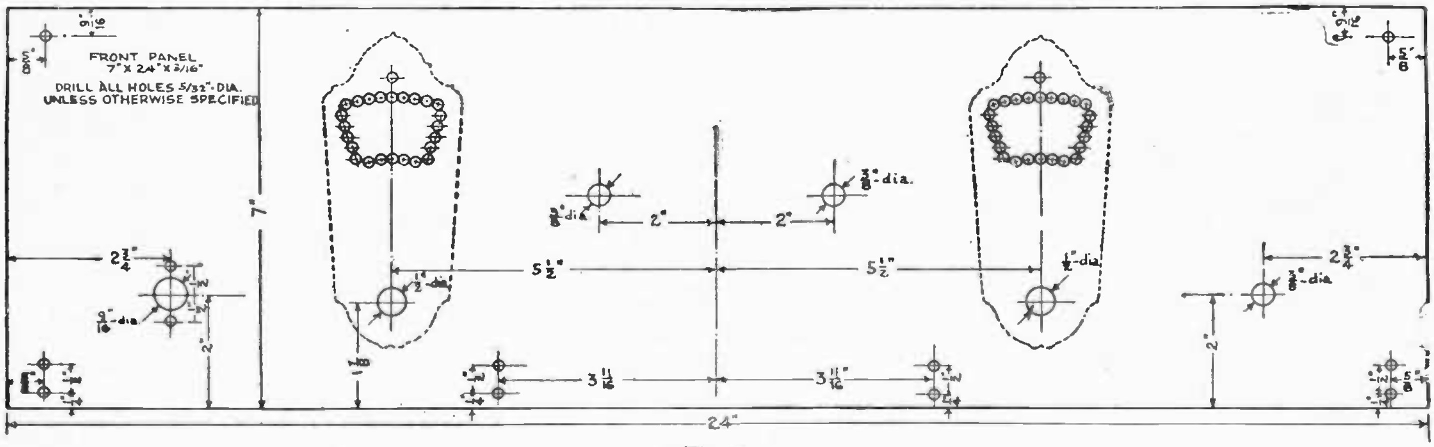


Fig. 4

The drilling diagram of the "A.C. Screen-Grid DX-er" for those who wish to do the work. Templates furnished with dials should be used.

More About Harmonics of Long-Wave Broadcast Stations

NOTWITHSTANDING the explanaation in our March issue (page 841) of the appearance of broadcast stations in short-wave receivers, many of our readers continue to inquire about the phenomenon; especially as they note long-distance reception on stations of comparatively low power in this way at times.

Some fans may have noted the absence or weakness of the harmonics from some of our largest broadcast stations; this is due to the method of operation of these large transmitters, which incorporate what is known as the "master-oscillator" system. A transmitter of this type uses a small tube as the producer of the radio-frequency carrier-wave oscillations, and all the other tubes in the transmitter proper are radio-frequency amplifiers. These radio-frequency amplifiers are very carefully neutralized to prevent them from producing oscillations of their own and each of them is tuned to the wavelength that the transmitter is operating on. Because of the tuning in these amplifiers the harmonics are not amplified or, at least, they are comparatively weak in comparison to the fundamental when they leave the amplifier. Most of the smaller transmitters, on the other hand, have their oscillator tubes directly coupled to the aerial and the harmonics are transmitted quite strongly. In some of these stations, tuned filters are used to suppress some of the strongest harmonics; but it would be impractical to suppress more than the first few because of the amount of apparatus and expense required for the filters.

Although the harmonics produced by transmitting stations are apparently only a nuisance to the short-wave listener, they have uses in the field of communication. In a master-oscillator transmitter, the oscillator may be tuned to one frequency, while the amplifiers are tuned to its harmonics. In this way the transmitter may be operated on a wavelength lower than the fundamental of the crystal-controlled oscillator and, by coupling different amplifiers to the oscillator, a number of signals may be sent out simultaneously. This latter system is sometimes employed in commercial radio work.

While discussing the subject of harmonics, it is interesting to follow the sequence of the various harmonics of a broadcasting station. Suppose we have a certain station operating on a wavelength of 399.8 meters; this is equivalent to 750 kilocycles. The second harmonic will have just twice the frequency, or 1,500 kilocycles. The third harmonic, which is the lowest that can be heard at any great distance from the transmitter, is at 2,250 kilocycles. The following harmonic are then at 3,000, 3,750, 4,500, 5,250, 6,000, etc., kilocycles. The corresponding wavelengths are 133.3 meters for third; 100 for the fourth; and 80, 66.6, 57.1, and 50 meters for the consecutive following harmonics. Given the order of a harmonic, it is necessary only to multiply the frequency or divide the wavelength of the fundamental by that number.

Considering the number of broadcast stations operating between 200 and 550 meters, it is not surprising that so many stations may be heard with a sensitive short-wave receiver. However, the above explanation may help to clear up this matter in the minds of some of our readers.

Tube Data for A. C. Sets

MOST service men who have repaired power-operated receivers are familiar with the difficulties that are encountered with some of the a.c. tubes. Mr. J. A. Ess, who is a service man in Hopkins, Minn., has analyzed the troubles encountered with these tubes, and although his statements are rather "strong" in the matter of certain types of a.c. tubes, his suggestions are quite interesting, and we feel sure that they will solve some of the queer problems that are encountered with the operation of these tubes:

"Most service men have encountered servicing problems with a.c. sets, in which the '27 type tubes would not stand up. The reasons for these tubes failing to operate over a considerable length of time are rather numerous, but they are usually brought down to several main points, such as fluctuations of line voltage, and excessive filament temperature. Fluctuations of the line voltage usually cause more trouble when only one of the '27 type tubes is used in the set, since there is only one filament shunted across the winding. In some cases, the breaking of the filament may be due to the differences in the consistency of material used in the insulation sleeves surrounding the filament. It seems that the expansion and contraction of turning the set on and off breaks the filament eventually. This trouble may be noted in some cases by the periodical interruption of reception or by testing the tube in a regular tube or set tester.

"This variation of tube breakdown is a rather interesting one, since the tube seems to act as a thermostat and when the set is turned on, reception will be normal immediately after the set gets 'hot' and then gradually fades to nothing, in the period of time varying between 30 seconds and a minute. Then reception builds up again, as if the switch had been turned on again. The reason for this phenomenon, of course, is due to the filament heater expanding as it becomes hot. If the filament wire is broken, this expansion of the insulating material and cathode separate the two sections of the filament until the cathode begins to cool. At this time, the two parts of the filament are brought together again and reception starts for a short time until the heating again separates the sections of the filament.

"Then there is the type of tube which has a 'bright spot' or a very bright filament. This is usually due to the filament being short-circuited inside of the insulating sleeve so that only part of the filament is heater. Naturally this shortening of the filament length causes it to get very hot and the life of the tube is usually short. Some makes of tubes show this more readily than others, and in some cases it is not possible to note the difference until the filament has finally 'burnt out.'

"Another affliction to which these tubes are subject is the soft, rasping sound varying in intensity (very similar to the noise caused by the arcing across sections of a high-voltage supply but much lower in intensity) and is due to a break in the filament similar to that mentioned above. In some cases, the noise is only heard when the volume is turned very low and meter readings will not show up the extremely small arcing of the sections of the filament. On one occasion, I sat fully forty minutes watching the filament of a '27 type tube after giving every conceivable test. After this period of concentration, I was finally rewarded by noting a tiny flicker of the filament of the '27 corresponding with the intermittent rasping noise issuing from the loud speaker. (By the way, this was a brand new '27, installed that same day to replace another defective tube of the same type.)

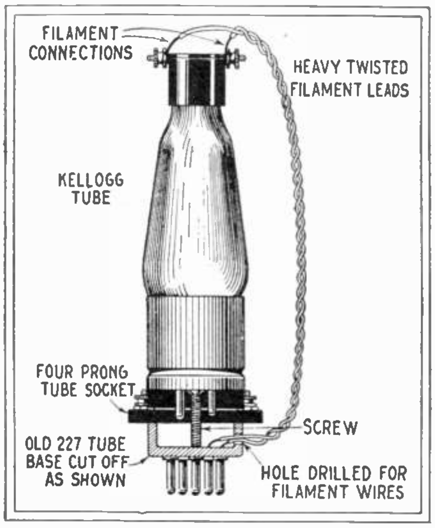


FIG. 1.

"Of course, the latter case was an extreme one and it required considerable length of time to cöordinate the noise with the slight flickering of the filament. Service men will only receive calls for this last-mentioned cause, from critical music-loving fans who are very particular how their sets reproduce. Ninety fans out of one hundred would not notice this, since most of them use too much volume to detect the noise and others do not care, since they expect a certain amount of noise from their sets. Even service men very seldom detect it unless their attention is called to the condition by their customers.

"I could go on for hours relating experiences with filament fracture in its different stages, and the way in which it shows up in different sounds issuing from the loud speaker. One solution to the problem is to install a new tube of the same type, but trouble is usually encountered again after a short time, and I have found a solution to the problems which is very gratifying. This consists of replacing the '27 tube with one of the 'Kellogg' or similar types. Since these tubes have a four-prong base, some alterations have to be made in order to use them.

"I secured an old type '27 tube and removed the glass, leaving only the base. In the side of the base about ¼" from the bottom, I drilled a 3/16" hole and fastened a twisted cable to the two filament prongs after passing it through the hole. This cable provided the means of lighting the filament of the 'Kellogg' tube, as the filament terminals of this tube are at the top. Then I fastened a four-prong socket to the five-prong tube base, as shown in the illustration, by passing a machine screw through the middle of the tube base. Finally, I fastened the grid, plate and cathode terminals on the tube socket to the corresponding terminals on the five-prong base, by soldering short wires between them.

"It is only necessary to plug the four-prong tube into the socket, connect the two wires to the filament terminals of the top of the tube, and place this complete unit in the five-prong socket provided for the detector in the set. As the filament rating of the new tube is three volts, and the voltage supplied to the '27 tube is only 2½ volts, there is a ½ volt safety margin which prevents the new tube from being injured. The tube under these conditions takes slightly longer to heat up, but of course this is an insignificant point when compared to tube injury.

"In some cases, this plug-in arrangement cannot be used, since the set is not sufficiently large and the top of the cabinet will not close. In this case, the base of the Kellogg tube must be removed and the connections made directly to a five-prong tube base. The proceedings are the same in this case, except that the grid, plate and cathode terminals are connected directly to the wires running from the tube instead of to the four-prong socket.

"Because of the long life of these tubes when used with the lower filament voltage, I have been able to increase my business considerably from the boosting I received from the customers using these tubes, and I feel well paid for the time and trouble spent in preparing them. Up to date, every tube has stood the test where others failed."

Mr. Ess's experiences are rather unusual, since the five-prong tube usually stands up very well in a.c. sets. Of course, where the voltage fluctuations are bad, these tubes have a comparatively short life unless a voltage regulator is employed In this case, the use of the a.c. tube with a higher filament voltage characteristic will probably supply a solution to the problem. We also believe that Mr. Ess's explanation for the failure of the tubes, due to the fracture of the filament, is a rather logical one, and we feel sure that other service men have encountered the same problems.

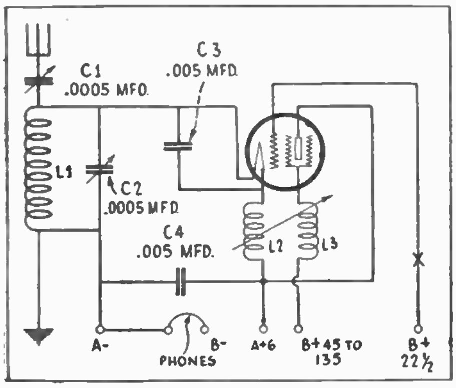
The Radio Constructor's Own Page

Wherein Custom and Home Set Builders and Experimenters All Over the World Swap Experiences and Suggestions About Hookups and Accessories

TURNING THE 222 INPUT-OUT

Editor, RADIO NEWS:

In your October number you stated that you would like to hear from experimenters with the idea of filament input and grid output. I have had very good results, not with the 199s and 201As as described, but with a Cunningham 322. The circuit shown seems to be equal to or better than the standard regenerative set. As for volume, on most



Mr. Hall's single-tube receiver employs a screen-grid stage in unusual fashion.

nights WCSH, WBZ, KDKA, WPG, WBAL, etc., are too loud to be agreeable, with two sets of headphones in series. I can usually separate KDKA and WBZ completely; which, considering their location and power, and my location with respect to them, is all that can be asked and more than one should expect. I am convinced that a non-inductive rheostat and potentiometer control of bias and "B" battery would be of considerable advantage.

The bias on the plate of this tube, here used as the grid, is positive. The voltage on the screen-grid, here used on the plate, may be anything up to 135 volts. The voltage on the inner grid (regular control-grid) may vary from one-third to two-thirds of the plate voltage. There is a best value, but it is in no sense critical.

The voltage of the "A" battery should be from 4 to 6; as it must overcome the resistance of the coils L1 and L2. A voltage slightly less than normal, however, is needed across the filament. Too much current here will cause the set to operate poorly, or not at all.

The rheostat setting is quite critical, and varies slightly when "B" voltages are changed. The phones may be placed as usual between the tickler and "B+," a by-pass condenser making but little difference. Some body capacity may be experienced with phones here; but none will be found when set is properly tuned when they are placed between "B—" and either "A+" or "A—." The phones are now common to both plate and control-grid circuits and this sems to give a little more volume.

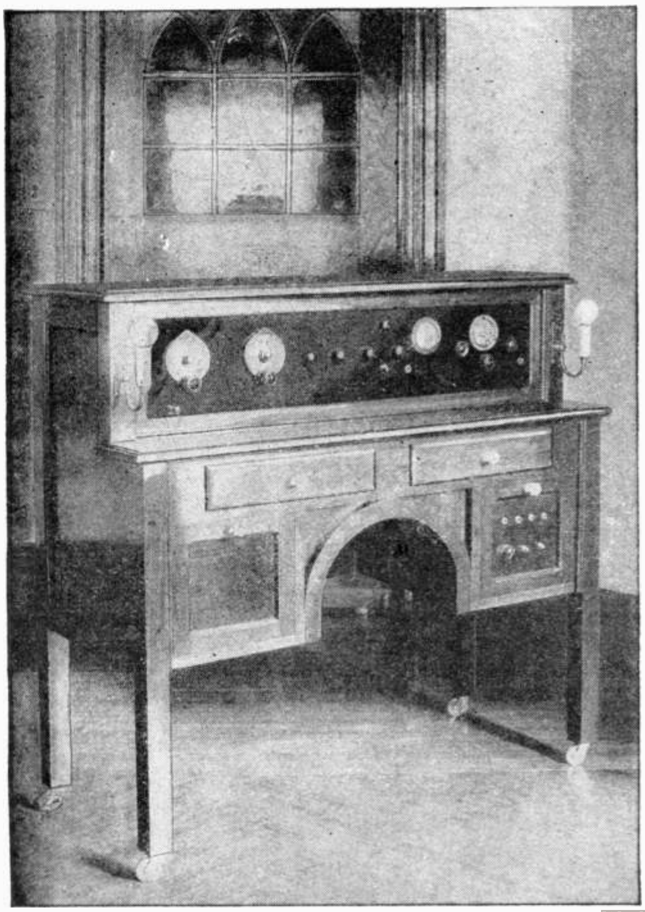
The set is in proper condition when a sound like escaping steam is heard. A loud, but regular beat or note, varying in frequency with the movement of the tickler, may be heard when the set is in this condition.

To tune, set C1 about right, and use C2 and tickler as in any regenerative set. Use any aerial of thirty feet or more.

I use spiderweb coils, 5-inch diameter, 50 turns of No. 22 on each. Coils L1 and L2 may be placed in almost any inductive relation, so long as they do not neutralize each other. L1 and L2 are placed in the same plane edgewise, 8 inches center to center. L2 and L3 are parallel, edge of L2 to center of L3, and variable from ½ to 6 inches apart. The width of the band covered, selectivity and volume will vary considerably with the different positions. A second tickler might be added in the "B+22½" circuit, and in variable inductive relation to L1.

GEORGE F. HALL,
Center Barnstead,
New Hampshire.

(Mr. Hall's circuit is certainly different from anything yet presented. It may be of interest to the constructors who are ready to try anything once. It is presented here purely as a basis for further experiments.



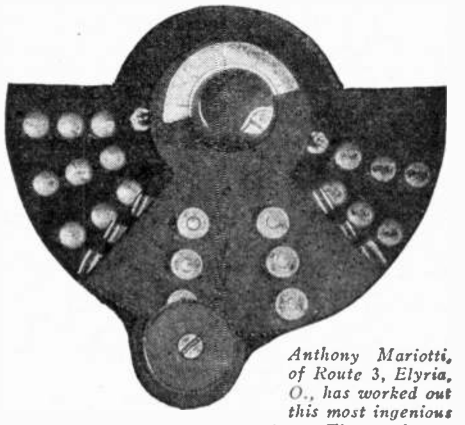
It seems to us that there is an ecclesiastical air about this very substantial piece of radio furniture. Possibly that is because it was constructed for the Rev. J. W. Bittner, pastor of St. John's Lutheran church, Kutztown, Pennsylvania, who used it to house the Strobodyne receiver which he built. It was designed by Mr. Bittner and built of walnut. Mr. Bittner sent in the photo; inquiring the feasibility of using a screen-grid R.F. stage in this receiver. This can be done with the mere change of the R.F. coupler to use a primary giving higher impedance, and the usual choke-coil and by-passing arrangement.

A FANCY HORN

Editor, RADIO NEWS:

With regard to my horn, illustrated by you in the April issue of your magazine, here is some more information.

The diameter doubles at equal intervals of 22 inches. To those who are familiar with the slide



Anthony Mariotti, of Route 3, Elyria, O., has worked out this most ingenious multiple switch for coil changing. The workmanship is very precise.

rule, figures for an exponential horn are easily obtained. Use 602 on scale of equal parts, and divide this figure by the number of inches you wish each interval to be; and then calculate the same as compound interest.

I chose battleship linoleum as a liner, because of its deadness to vibration, thickness, smoothness, flexibility and ease of working. The ribs, of which there are 75, are made of dry sugar pine, cut on a bandsaw and sanded to a hairline. Each rib is made of four pieces glued and screwed together; otherwise it would have taken an 8-inch board to make each rib. They are sawed straight on the outside and follow the exponential curve on the inside, to simplify the making.

Up to where the horn is 12 inches in outside diameter, it is made of solid timber, cut in sections four inches long and turned in a lathe to the dimensions corresponding, with an allowance of .006-inch for the thickness of the paint (ivory enamel). These sections are turned with male and female joints, and then glued together. A long bolt is run through the center of the horn, and then tightened up.

The first interval of 22 inches is made of heavy zinc, .045-inch thick, which has a brass flange on the large end to fasten to the wooden section, and a piece of brass threaded and soldered to the small end to receive the unit. The latter is a Utah De-Luxe which has an 11/16-inch opening.

AL. MORRISON,
81 *So. Sherman St., Denver, Colo.*

(Few readers will have the equipment to attempt duplicating Mr. Morrison's fine work. As for calculating size of an exponential horn, the June 1928 issue of RADIO NEWS *contains rules for determining the diameter of different sections with the aid of simple arithmetic.*—EDITOR.)

GROUNDS VS. AERIALS

Editor, RADIO NEWS:

Radical as the statement may seem, I am forced to the conclusion (and my opinion is confirmed therein by clear, distinct reception night after night of all local stations within a radius of twenty miles) that the aerial is superfluous and is only, in fact, a poor ground.

In the room in which I operate I have two pipes making ground connections; one a gas pipe and the other a water-supply line, both ¾-inch. By simply connecting the set terminals with these two pipes, better reproduction is obtained than when the aerial is used. I mean just that; when the aerial is cut in there is a material drop in volume. It would appear, therefore, that the real transmission of radio waves is through the ground and such as are picked up on aerials are merely

(*Continued on page* 87)

"The Beginner's Three"—A Good Little Receiver

THE set described here was designed especially for those readers who are as yet not well versed in the art of set construction, who are using either a crystal receiver, a small one- or two-tube set, or no set at all. There are, we know, a great number of crystal and one-tube sets being used at present, despite the reductions in the price of larger apparatus and the great number of inexpensive larger receivers that have been described in radio magazines and newspapers. Many beginners believe that the construction of a larger set would be beyond their scope, but it will be found (by those who try) that the construction of a good, if simple, receiver is quite easy.

This "Beginner's Three" has been designed with several points in view. In the first place, the cost of the parts is an important consideration; for most beginners are rather skeptical about spending very much as they are not sure that the set will work properly. This hesitancy can be overcome by careful choice in the matter of the circuit and the apparatus. It is for this reason that some of the parts used in this receiver are somewhat old in their appearance.

Another question, equally important with the cost, is that of the efficiency of the receiver; and for this reason, in the vital parts of this set, the best available apparatus is used. Such parts as the new-style dials, while they add much to the appearance of the receiver, have very little effect on its actual operation; and those of the older style, which can be obtained quite cheaply from your local dealer, are quite suitable for our purpose. Should the constructor desire to "dress up" the little set later on, he may readily do so. Many readers who would be interested in building a set of this type, will have some parts already in their "junk-box" and, of course, these will help to keep the cost at a minimum.

WHILE the set described is not complicated, this is not to say that it is inefficient. This receiver is capable of distance, using the tubes specified here; it will do good work even with general-purpose tubes. For loud-speaker operation, however, except on locals, the addition of another stage of audio is recommended; and this will be described in another article. In the meantime, the builder of this receiver will find that he has invested his money and time well.

SIMPLE AND COMPACT

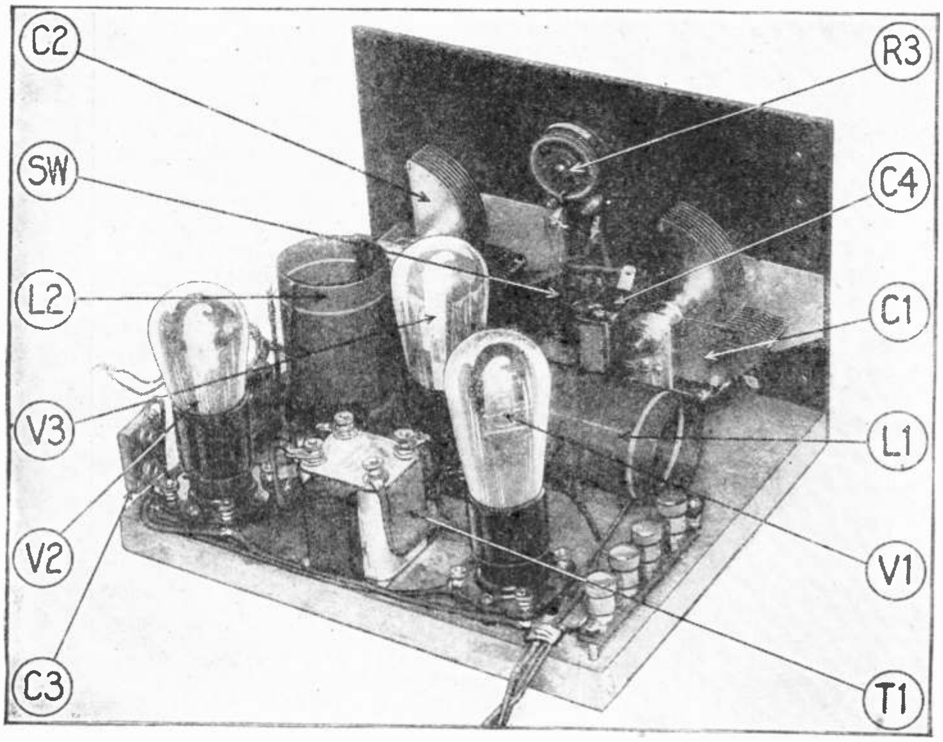
The "Beginner's Three" contains one stage of radio-frequency amplification, a regenerative detector and one stage of audio-frequency amplification. In locations where one or more broadcast stations are within a few miles, loud-speaker volume can be obtained; although the receiver was not designed with this point primarily in mind. It cannot, of course, be recommended in a congested district with many locals operating at once.

A combination "B" power unit and amplifier will be described in a forthcoming issue, which will supply plate current for all the tubes, as well as increase the volume so that loud-speaker results can be obtained. By designing the receiver in this way, it will be more attractive to constructors, who would not otherwise attempt to build it. until more certain of its possibilities. Also, the sectional construction will be more suitable to the beginner; who will gain experience by building the three-tube set first. After it has been made and is operating properly, the fan will be more confident as well as, perhaps, better prepared financially.

The first thing to do, when building any receiver, is to collect all the necessary parts. The apparatus used in the original set is as follows:

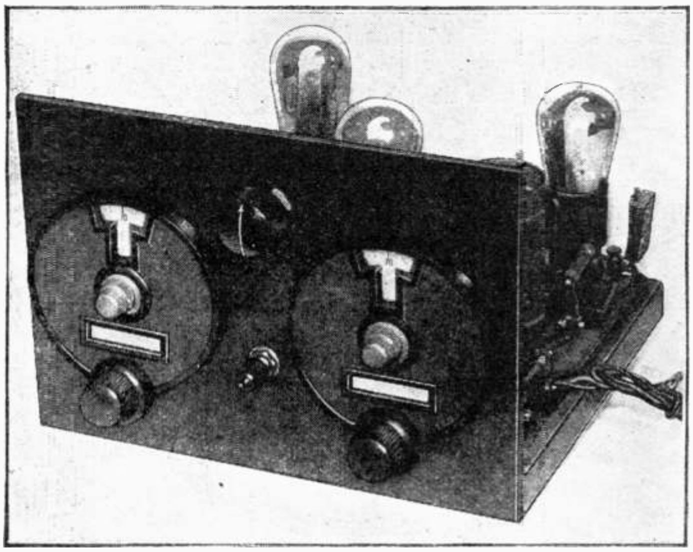
LIST OF PARTS

One length of Hammarlund two-inch (diameter) inductance strip, 6¼ inches (L1, L2);
Two Hammarlund variable condensers, .0005-mf. with panel shields (C1, C2);
Three Pilot UX tube sockets, baseboard type;
One Thordarson audio-frequency transformer, 6:1 ratio (T1);
One Electrad "Phasatrol" (PH);
One Cunningham 301A tube (V1);
One Cunningham 300A tube (V2);
One Cunningham 112A tube (V3);
One Electrad "Royalty" variable resistor, 0-500,000-ohm (R3);
Two Silver-Marshall (old-style) vernier dials (a later model may be used, if the constructor desires to improve the appearance of the set);
One Aero "Type 60" radio-frequency choke (L3);
One Lynch "Equalizer" and mounting, "Type 4/3" (R1);
One Electrad by-pass condenser, 0.5-mf. (C4);



The view of the "Beginner's Three" above shows how snugly it may be put together; a very small cabinet may be improvised. The radio-frequency leads are as short as possible; note the coils are at right angles.

One Aerovox .002-mf. fixed condenser (C3);
One Electrad filament switch (SW);
One Insuline bakelite panel, 7 inches high, 10 inches wide;
Four X-L binding posts;
One roll Cornish "Braidite" hook-up wire;
One baseboard 10 inches long, 8¾ inches wide and 1 inch thick;
Screws, angles, washers and several strips of bakelite for coil mounting and for the binding posts.



The dials used here are out of fashion, but highly efficient. The builder may use a later model to suit his taste.

The inductance strip mentioned is space-wound on a thin celluloid support and is a very convenient article for the experimenter. This method of construction gives very low self-capacity and dielectric losses; while it is very substantial, as the celluloid holds the wire firmly and is easily attached to a mounting bracket. The two-inch size is now favored over larger tubing formerly used.

The coils are made by taking the strip of inductance winding and measuring 2¾ inches from one end. A sharp knife run through the thin insulating form, will separate the two coils at this point. The wire joining the two coils should then be cut. The next point is to count 17 turns from the end of the 2¾-inch coil, and cut the wire at this point, with a sharp instrument. If a pair of cutting pliers is not available, an old pair of scissors will be satisfactory. The wire is then loosened from the form, a turn and a half on each side. This leaves a space equal to three turns from the two sections of the aerial coupler and supplies two windings, one of 15 turns and the other 86 turns.

The other coil is then prepared in the same way, except that a space of five turns is left between the primary and secondary. This is done by counting 18 turns and removing 2½ turns from each side of the cut. On the farther side of the coil, 86 turns should be counted and at two turns further the wire should be cut. Here also, the wire should be removed from the insulating form; in this case, 1½ turns are loosened on each side, leaving a space of 3 turns between. The end of the coil, which is the tickler, should give 20 turns. If the remainder of coil is longer than the space covered by these turns, the extra wire should be loosened from the insulating film and a sharp knife should be used to trim down the extra insulation.

Those who desire to make their own coils, rather than use the prepared tubing made by the Hammarlund Company, may use 2-inch forms. The secondary of each coupler contains 86 turns of No. 28 S.S.C. wire. The turns should be space-wound, by placing a piece of silk sewing-thread beside the wire. The primary of each coupler contains 15 turns and the tickler (on the detector coupler) 20 turns.

Some fans may have on hand smaller condensers such as .00035-mf. and, in this case, the outlay for the set will be reduced by using them. The same size of Hammarlund coil strip may be used as for the coils described above; but in this case, the secondaries should be arranged so that 115 turns are left for each of these coils. The use of these smaller condensers will make the coils longer and a longer piece (7¾ inches) of the coil strip must be obtained.

If difficulty is encountered in purchasing this prepared inductance strip locally, it may be obtained directly from the manufacturer. While the manufacturer does not ordinarily sell this inductance strip directly to set builders, a concession has been made in this case; so that it may be obtained by those who desire to build the receiver, if it is not available from a dealer.

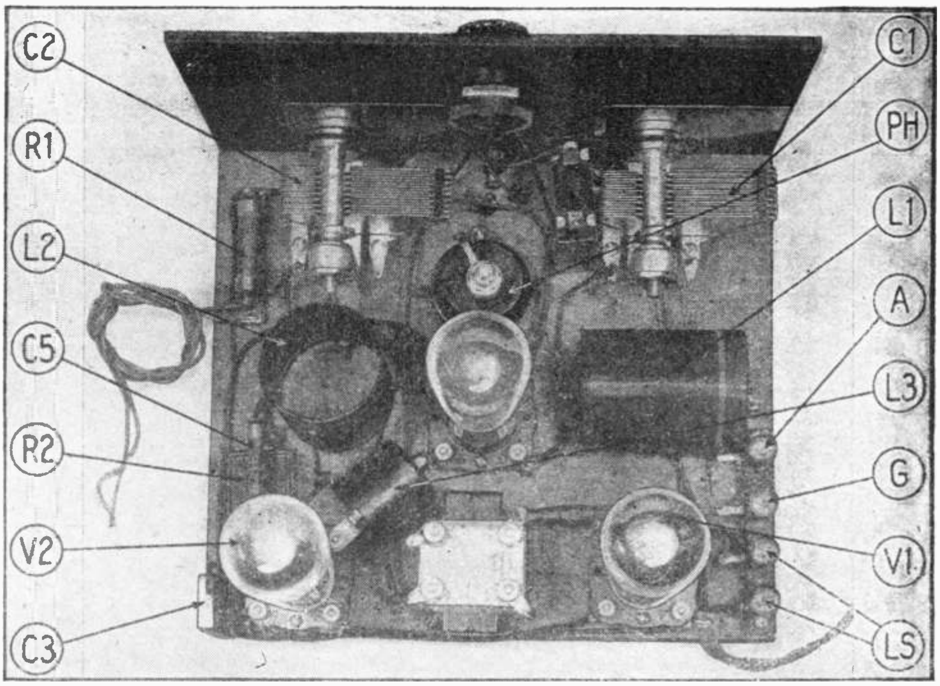
MOUNTING THE COILS

After the coils have been arranged, the next point is to mount them. The strips for mounting the coils are cut from bakelite, hard-rubber or fiber panels. They are each 3½ inches long, ½ inch wide and ¼-inch thick. That for the aerial coupler (the one with two coils) has a hole drilled in each end to hold the mounting screws. The other is drilled at one end only. While the strips for the coils are being made, it may be well to make the binding-post strip also. This strip is also cut from ¼-inch panel material, and is 3½ inches long by ½-inch wide; in this, however, six holes are drilled. The two at the ends are for the mounting screws; four others are then evenly spaced over the remaining space, for the aerial, ground and two phone binding posts.

After the strips have been prepared, they should be cemented to the coils. Collodion (or liquid court plaster, as it is sometimes called) is a very convenient material for this purpose. It can be obtained from the corner drug store in a small bottle and should not cost more than 25 cents.

When the cement has dried, the coils are ready for mounting on the baseboard. It may be well to explain how this is done, even though we are not quite ready for asembling all the parts. The antenna coil is secured to the wooden base by two long wood-screws, passed through the holes in the coil mounting strips, and through a suitable washer which raises the coil above the base. The washer may be made from a piece of metal tubing; or any other suitable method which suggests itself to the reader may be used. In the original set, two old binding posts of the metal type used several years ago (those with a screw in the top and a hole in the side for the wire to pass through) were drilled out so that the wood-screw would pass through.

The detector coupling coil (the one with the three windings) is mounted by a small



The layout of parts in the "Beginner's Three" is shown so well above that a diagram is hardly needed but the wiring may be traced with the aid of Fig. 2. The leads at the right are for the "B" and "C"; those at the left for the "A." The arrangement is convenient.

angle-piece which is screwed to the coil strip and is secured to the baseboard with a small wood-screw. A 6-32 machine-screw and nut are used to fasten the coil strip to the angle, which is one of the small brass brackets found in the local 5-an-10-cent store.

OTHER ASSEMBLY

After the coils have been prepared, the next point is to drill the panel for the tuning condensers, oscillation-control resistor R3, and the filament switch. The templates supplied with the condensers will provide the most convenient way of laying out the holes for these instruments. The resistor and switch are centered between the two condensers, as shown in the illustrations. If the specified type of condensers is used, the panel shields should be placed between each condenser and the panel; so that the possibility of the set being effected by hand-capacity will be kept at a minimum.

The pictorial layout (Fig. 2) shows the positions of the other parts of the set. The coils are placed at right angles to each other, so that there will be the minimum of interaction between them. They are also so located that the wiring between the grid end of the coil and its condenser and tube-socket terminal is as short as possible. The radio-frequency choke, which is equipped with a machine screw for sub-panel mounting, is fastened to a small brass angle; which is in turn fastened as shown, to the plate (P) terminal of the detector tube socket. This is done for convenience only, as the mounting bracket is not connected in any way to the terminals of the choke.

The "Phasatrol" stabilizes the radio-frequency amplifier, and the resistor R3 is used to control the detector as mentioned before. The latter resistor is shunted by an 0.5-mf. by-pass condenser which serves to carry the audio-frequency currents in the primary circuit of the transformer, so that they will not have to pass through the high resistance. In order to make the set as low in cost as possible, a cable has been improvised from the hook-up wire. This reduces the cost of the cable and still permits the convenience of the cable leads; though a manufactured cable, the cost of which is low, will enhance the convenience of connecting and disconnecting the battery.

The set is wired with the convenient "Braidite" insulated hook-up wire. Point-to-point wiring is used, so that the leads will be as short as possible, and also to keep them from running parallel. The wires

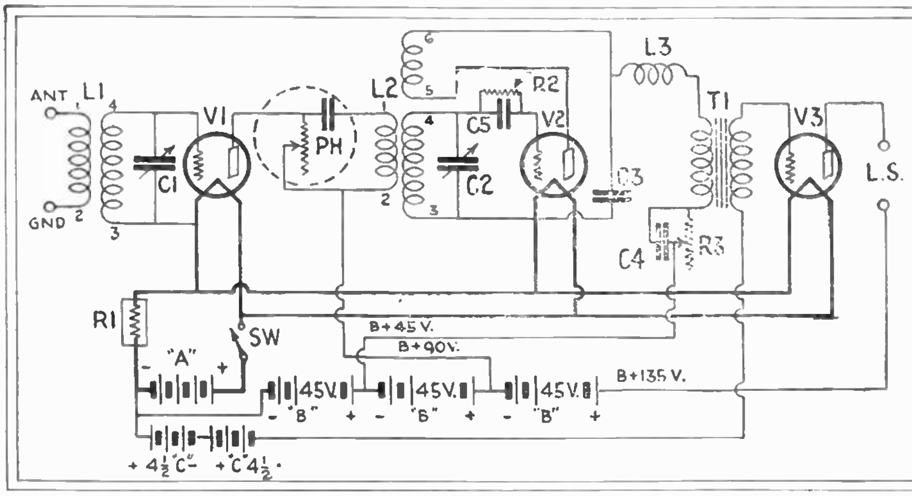


Fig. 1

The "Beginner's Three" is shown here with all the connections to the batteries, for the convenience of the beginner. An experienced friend should check a beginner's work, however.

which connect to the batteries are arranged with an excess length of several feet, and are brought together at the back of the baseboard. These wires are used as a cable, and they may be braided together if desired. A staple, driven into the base, will serve to keep the wires of the cable together.

CHOICE OF TUBES

The tubes used in the set were chosen to give the best and most stable results. The standard 301A-tube is used as the radio-frequency amplifier; this stage serves the triple purpose of increasing the volume, the sensitivity and the selectivity of the receiver, while preventing the oscillation in the detector stage from causing interference in neighboring sets.

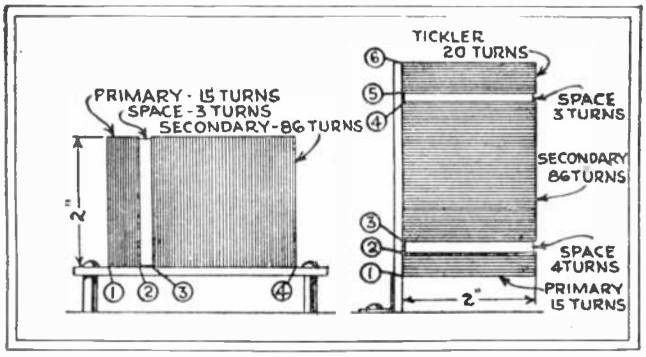
The second tube is of the special-detector, high-amplification type; since this tube is far more sensitive than the 301A type, when properly used. It will be noted that the grid return of the detector is connected to *the negative side* of the filament, contrary to the usual procedure. Since this might cause confusion in the minds of some of our readers, it is well to mention that this is done solely because of the special type of tube used in this socket. If the regular 301A tube is used in this socket, the grid return should be connected to the positive side of the tube filament.

The tube in the audio-frequency stage is a 312A semi-power tube. This was chosen because of the better quality resulting from its use. This is especially true if a second audio stage is to be employed and, since we are building the set with the thought in mind that a power amplifier and "B" power unit may be built later to give good loud-speaker volume, we have incorporated the 312A in the original set.

TESTING AND OPERATION

After the set has been completed, the next point is to test the wiring to be sure that no mistakes have been made. This is done by connecting a "C" battery and a pair of headphones in series and applying this test unit across the various cable connections in turn. With the tubes out of the sockets, no click should be heard between any of the wires; either in the filament line or the wires to the plate supply. If no clicks are heard, the batteries are connected as shown in the schematic diagram (Fig. 1) and the tubes then inserted in the sockets. The headphones should be connected to the terminals marked "L.S."; and the aerial and ground connected to the other two terminals on the binding-post strip. The set is then ready for operation, and the filament switch may be closed.

It is not important which side of the primary coil is connected to the aerial and which to the ground. In some cases, however, the operation of the receiver may be improved by connecting the "—" (negative) side of the "A" battery to ground. If



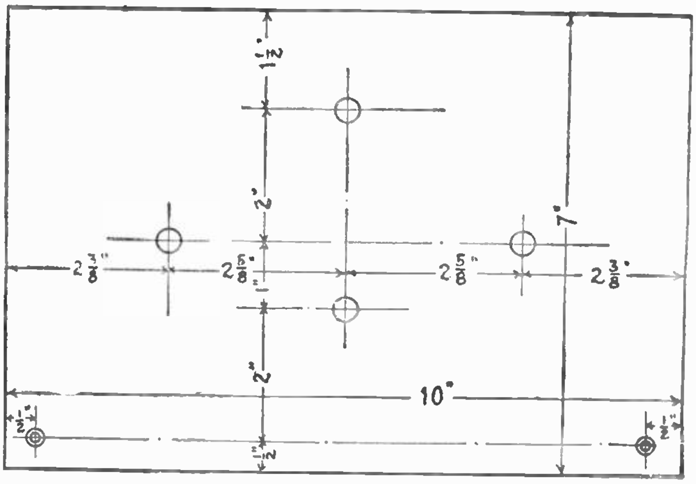


Fig. 3 (above) **Fig. 4** (right)

The details of the two coils used are shown above, with the terminals indicated, as in Fig. 1, to avoid error. The loosened wire is suitable for connections. At the right, locations of the six panel holes needed.

Stations WRNY and W2XAL to Serve Aviation Interests

IN the reorganization of the Experimenter Publications, the twin radio stations WRNY and W2XAL, which they have maintained and which are familiar to thousands of our readers, have been sold to the Curtiss Aeroplane and Motor Company. They will be used, in addition to their other functions, to further the growth of aviation and the service of radio to that important utility—a purpose with which it need hardly be said, RADIO NEWS *is heartily in sympathy.*

"WRNY," stated President Clement M. Keys of the Curtiss Co., "will continue to be a regular commercial station, although it will endeavor to feature aviation activities. As W2-XAL is excellently adapted to better the flying services in this part of the country, it is planned through this station to make available at all the fields of the Curtiss Flying Service, throughout the nation, immediate information concerning weather forecasts and other vital facts to fliers; so that any one flying toward New York from any direction can stop at any Curtiss field and obtain definite information as to the conditions which will be encountered on the way. The forecasts will be inclusive of conditions in New York, Philadelphia, Chicago, St. Louis and other important flying centres. The service will, of course, involve the use of telegraph lines in addition to the radio."

this is found to effect an improvement, the wire may be incorporated directly in the receiver itself; it is then important to have the ground connected to the correct terminal. The additional wire is merely connected between the negative filament "F—" terminal, of the first or radio-frequency tube, and the "Ground" binding post.

It will be found that the set will whistle when the resistor knob of R3, on the panel, is turned too far to the right. While tuning the set, the resistor should be turned back until the whistle stops, and the dials should be turned again. If a soft whistle is heard, the "Phasatrol" is turned too far, and its screw should be turned to the left until the whistle stops. When the "Phasatrol" is adjusted and the resistor is turned to the correct position, no whistles will be heard (except those caused by other sets in the neighborhood, which unfortunately, may be heard in any set). When the set is first placed in operation, it is advisable to turn the screw of the "Phasatrol" all the way to the right; so that trouble will not be encountered in picking up signals until the receiver is adjusted properly.

If the amplifier and "B" power unit is to be built later, it is more economical to buy very small "B" and "C" batteries, so that the cost of the set can be kept low. The filaments of the tubes are lit by a storage battery of the usual type, and a good one should be obtained, since it will be used with the complete set. If it is desired to operate the set entirely from the electric-light lines, an "A" power unit may be purchased instead of the battery.

A FEW POINTERS

Every receiver, however simple, has a number of points at which trouble may be encountered; and those not familiar with "trouble-shooting" might find them difficult to locate, if the set does not work right at first. The first thing to suspect is the tubes; take them to the dealer from whom you purchased them and have them tested. If the tubes are all in satisfactory condition, look over the aerial. This is a very critical point; especially if the aerial was erected some time before the set is built. The insulators should be checked, and the lead-in should be looked over very carefully. A poor contact in the wire, or poor insulation at the point where the lead-in enters the building, often causes a good set to operate poorly.

If the testing of the tubes and the inspection of the aerial and ground are satisfactory, the batteries should be tested with a voltmeter. Again test all the wires and connetions with the "C" battery and phones mentioned above, to be sure that they are all tight. In this test, with the phone and battery, a coil should give a loud click through the winding and none between windings (this is between primary and secondary). An audio transformer gives a weak click in both the primary and secondary

(*Continued on page* 85)

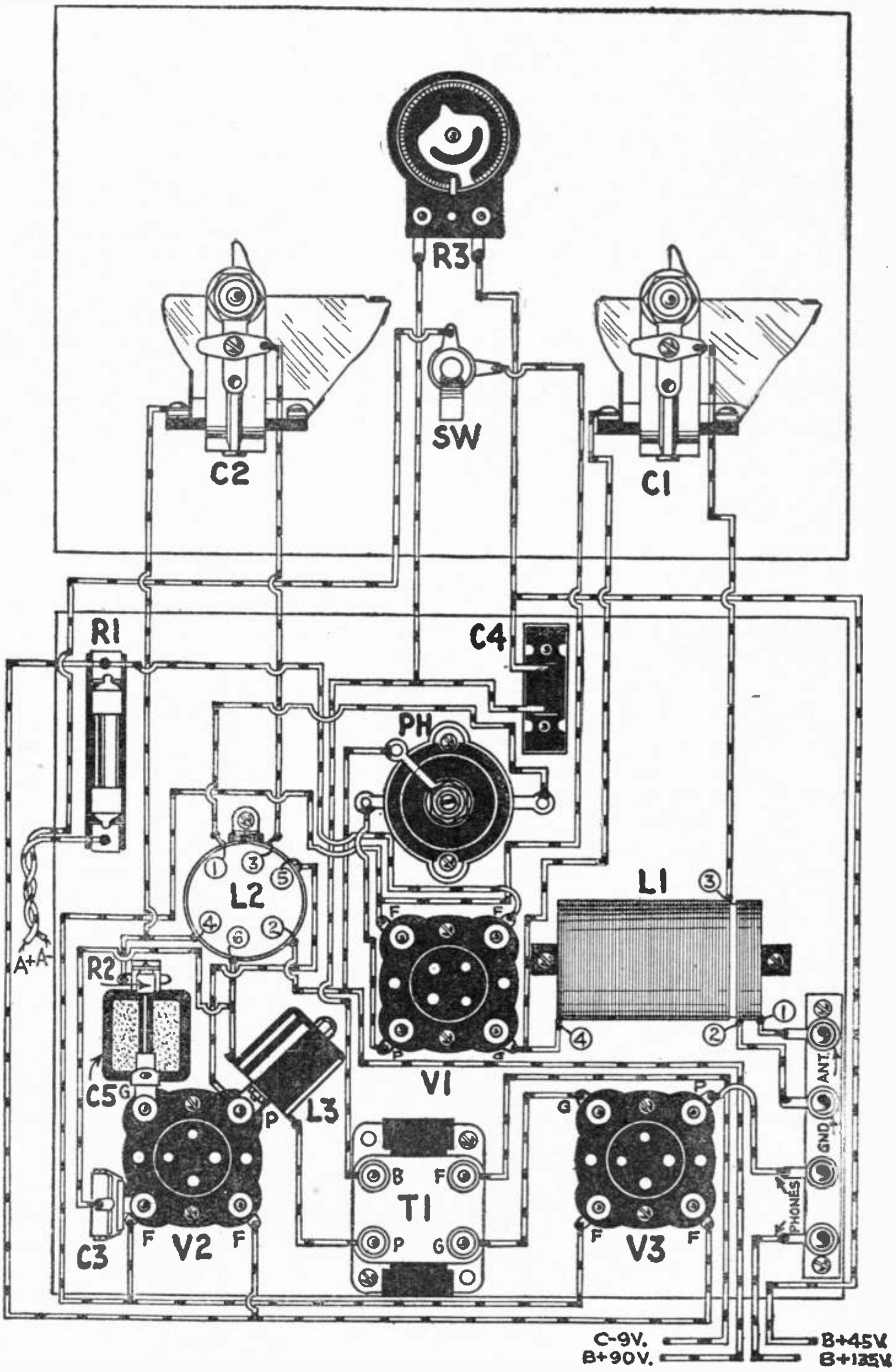
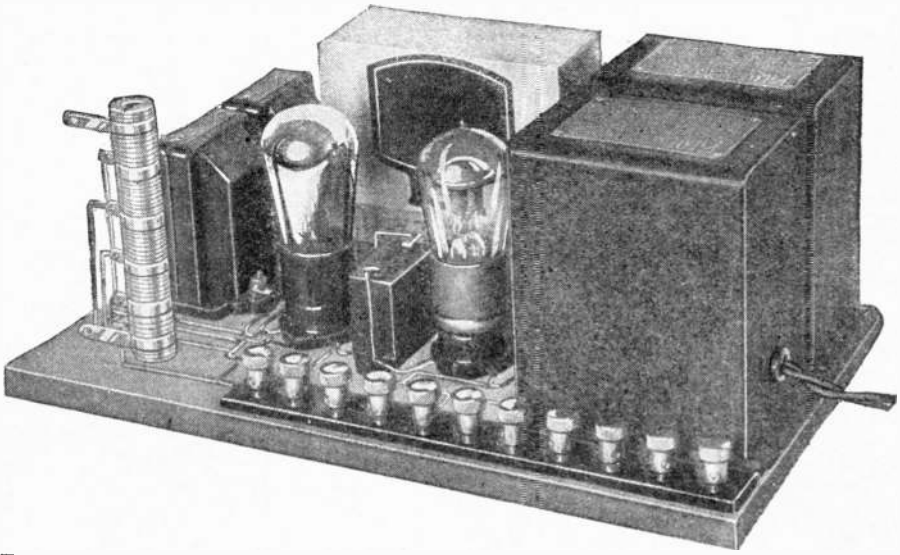


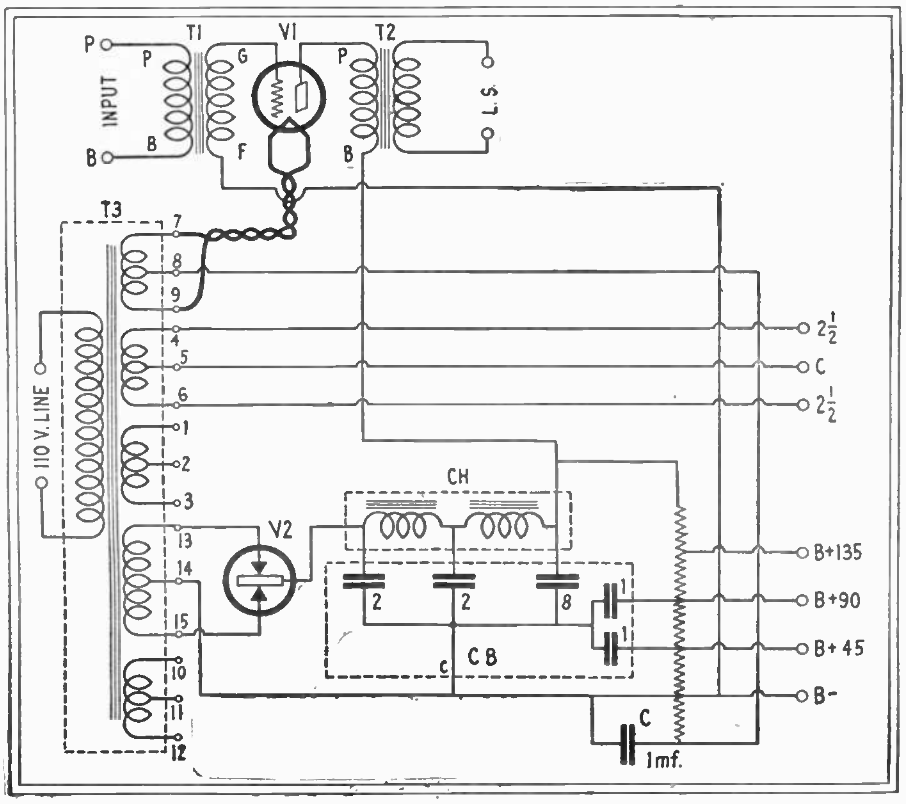
Fig. 2

The wiring and parts layout of the "Beginner's Three" is shown here very plainly; the wires are here indicated at right angles, for the sake of clearness, but in actual work they are run more directly between terminals, as the photographs show. The numbers of the coil terminals should be observed closely when making connections,

An Amplifier-Power Supply for the "Beginner's Three" Receiver



The completed combination amplifier-power supply unit. It should be compared with the layout of parts on page 64



The circuit connections for the amplifier-power supply unit illustrated above are given here

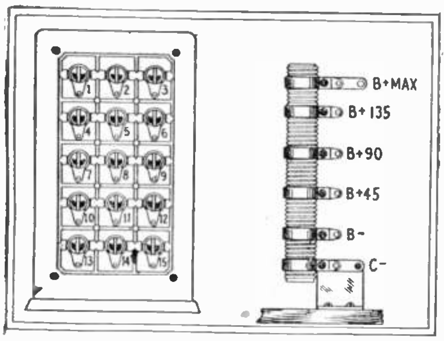
IN the description of the "Beginner's Three" receiver last month, we promised to publish the constructional details of a "B" power unit and an extra audio amplifier in order to make the set suitable for loud speaker operation. The original three-tube receiver will give loud speaker volume only when powerful signals from "locals" are being received. However, when we are trying to pick up stations some distance away, it is necessary to use headphones unless extra amplification is employed.

Herewith we publish the details for making this combined "B" power unit and power amplifier. The unit has been designed in the same way as the original three-tube receiver; to be as simple as possible and to be as economical in the selection of parts necessary without sacrificing tone quality. The apparatus chosen for this set was picked out because it supplies all the conditions required in the matter of simplicity, economy and quality.

The power transformer is made with a number of low-voltage windings in order to supply current for a.c. tubes of different types as well as to supply the high voltage necessary for the "B" section. The double choke-coil unit is of the same manufacture as the transformer and is designed to operate in conjunction with this power transformer. The condenser block has a sufficiently high working voltage so that no trouble will be encountered from breakdown. The voltage divider has a number of output taps which are used to supply the required "B" voltage to the three tubes of the original receiver.

While this power pack is designed particularly for use with the "Beginner's Three" it is equally applicable to any set which requires voltages up to 180 and a power amplifier of the 171 type.

We mentioned in the previous article that a storage battery could be purchased for the filament supply of the first three tubes, since this filament supply can be permanent. There are still a great number of people who prefer using batteries to "A" power units or a.c. tubes, but there are still many who feel that the convenience of the electric tubes compensates for any slight difficulty which might be encountered from hum, etc. Since our power transformer has a number of filament windings, we can use these windings for the filament supply for the three-tube receiver by making several changes in its construction. We will describe later how these changes can be made so that the '27 type tubes can be employed. When using the a.c. tubes, the "C" bias for the first audio tube can be obtained through the voltage drop in a resistor connected in the plate return. When the storage battery is used for the filament supply, it is more satisfactory to leave the "C" battery connected.



WHEN MAKING CONNECTIONS TO THE POWER TRANSFORMER AND VOLTAGE DIVIDER RESISTANCE THE NUMBERED TERMINALS AS SHOWN ABOVE SHOULD BE COMPARED WITH THE NUMBERED LEADS SHOWN ON THE LAYOUT ON THE PRECEDING PAGE

negative end of the circuit. The first three sections of this condenser block are connected, as shown, to the double filter choke and the whole constitutes the filter circuit. The other two sections, which have a capacity of 1 mfd. each, are used for by-passing two of the output taps from the voltage divider. Since a third 1 mfd. condenser is needed for by-passing the "C" bias section of the divider, a separate condenser, C, is used.

Operating the Unit

After the wiring has been completed, it should be checked very carefully to make sure that there are no errors. After it is proved that the wiring is all correct, the unit can be connected to the a.c. line, the while watching the tubes carefully. The filament of the 171 tube should light and a slight purplish haze may appear in the Raytheon tube. After the unit has been in operation for several minutes, the Raytheon tube will get quite hot; this is quite normal and should not cause any worry.

The B battery cable leads from the receiver itself can be connected directly to the binding post strip of the power pack after the operation of this unit has been checked. The negative terminal of the storage battery should be connected to the negative "B" battery terminal and the three "B" plus terminals should be connected directly to the wires running from the set. These terminals are "B" plus 45, B plus 90 and B plus 135. They should be connected to the corresponding terminals on the terminal strip of the power unit.

As mentioned above, when the storage battery is used for lighting the filaments of the three tubes in the set, a 9 volt "C" battery should be used to supply a grid bias to the first audio frequency tube. Since practically no current is drawn from this battery, it will last for a considerable length of time. The positive terminal of this "C" battery should be connected to the negative filament, as mentioned in the previous article.

The two terminals on the power-amplifier labeled "input" (B plus and P) are connected to the output of the three-tube receiver, with the P terminal connected directly to the plate of tube V3 and the B plus terminal connected to B plus 135. There are only two terminals remaining on the binding post strip which as yet have not been considered. These terminals are marked "output" and they are used for the connections to the loudspeaker. The set is now ready for operation unless the "A" battery is to be dispensed with.

Converting the Set for Alternating Current

A number of changes must be made in the grid leads and filament wiring in the set in order to convert it for operation with the '27 tubes. In the first place, 5 prong sockets are necessary and the standard 4 prong tube sockets must be removed and be replaced with the former ones. All of the filament wiring must be taken out of the set, and a twisted cable should be used for connecting the filaments together and to the 2½ volt filament terminals on the power unit.

Since we cannot connect the grid return of the radio frequency amplifier tube to one side of the filament, as in the case of a battery-operated set (this would cause a very annoying hum and the amplifier would not work properly), a negative bias must be supplied to the tube in some other manner. This is done, as will be noticed, by connecting the grid return of this tube directly to the negative "B" battery wiring and placing a resistor of 1,800 ohms, R4, in the lead from the cathode to the negative B battery wiring. This biasing resistor is shunted by a 1 mfd. condenser so that the resistor will not interfere with the operation of the set. The "C" bias for the first audio frequency tube is obtained in the same way and resistor R5 having the same value as R4 is connected in the cathode lead.

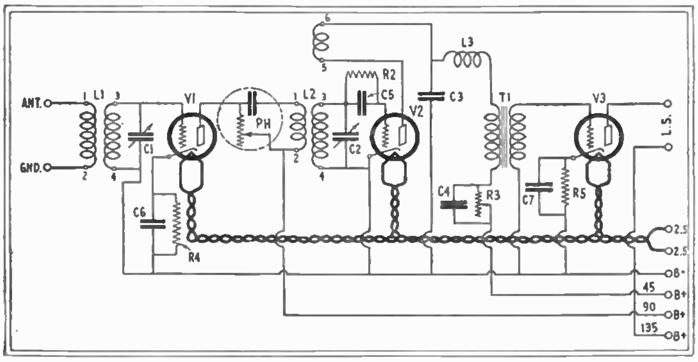
The grid return of the detector tube is connected directly to the cathode, and the by-pass condenser C3 in the plate circuit of the detector is also connected to this point.

The use of alternating current for the filament supply often necessitates the removal of the battery switch, SW, since this switch will not carry 110 volts from the power supply line. If the power pack is used only with the three-tube receiver, a switch may be incorporated on the panel of the set which will carry the 110 volts and in this way both the set and power unit. The terminal marked "C," turning the switch on the panel of the set. However, if the power unit is used for operating any other set, this is not a very convenient way of turning it on and off. In this case it is better to use two separate switches, or to leave out the switch on the set itself.

The twisted leads from the filament terminals of the three-tube sockets are connected directly to the two filament terminals on the terminal strip of the power unit. The terminal marked "C," which is the center point of the filament winding, is connected to ground in order to make the set as quiet as possible in operation. The two terminals marked 2½V are connected to the twisted wires from the filament circuit of the set. When using the five-prong sockets for the '27 tubes, the positions of the grid and plate wires are changed slightly, but this point should cause no trouble since they are plainly marked on the tube sockets.

After the power unit has been tested successfully, a metal box may be made to fit over the top, and may be screwed to the sides of the wooden baseboard. This metal box, which may be made of sheet iron or other suitable metal, should be connected to ground and will prevent any interaction from taking place between the set and power unit. It will also serve as a protection of the apparatus in the power unit and will keep dust from collecting in it. None of the parts in the unit will get hot except the BH rectifier tube and because of this, no ventilation is required. The heating of this tube is quite normal and will not affect its operation in any way.

IF IT IS DESIRED TO REWIRE THE BEGINNER'S THREE RECEIVER FOR A.C. OPERATION, THE CIRCUIT SHOWN HERE SHOULD BE EMPLOYED



Trouble-Shooting

As mentioned in the original article, every receiver or piece of radio apparatus, however simple, is subject to breakdown or injury. These defects may not be very apparent and in some cases it is very difficult to locate them, although they have a great effect on the operation of the apparatus. The first thing to suspect, when the set or power unit does not work properly, is the tubes. Although vacuum tubes have been brought to a high degree of perfection, they are still delicate instruments and are easily injured.

The first thing to do, then, if the set does not operate properly is to have all of the tubes tested. Next, suspect all of the wiring in the set and check it over, expecting to find some mistake or defect. If the wiring and tubes are all in good

(*Continued on page* 88)

The "RE 29" Receiver

The Last and Most Sensitive Model Developed by the Inventor of this Efficient System

By R. E. Lacault

The late ROBERT E. LACAULT

WHEN I placed my hand near the antenna binding post of the "R E 29" that I had just completed, there was enough field strength to produce signals from every local station in New York City, proving that the new circuit was amazingly sensitive. And it is in the direction of sensitivity that circuit designers are working, especially when a man is asked to build a set himself; for the inducement is that he shall possess a receiver that will "run rings around" others.

I have bent my energies toward the production of a receiver design that will not only prove dependable and practical, even for the novice, but one that will respond to the faintest impulse that could be expected to produce a signal. More than that, I have endeavored to provide every item of efficiency necessary to exceed even the occasionally unreasonable demands of set builders; and I believe I have succeeded. Never have I tuned a set more sensitive, more satisfactory than the "R E 29."

The circuit is in two parts: the radio amplifier, detectors and first audio, which constitute six tubes, and the push-pull power amplifier and B supply, using two 210 tubes as output and two 281 tubes as rectifiers. Thus the total receiver has eight tubes and the "B" supply two tubes. In this article I will confine myself to the receiver and with one audio stage, built into a table-model cabinet; while the construction of the power amplifier and "B" supply will be discussed separately.

Screen-grid tubes are used in the modulator and the two intermediate stages of the receiver (for they are, when properly used, the most sensitive tubes extant) an all-sufficient selectivity is attained through proper coil design.

R. E. LACAULT, well known to all readers of RADIO NEWS *as one of the world's foremost authorities on superheterodynes, was—most unfortunately—to survive but a few days the completion of the receiver described here, which he regarded as his masterpiece, and to which he had devoted his failing strength, but still brilliant genius. The circuit used has enthusiasts throughout the world who regard it as unsurpassed; they will welcome this receiver as one which adds to the sound design and fundamental efficiency of former models the amplification properties of the screen-grid tubes which give it where possible even greater range and efficiency.*

EFFICIENT OPERATION

The modulation system is that which I invented, and which is used now for the first time in conjunction with a screen-grid tube. Although the modulator tube is used in three-element fashion (by joining together the plate and screen-grid) there results a lower plate impedance and improved detecting efficiency. Thus, a sensitivity is developed exceeding that of the leak-condenser method; for negative grid-bias detection is used in the "R E 29." Better selectivity and improved tone also result from

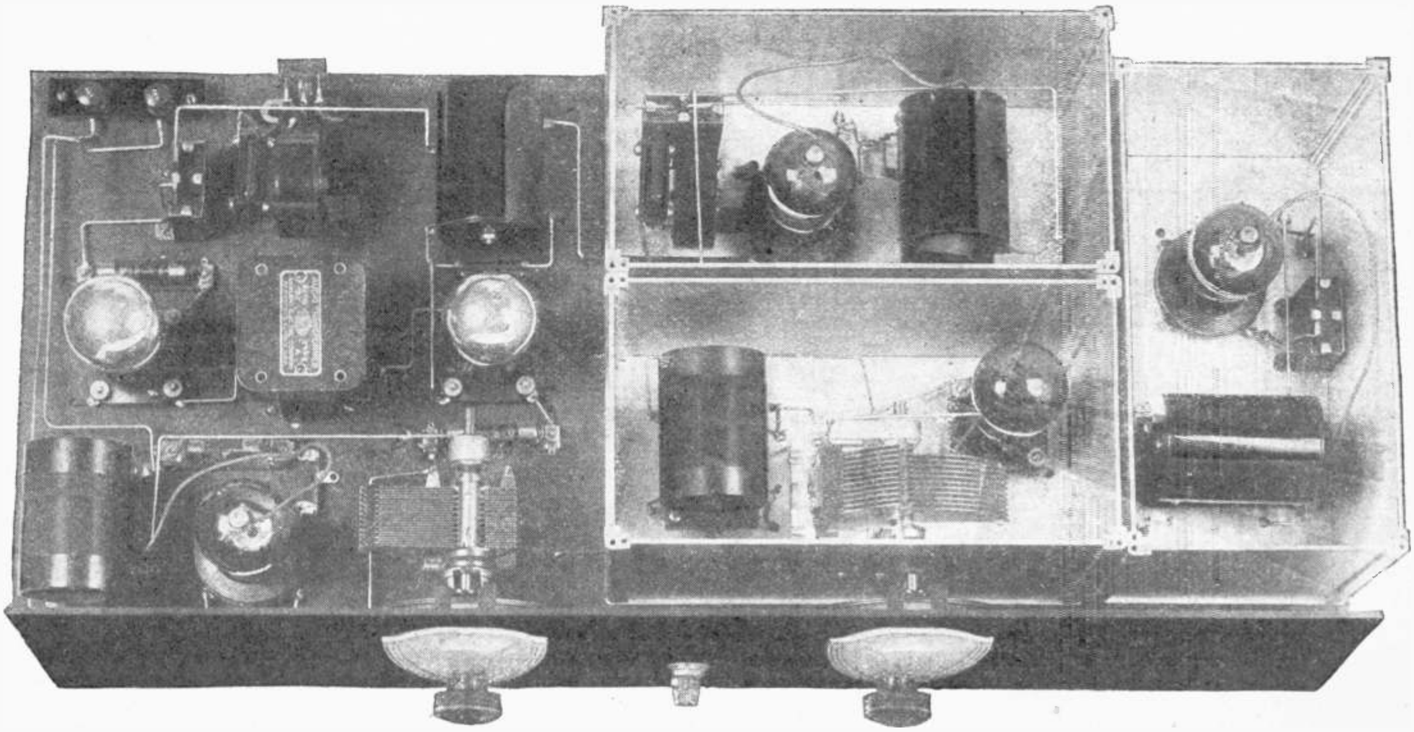


Fig. A

Viewed from above, with the tops only of its shields removed, it may be seen how the new "RE 29" combines effective placement with ample room, required for efficient working of a receiver which is to give enormous amplification of which screen-grid tubes are capable.

grid bias detection. The bias, 2.7 volts, is equal to the drop in R1.

No direct plate current is used on the modulator. This is no novelty to those who have built previous receivers of my design; since the efficiency of the special modulator circuit is abundantly attested by the great distance-getting records established by receivers using this system.

While there is no *polarizing* voltage on this "plate" (the combination obtained by connecting "G" post and "P" post in V1), there is a high *alternating* voltage; which frequently rises to many times what would be the polarizing voltage in another circuit.

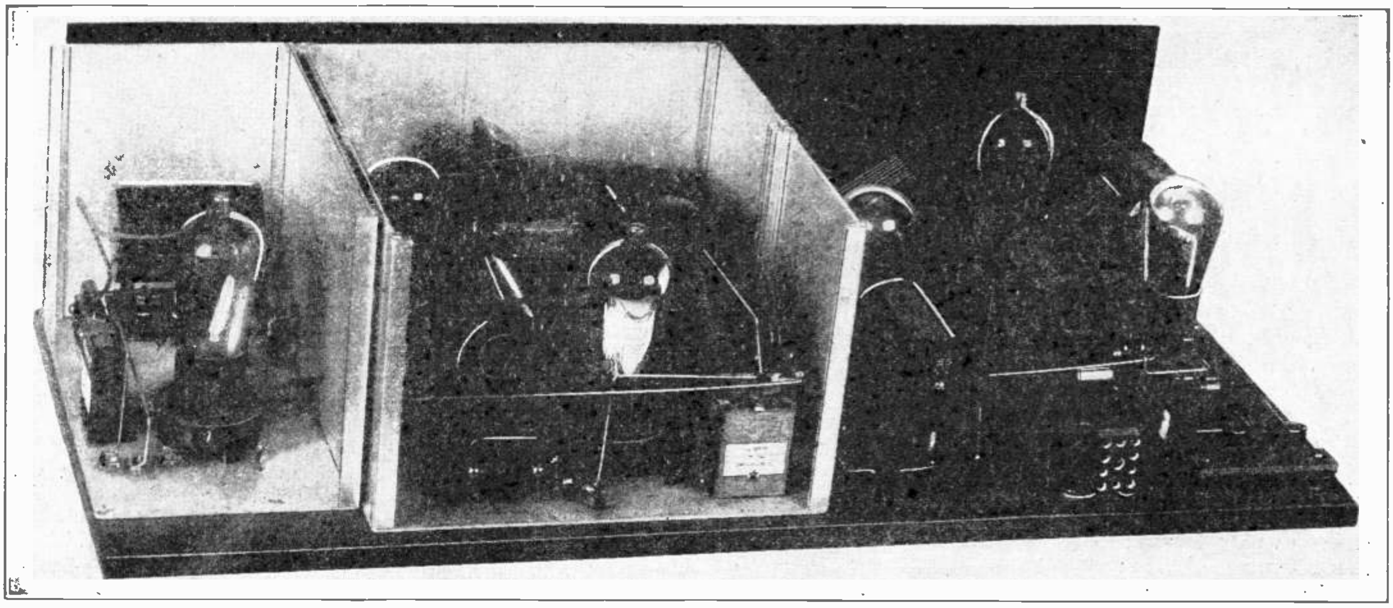
The alternating voltage in the plate of V1, then, is the resonant radio-frequency voltage across the tuned oscillator circuit which has in its plate circuit a high-impedance primary, to assure a high gain from the wonderful amplifying tubes used in conjunction with them.

The fifth tube is the true detector—the so-called "second-detector"—and it uses a higher order of bias (5.5 volts effective) than was supplied to the modulator. The "C" battery supplies 4.5 volts, while the extra volt is accounted for by the voltage drop in R5.

An audio transformer couples the detector to V6, the first audio tube. Note that only one lead is shown at the output—the plate lead; the "B+" connection is established at the power-pack's terminal strip, through the primary of a push-pull input transformer.

between the two carriers, so that one station will be very weak; but this does not prevent squealing, because the squeal's intensity is proportional to that of the strong signal, to which the set is tuned. Furthermore, the R.F. tuner cannot discriminate sufficiently well between two frequencies only 60 kilocycles apart.

When the intermediate frequency is 120 kilocycles (as in the present circuit), the carrier-frequencies which might interfere are 240 kilocycles apart. Even an ordinary R.F. tuner is sharp enough to suppress one of these when the circuit is tuned to the other. And, when the R.F. tuner is very sharp, the interfering carrier is so weak by the time it gets to the modulator that it cannot produce audible disturbance.



The "RE 29" is shown here with its rear and partition shields removed. The wiring is run with the utmost directness. The first or modulating tube, which in this system is not a "detector," employs its screen-grid and plate as a single element, of high effectiveness.

L2C2. The voltage is alternately positive and negative; the positive loops of this voltage are modulated by the signal impressed on the grid of the first tube.

The modulator (or first detector) establishes a high detecting efficiency because the impedance of the load on the tube is high for the detected frequency and low for the signal frequency. The fixed-tune circuit C3 (primary) C3, is parallel-tuned for the intermediate frequency, and its impedance or resistance is extremely high.

The condition for low impedance at the signal frequency would not be met were not the signal frequency always much different from both the intermediate frequency and the oscillator frequency. Currents of the signal frequency pass through C3 with practically no impedance. Likewise they pass through either C2 or the secondary of L2. If the higher frequency setting of the oscillator is used, the signal frequency is lower, and hence passes through the coil. If the lower oscillator frequency is used, the signal frequency is higher and therefore passes through the condenser C2. This is a band-pass filter action.

LATER STAGES

The next two tubes, V3 and V4, are the intermediate-frequency amplifiers, each of

Besides the foregoing, the circuit diagram reveals filters C8-L6 and C9-L7, to stop radio-frequency currents from entering the "B" supply; an antenna-ground input; shielding of the modulator and intermediate stages (denoted by dotted lines); two dial lights; and a switch.

By making a study of the circuit which is deeper than a bare analysis of a diagram, we ascertain why amazing sensitivity is attained, why selectivity is abundantly present, and why tone quality is preserved all the way through.

I.F. CHARACTERISTICS

A superheterodyne will bring in two different stations, separated by *twice* the intermediate frequency, at the same setting of the oscillator condenser. If the intermediate frequency is low, this will cause much interference. For example, suppose the intermediate frequency is 30 kilocycles; any two stations will then be brought in at the same setting of the oscillator, if the carrier-frequencies of the two stations differ by exactly 60 kilocycles. Since there is now at least one station for every 10 kilocycles, there is practically no chance of getting any station free of all interference.

The radio-frequency tuner discriminates

And that is not all. When a high intermediate frequency is used, there will be a wide band in which there cannot be any cross-talk at all between broadcast stations. Hence the two main advantages of using a high frequency are effectiveness of the R.F. tuner in suppressing any interfering station and the absence of all cross-talk in a certain band.

However, there is a practical limit to the increase in the intermediate frequency. The higher it is, the less will be the amplification and the selectivity, and the lower will be the stability. The frequency selected, namely, 120 kilocycles, is an optimum compromise between the two sets of opposing factors.

From 670 kc. to 550 kc. the oscillator tunes as a "one-spot"; that is, there are no repeat tuning points on the oscillator above 670 kc. (447.5 meters).

ANTENNA COUPLING

There has been some loose talk that a superheterodyne cannot be used successfully with an outside antenna, and that a loop must be used. The idea has been disproved many times; and aerials are coming into use more and more all the time for this type of circuit.

Hence an aerial is used with this receiver

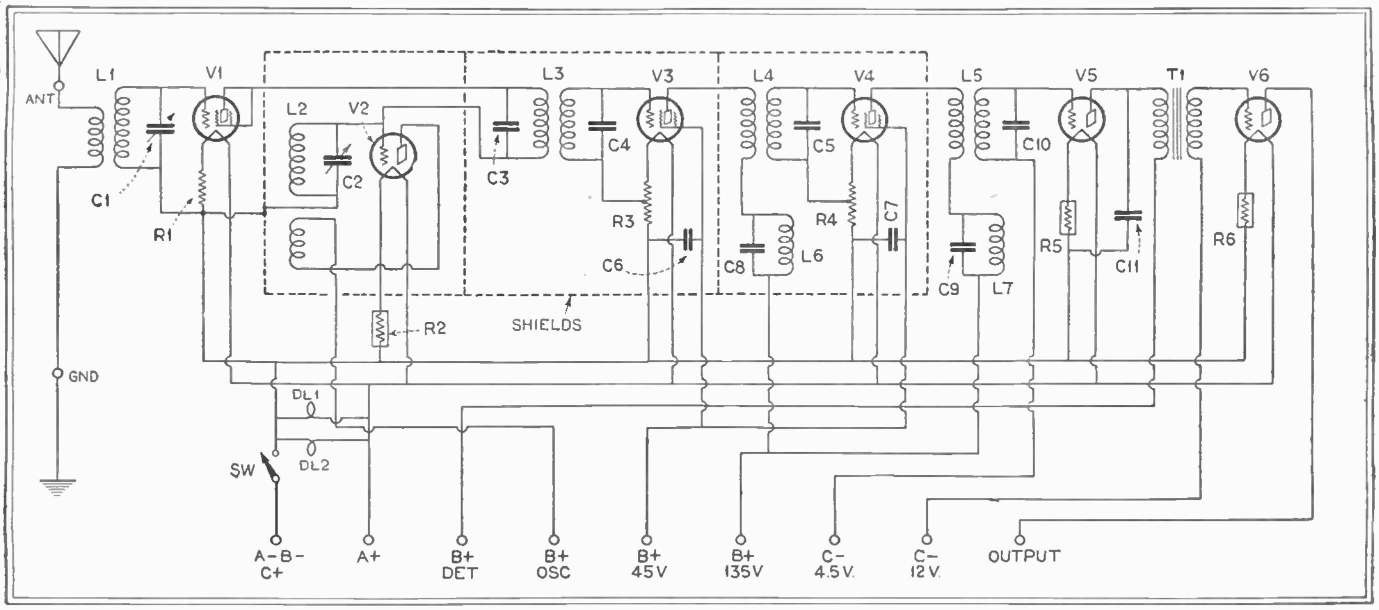


Fig. 1

The "RE 29" utilizes its designer's frequency-changing system, with a modulating tube, on whose plate there is no "B" potential; two screen-grid intermediate-frequency amplifiers; and a single audio stage, adapted for connection to an external power amplifier.

because it is more effective; it eliminates the necessity of another tube; it is much more convenient to use, once it has been installed; and it is less conspicuous in the home.

The antenna coil L1 and the oscillator coil L2 are of special design and are provided with plugs, so that other sizes of coils may be inserted into the circuit to cover other wavelength ranges. These coils are tuned by the .0005-mfd. Hammarlund "Midline" condensers C1 and C2. Note that the rotors of both these condensers are grounded to the shields, so that there will be no body capacity. While this is usual for the antenna condenser C1 it has not been so for an oscillator condenser. One of the chief difficulties with superheterodynes is eliminated by this simple connection.

INTERMEDIATE TRANSFORMERS

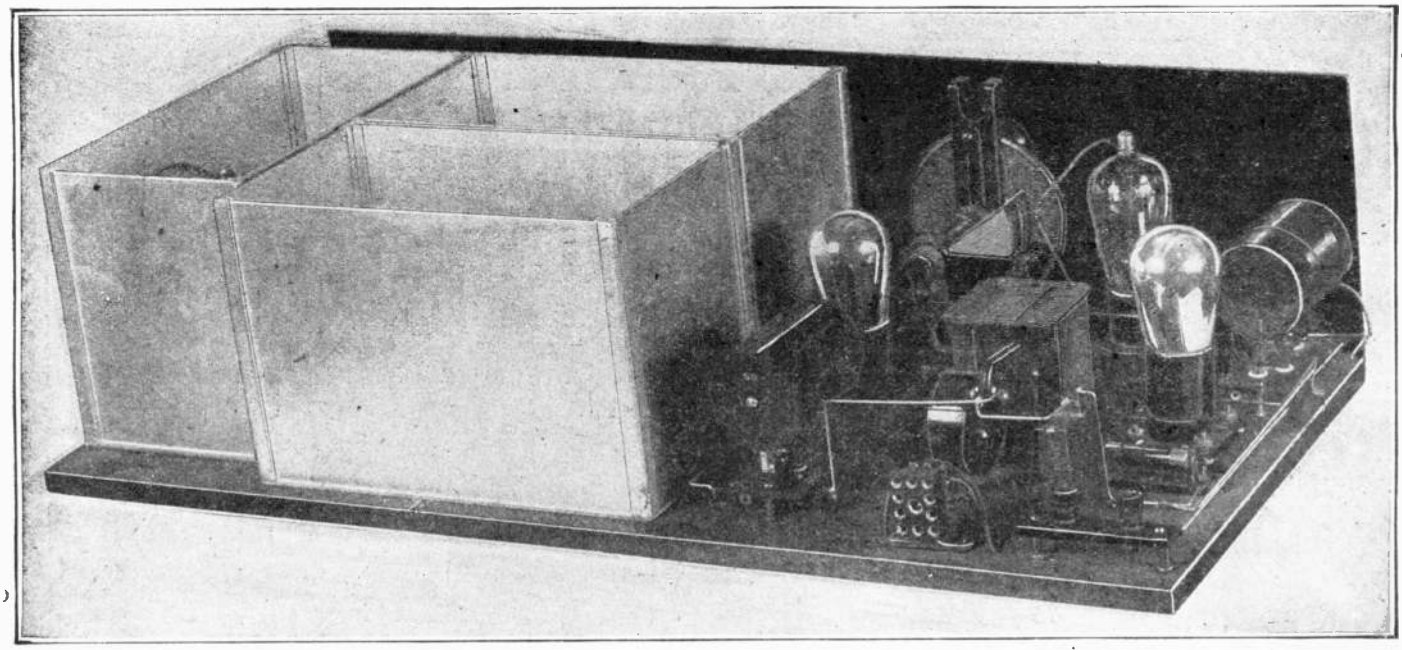
The intermediate amplifier consists of two screen-grid tubes and four tuned circuits. The first of the intermediate transformers, L3, is doubly tuned; that is, the primary is tuned by C3 and the secondary by C4. This coil is so constructed that it is a band-pass filter having a suitably wide transmission band. The double tuning insures thorough filtering, as well as a high step-up of the intermediate-frequency voltage.

The coupling coils L4 and L5 are identical in construction and tuning, the secondary of each being tuned. The primaries are wound to match the plate impedance of the screen-grid tubes, and to utilize the amplification of the tubes to a large degree.

All the three coupling devices (L3, L4 and L5) have been constructed to rigid specifications, as dictated by careful laboratory experiments. They provide a highly selective intermediate filter without cutting sidebands, and at the same time they step up very highly the amplification in the transmission band.

All told, the receiver is one I would encourage everybody to build for its distance-getting ability, tone quality, selectivity and ease of operation. Preferably build it as shown—with battery operation of the six filaments, but A.C. operation of the last audio stage from the "B" supply. The volume control will be in the supply unit. You will have a receiver of such extraordinary power that you will feel triply repaid for your efforts.

(*List of parts on page* 89)



The modulator tube, between its tuning condenser and coil, is in need of no shielding; neither are the second detector and first audio-stages, here shown at the rear right. The shielded oscillator is in the forward can; the intermediates in the other two.

The RE-29--Part Two

Presenting Complete Constructional Details of the Receiver, Audio Amplifier and Power Supply

By R. E. Lacault

EXTREME sensitivity features the RE-29, with every protection afforded for high selectivity. The six tubes are efficiently used. Three are screen grid, three are 201A. The filaments of these are battery-heated, but the plate voltage and current will be obtained from an a.c.-operated power-pack. As the 6-tube design includes one audio stage, the power pack contains the other, which is a 210 push-pull.

The six tubes constitute the most sensitive super-heterodyne receiver I have ever tuned, and this height of receptivity is due to the use of screen-grid tubes with proper load impedances, in conjunction with my system of modulation.

The receiver is built on a baseboard 25½" x 12¼" of wood that will not warp. With a square and rule draw a line right in the center of the board from front to back. Then draw another line 1½" to the left of the center line. Last of all, draw another line 1¼" away from the front edge of the baseboard. Next place two blocks or legs in the back corner to raise the baseboard so that the surface is 1" above the bottom of the cabinet.

The thickness of the blocks or legs in the back depends, of course, upon the thickness of the baseboard. Next mark all the aluminum shields for drilling according to the templates which are furnished with the official set of blueprints. The blueprints may be placed over the various shield pieces and the holes punched with a sharp tool or regular punch. Then drill each piece of aluminum separately by placing a board underneath and using a sharp drill so that the holes are drilled straight.

THIS informative article gives detailed information on actual construction as well as full data on the power pack designed for use with this receiver.

Mr. Lacult died just after completing the article. He left also a sketch and some information on constants for an external automatic volume control to be used with the installation. This control is described in the addendum to the present article.

Next place the bottoms of the shields on the baseboard so that the left edges of the front and back shields are exactly on the line drawn 1¼" to the left of the center line on the baseboard. At the same time the front edge of the forward shield should be exactly on the line drawn 1¼" away from the front edge of the baseboard.

The right-hand shield is lined up on the front line and against the others as shown in the pictures. The shields are held in place by screwing down the coil bases and the sockets. These bases are raised above the shield with two spacers furnished with the coil, and once these are screwed down they hold the bottoms of the shields in place.

When mounting the coil bases, it is important to note the position of the white holes into which the coil is plugged. One hole is in the center of the base, while the three others are offset. It is essential that these bases be mounted in the right way.

Next, mount the other apparatus (on the left side of the baseboard) and drill right through the baseboard. These holes are used for the wiring which is made under the baseboard. Use a ¼" drill to drill the wiring holes in the shields and the baseboard.

To support the tube shields covering the shield-grid tubes it is necessary to modify three sockets. The easiest way is to proceed as follows:

Countersink the mounting holes so as

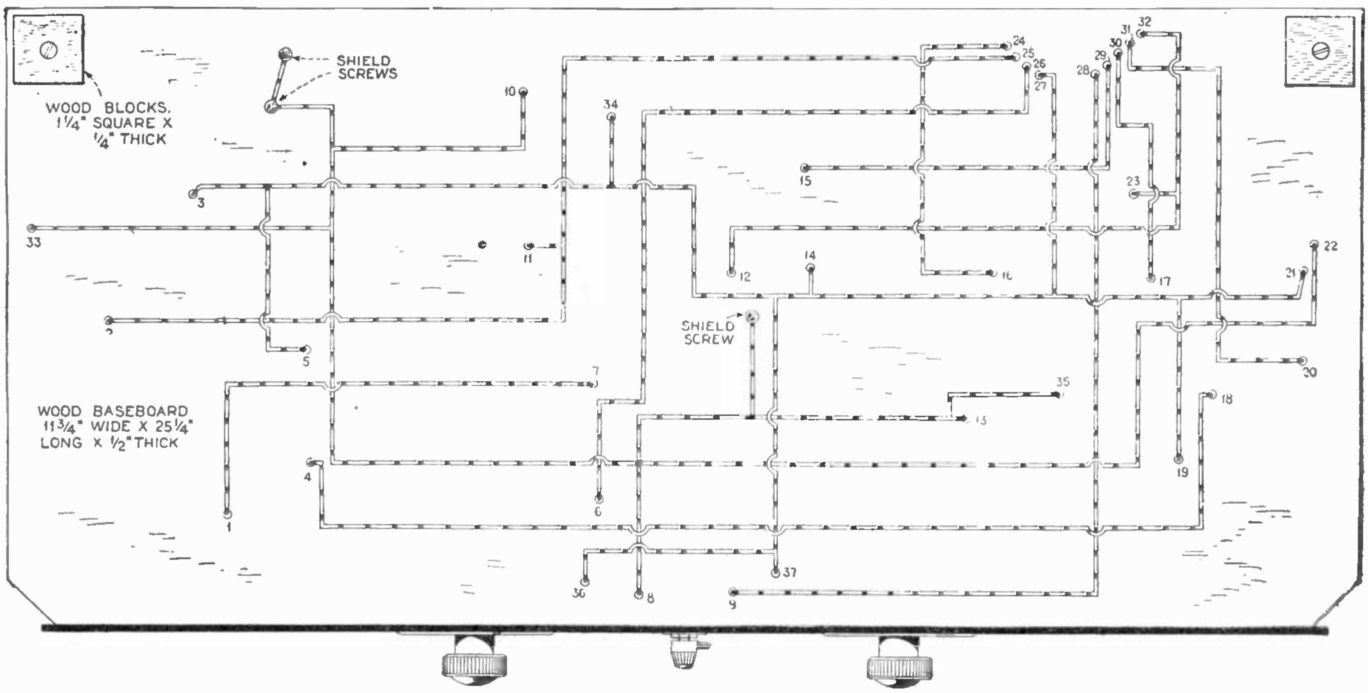


FIG. 1. THE UNDER SIDE OF THE BASEBOARD SHOWS THE WIRING OF THE SET. THE TWO WOODEN BLOCKS ATTACHED TO THE BASEBOARD ALLOW THE PLACEMENT OF WIRING UNDERNEATH

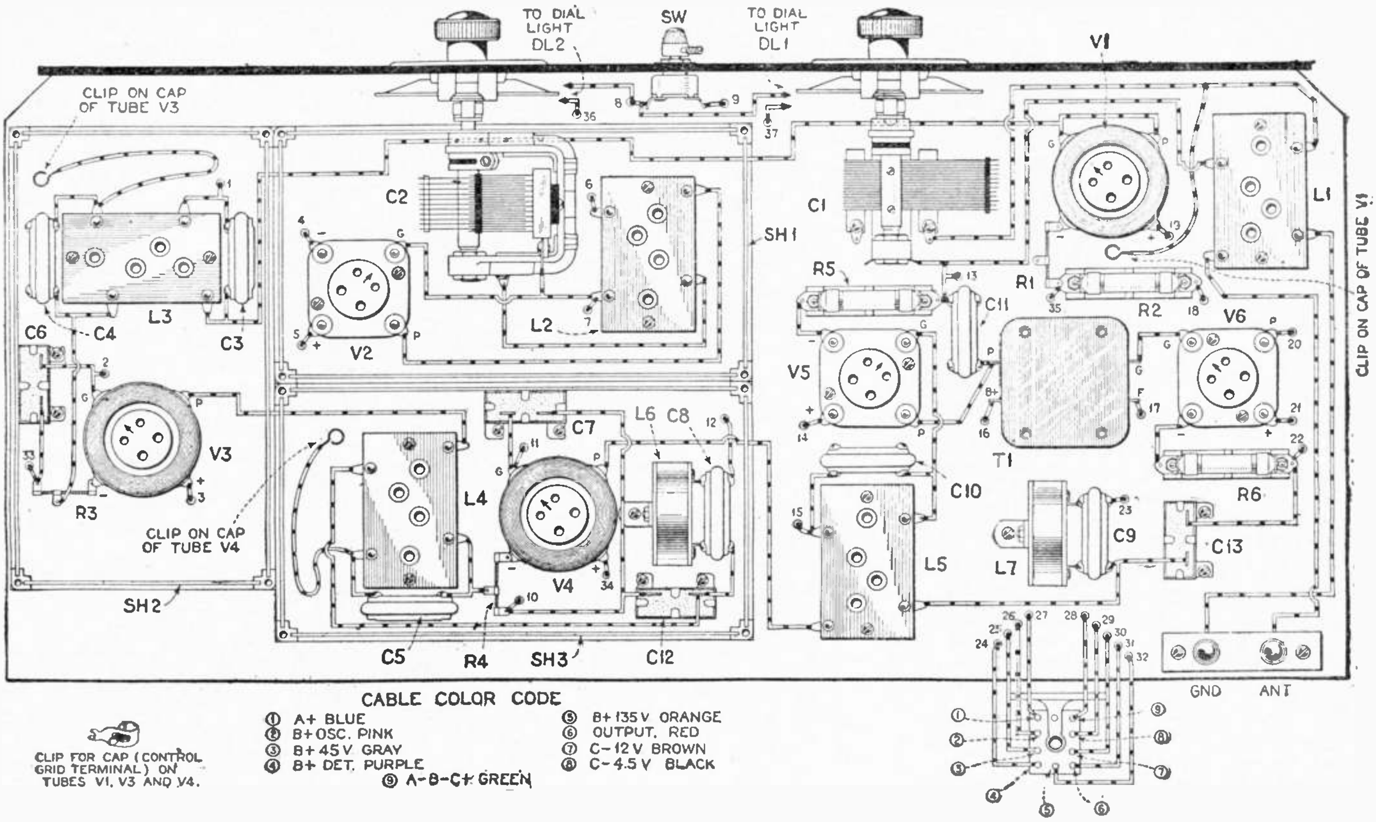


FIG. 2. THE POSITIONS OF ALL THE APPARATUS IN THE SET ARE SHOWN IN THIS ILLUSTRATION. FIGS. 1 AND 2 CAN BE USED FOR WIRING THE SET, AFTER THE APPARATUS HAS ALL BEEN MOUNTED

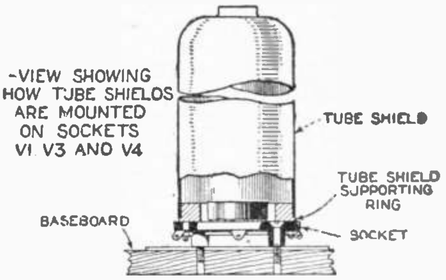


FIG. 3. THREE OF THE SOCKETS ARE MODIFIED SO THAT THE TUBE SHIELDS FIT PROPERLY. THE METHOD OF FASTENING THE SUPPORTING RINGS IS SHOWN HERE

to use a flat-head machine screw. Then remove the thumbscrews and nuts which are holding the floating part of the socket. Once the screws are removed, be careful not to turn the center part of the socket, since each blade must remain in its original position.

Then place two No. 6/32 flat-head brass machine screws in the mounting holes to fasten the socket later on the baseboard, and place the bakelite insulating ring over the socket after the four nuts have been removed from the threaded studs. These studs take the place of the screws and nuts which originally held the socket together. After the four brass nuts have been placed back on the studs, the socket is again assembled but with a bakelite ring around the floating part. On each one of the rings you will notice that one of the studs shows through the bakelite on the rim. This particular stud should be placed so that it holds the minus "A" terminal on the socket. This arrangement is provided to ground the tube shields to the minus "A" when they are slipped over the tube.

If the insulating rings you obtain do not have the stud showing through the bakelite, merely solder a wire to the bottom of the tube shield and fasten the other end of the wire to the aluminum shield under a screw or nut.

The templates for the National type E dials are furnished with the dials. The panel is mounted last of all and is adjusted as follows:

Lift up the set and let it rest on the back shield so that the front of the set is flat and on top. Unscrew the set-screw of the right-hand dial and drop the panel so that the right condenser shaft fits in the dial hole.

Straighten the lower edge of the panel with the baseboard and with a sharp tool punch the edge of the board through the three mounting holes. In this way one avoids the binding of the right dial.

After all the parts are fastened on the board you may start the wiring. The wire (rubber covered) is looped, cut and soldered to the various lugs. This is an easy and rapid way of wiring.

When connecting the various wires to the fixed part of the cable plug which is fastened on the baseboard it is best to tin the wires. It is then easy to heat the small tubes into which the wire slips.

As you solder the wires to the plug, make sure that there are no strands of wire touching the next plug.

One must be careful, however, where the wires pass through holes in the shields. Once all the wiring on the baseboard is done, the partitions of the shields may be installed and the wires passed through the holes which have been drilled previously. Begin with those connections right behind the panel and work toward the back. It is easier to solder the connections. The corner posts of the alumnium shields are fastened with long machine screws through the baseboard. The head of one of the screws holding a corner post of each shield should be soldered to the minus "A" wire so as to ground each shield. The panel supports only the two dials and the switch.

A good precaution is to check the wiring once it is completed and, leaving the minus of the "A" battery connected to the minus terminal, touch all the other wires in the cable to make sure that no tube lights. If one does light, there is something wrong in the wiring.

If everything tests satisfactorily, connect the power unit and adjust the voltages. An accurate high resistance voltmeter will show exactly what you get and we urge you to use one.

Some tubes work better with a little more plate and grid voltage, others with less. In other words, the set has to be adjusted for the tubes in use.

Now for a discussion of the power pack, the diagrams and photographs of which are published herewith.

Two 281 tubes are used, for full-wave, high-power rectifiers, the power transformer supplying the necessary a.c. voltage, and the potential-dividing network at the output, suitably by-passed, affording accessible rectified voltages of C—12, C—4½, B+Det., B+45, B+Osc. and B+135. The full 350 volts are applied only to plates of the pair of 210 tubes used in push-pull, hence no outlet post

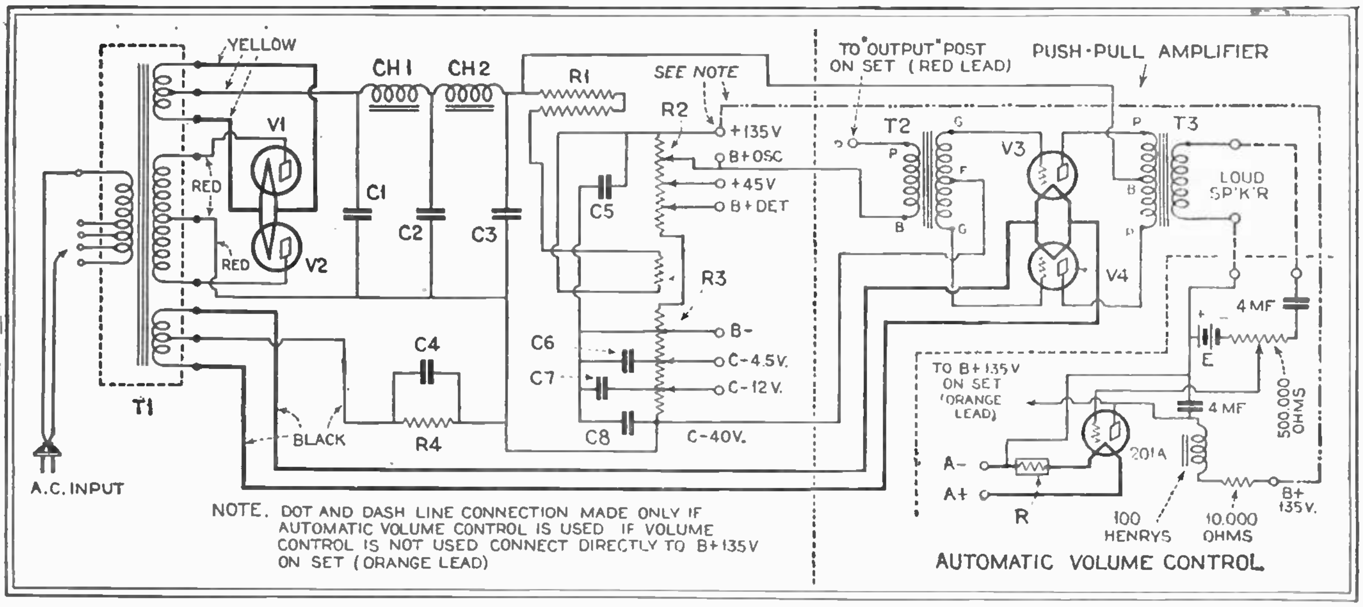


FIG. 4. THE SCHEMATIC DIAGRAM OF THE POWER UNIT, THE AMPLIFIER AND THE AUTOMATIC VOLUME CONTROL THAT THE AUTHOR SUGGESTED IN HIS NOTES ARE SHOWN HERE

is necessary for this latter voltage.

Most of the accessible voltages are adjustable by sliders on the resistors.

The power transformer is so heavy that wood screws cannot be relied on. Hence, for mounting this transformer four large holes are drilled through the board and the transformer is mounted by means of bolts. If flat-head bolts are used, the holes on the bottom side should be countersunk. If any other type of bolt is used the holes should be sunk on the under side so that the heads of the bolts come below the surface of the board.

The baseboard for the power pack is 25¼" long and 12" wide; which allows ample room for all the parts without any crowding. This not only permits easy access when wiring, but it facilitates circulation of air for cooling the parts.

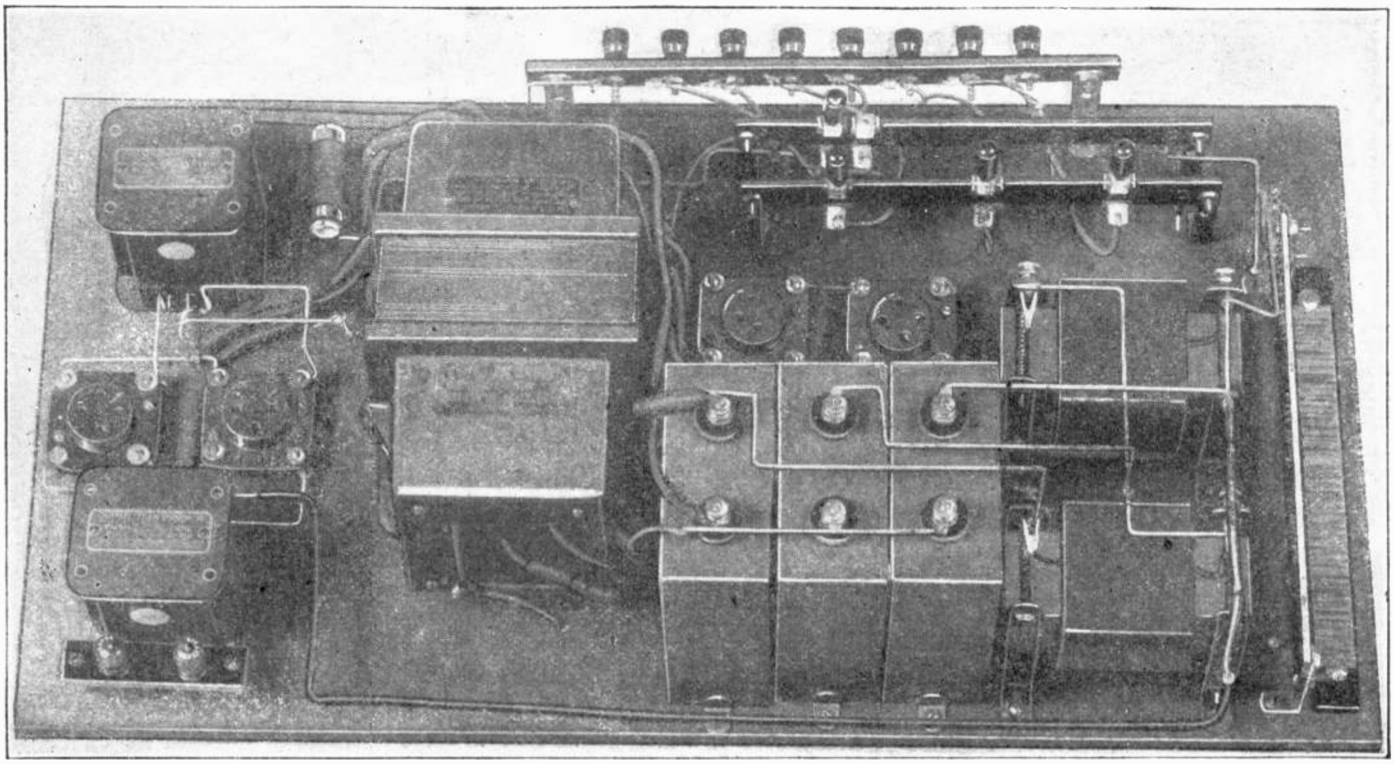
The actual layout of parts for the "B" battery eliminator and push-pull power amplifier is shown in Figs. 5 and 6. The power supply portion of the unit is shown at the right, and the push-pull amplifier is shown at the left. Some few parts, like small by-pass condensers, are not shown in the illustrations, although they are in the diagrams, and of course such parts should be included in the circuit.

The power transformer is an Amertran PF250. It is provided with five leads on the primary side. One lead is for zero, or the grounded side of the line, and the four others are for input voltages of 100, 110, 115, and 120 volts. The lead suitable for the voltage on the line is selected. Usually it is not necessary to provide for switching from one to the other because at any one place the voltage remains fairly constant during service.

The two leads of the plug-in cord should be securely connected to the proper terminals on the transformer and soldered. Then they should be wrapped separately with several layers of friction tape and finally taped together.

In building the power pack and push-pull amplifier the following procedure is recommended:

FIG. 5. VIEWED FROM ABOVE, THE POWER UNIT FOR THE RE-29 SHOWS THE EXTRA WIDE SPACING THAT WAS LEFT FOR VENTILATION. THE PUSH-PULL AMPLIFIER IS ON THE LEFT AND THE "B" POWER SUPPLY ON THE RIGHT



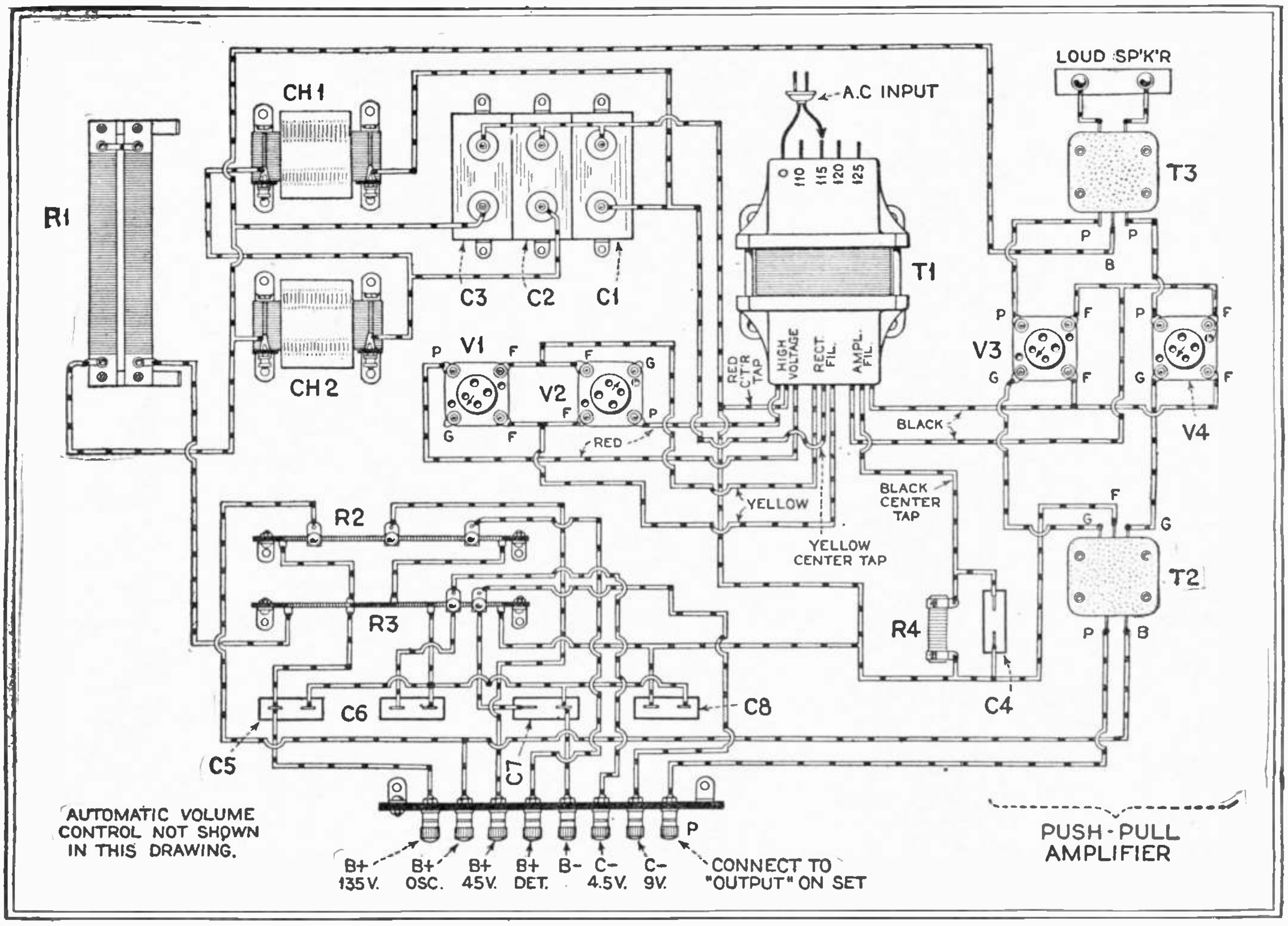


FIG. 6. THE LAYOUT OF THE PARTS IN THE POWER UNIT AND AMPLIFIER FACILITATES THE CONSTRUCTION AND WIRING OF THE UNIT. SOCKETS V1 AND V2 ARE FOR THE UX281 RECTIFIERS; V3 AND V4 ARE THE AMPLIFIER SOCKETS

First, place the parts on the board in the proper positions without fastening any down. Mark the position of each with a pencil and locate the holes for the mounting screws. Do this accurately so that all the holes may be drilled at once while nothing is on the board. Remove all the parts, and drill.

Next mount the power transformer. Do not connect anything to the primary leads of the transformer. When the transformer has been bolted down mount the two sockets for the rectifier tubes. They will be almost in the center of the board.

When this has been done, connect the filament leads from the transformer to these sockets. There will be three heavy yellow leads on the transformer. The outside two of these go to the F terminals of the two sockets. Connect the sockets in parallel with heavy leads, such as heavy bus-bar wire.

Next connect the outside red leads from the transformer to the plate terminals of the sockets, one to each. These are the high-voltage leads through which flows the alternating current to the rectifier. The two grid terminals are left blank. Avoid loose, uninsulated ends.

The next to be mounted are the three high-voltage Parvolt condensers. They are placed to the left of the transformer, back of the sockets already mounted.

Connect the three condenser terminals farthest away from the sockets with a piece of bus-bar and then connect the central red lead from the transformer to the same point. Then connect the central yellow lead on the transformer to the unused terminal of the condenser.

We are now ready to mount the two filter chokes. They are placed to the left of the condensers and the sockets. From the post on the first condenser to which the yellow lead has been connected, run a bus-bar wire to the nearest terminal of the first choke. This choke is at the back. Insulate the wire with spaghetti. While this is not vital, it is wise.

Next, run a bus-bar wire from the unused terminal of the middle condenser to the second binding post of the first choke, and connect this lead to the first terminal of the second choke. Insulate these leads. Now run a similar (insulated) lead from the unused terminal of the third condenser to the second terminal of the second choke coil.

At this point leave the "B" battery eliminator and go to the push-pull amplifier. Mount the two sockets first. Connect the filaments in parallel and run the outside two heavy black leads from the transformer to the filament terminals.

Next mount the two push-pull audio frequency transformers, the output transformer at the back and the input in front. Mount a binding post strip, containing two posts, directly behind the rear transformer on two long single brackets. Connect up these binding posts and also the grid plate terminals on the two push-pull

(Continued on page 93)

THE reader will find it interesting to observe that practically all of the more worthwhile receivers which are being offered to them this season are available at radio dealers' in kit form. This is true of the Lacault RE-29, and naturally, where maximum satisfactory performance is to be sought it is generally recommended that no substitution of the parts listed be indulged in by the builder. In no other way can results which are on a par with those obtained by the designers be expected. The blueprints which are referred to frequently in the accompanying text are full-sized and may be obtained separately or with the official kit and for that reason are not reprinted here.

Designing a Tuned-Radio-Frequency Transformer for the A. C. Screen-Grid Tube

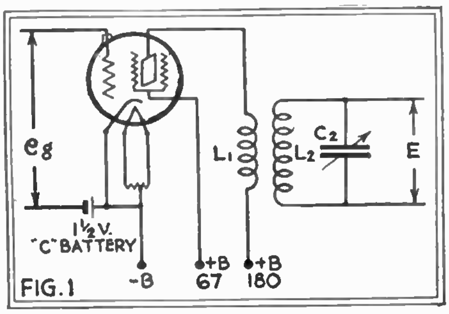
By Glenn H. Browning

THE screen-grid tube is probably the outstanding development among the radio receiving tubes which has been brought about in the last three years; for, not only does it do away with the problem of neutralization, but it also makes possible greater selectivity than has been practical before. However, the characteristics of this tube are so different from those of others that it necessitates considerable design work on the part of the engineer, in order to realize the possibilities inherent in this new device.

The relative ("factor of") merit of any radio-frequency-amplifier tube is indicated by its amplification factor divided by the square root of its plate resistance. Of course there is also the capacity between the plate and the grid to be considered, for, the larger this is, the greater the tendency to oscillation when the tube is used in a multiple-stage tuned-radio-frequency amplifier. In the case of the screen-grid tube this capacity is very small—a fact which alone is sufficient to strongly recommend its use. The following table gives an idea of the relative merits of the various tubes used as R. F. amplifiers.

"FACTOR OF MERIT OF TUBES"

Type of Tube	$\mu/\sqrt{Rp}$	Plate-Grid Capacity $\mu\mu f$.
01A	.076	12.0
22 (D.C. screen-grid)	.184	....
26	.085	12.6
27	.095	6.6
24 (A.C. screen-grid)	.485	....

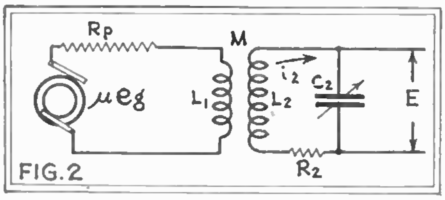


The schematic circuit of a screen-grid stage of R.F. amplification, indicating both input and output voltages.

It will be noted that the new A.C. screen-grid amplifier (the Y-24 type) is more than twice as good as the D.C. screen-grid tube, and five times as good as any of the others. It is also interesting to note that the 27-type is superior to either the 01A or the 26-type; both from the standpoint of the factor of merit and from that of the capacity between plate and grid.

SCREEN-GRID R.F. AMPLIFICATION

There are two methods of using the A.C. screen-grid tube to advantage in a tuned-radio-frequency amplifier; one is by a tuned-impedance system, and the other employs a tuned-radio-frequency transformer. Both of these have the advantage of amplifying while adding selectivity to the circuit. However, a careful study of the two will show that the transformer is superior



The virtual circuit of Fig. 1, showing the "mu" of the tube as a factor of the input, and its plate resistance at Rp.

from the standpoint of selectivity, while is is simpler to use in a kit set. As the radio-frequency amplifier in any set determines its distance-getting ability as well as its selectivity, the radio-frequency transformer characteristics are important.

The writer has been doing design work for the lost five months on radio-frequency amplifying systems for the new screen-grid A.C. tube, and was able, after careful study, to design the transformer, the analysis of which is given further on in this article. With four of these transformers used in a receiver, it not only was sensitive enough to bring in nine California stations in one eveing and KFI as early as 10 o'clock (the set was located in Malden, Mass.), but the selectivity was sufficient to cut out the local stations and bring in semi-distant ones where the frequency-separation of the two was only 10 kilocycles. In fact, the set performed so well that it was thought that many of the readers of RADIO NEWS will be interested in its technical development, which is explained below.

ANALYSIS OF THE TUBE CIRCUIT

It is necessary to make a critical analysis of the functioning of the transformer, in order to design one which will give the maximum gain while, at the same time, tuning is of adequate sharpness.

Fig. 1 shows the conventional circuit for A.C. screen-grid tubes used in conjunction with a tuned-radio-frequency transformer: eg is the voltage put into the grid circuit of the tube, while E is the resultant voltage developed across the coil-condenser system. For analytical purposes Fig. 1 resolves itself into Fig. 2; μe_g is the voltage which, acting in series with Rp (the plate resistance of the amplifier tube) develops the same current through L_1 (the inductance of the primary of the radio-frequency transformer) as would be developed were the amplifier tube present in the circuit. Therefore, μ is the amplification factor of the tube. The other indexes are L_2 (the inductance of the secondary winding); C_2 (the capacity of the tuning condenser); M (the mutual inductance between primary and secondary coils) i_2 (the current flowing in the secondary circuit); and R_2 (the inherent resistance of L_2—C_2 circuit. It is assumed that the capacity between primary and secondary is small.

Then the voltage amplification of the system will be E/e_g.

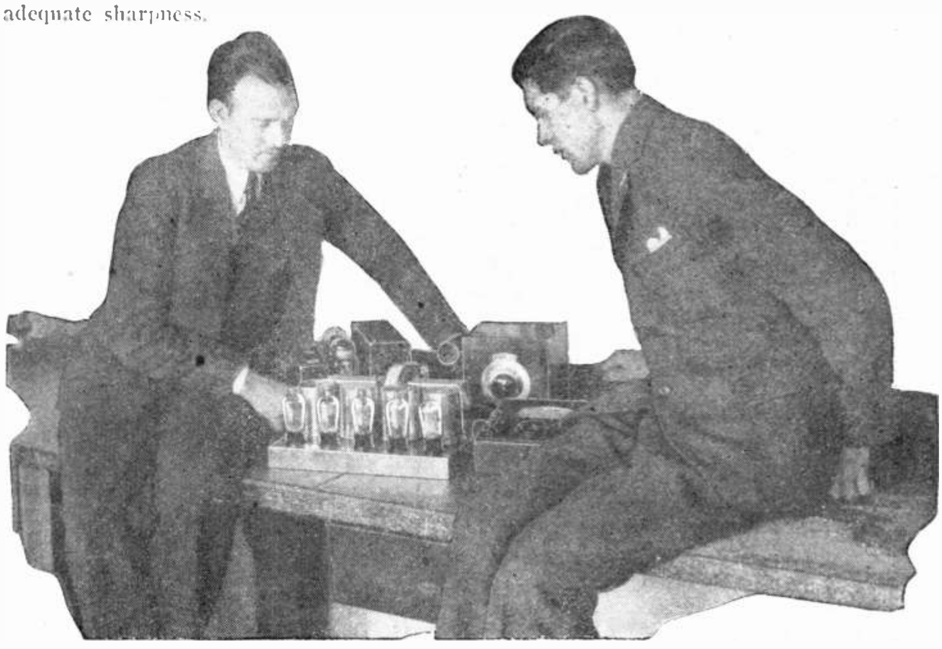
Where the incoming frequency of the signal, $f = \omega/2\Pi$.

$$E = L_2 \omega i_2 \quad (1)$$

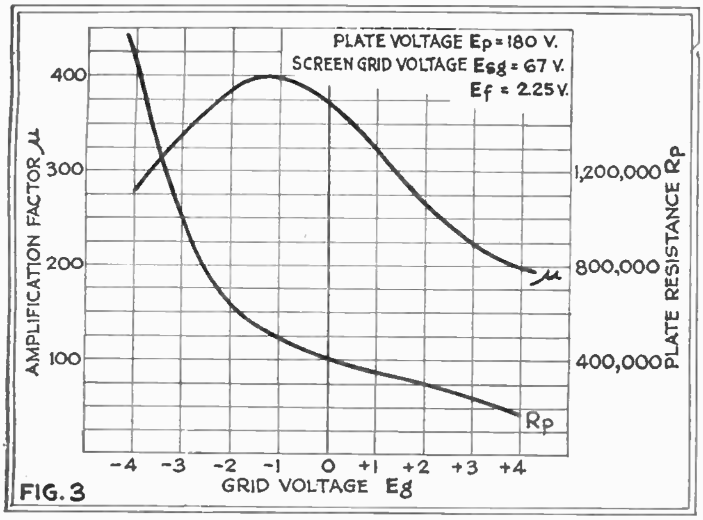
This equation holds true in all cases, provided $(R_2)^2$ is small compared to $(L_2\omega)^2$. This is always true in any ordinary tuned circuit.

It may be shown that

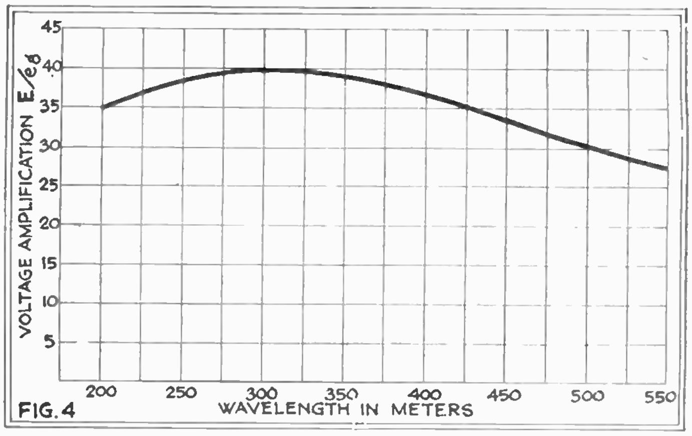
$$\frac{E}{e_g} = \frac{\mu\iota\sqrt{L_2/L_1}}{\sqrt{\eta_2^2+(1-\theta^2)^2}\sqrt{\left(\eta_1+\frac{\iota^2\eta_2}{\eta_2^2+(1-\theta^2)^2}\right)^2+\left(1-\frac{\iota^2(1-\theta^2)}{\eta_2^2+(1-\theta^2)^2}\right)^2}} \quad (2)$$



Dr. Browning (left) is well known to our readers as co-inventor of the Browning-Drake circuit. He is exhibiting here a tuning unit with four R.F. stages, using the transformer constants calculated here, and detector. It is designed to feed into the "Velvetone" amplifier seen behind it, and described on page 1099 by James Millen (right).



Above, the amplification factor of the A.C. screen-grid tube and its plate resistance are plotted against grid-voltage swing with the normal polarity of 1½ volts on the grid.



The voltage amplification of the transformer described in this article variesa s plotted avove over the broadcast band. It is slightly better at 300 meters; dropping off slightly at lower frequencies because the primary turns must be kept down so that the natural frequency will not fall in this band. This is overcome by proper design of the antenna coupling system.

where the following abbreviations are used:

$$\iota = \frac{M}{\sqrt{L_1 L_2}};\ \eta_1 = \frac{R_p}{L_1 \omega};\ \eta_2 = \frac{R_2}{L_2 \omega};$$

$$\theta = \frac{1}{\omega \sqrt{L_2 C_2}};\ \omega = 2\pi f$$

These abbreviations, besides being convenient, have physical meaning. For instance, ι, the co-efficient of coupling, depends almost entirely on the geometric relation of primary and secondary winding, and not on the inductance of either.

η_2 is inversely proportional to the sharpness of tuning of the secondary circuit when the primary is not present. The value of θ gives a very good idea how much off resonance the secondary circuit is, regardless of the waveband being considered. It should be noted then that equation 2 holds true regardless of the waveband, the position at which C_2 is set and the magnitudes of the quantities involved. Only two of the justified assumptions formerly named have been made.

For an incoming signal of given frequency, C^2 may be varied for maximum secondary current I^2. To determine this adjustment differentiate function E/e_g with respect to θ and set its first derivative equal to zero. Performing this operation we find that the proper adjustment is where

$$(3)\quad \theta^2 = \frac{\eta_1^2 + 1 - \iota^2}{\eta_1^2 + 1}$$

Placing this value for in equation (2) we find the voltage amplification at this point to be equal to

$$(4)\quad \frac{E}{e_g} = \frac{\mu \iota \sqrt{\eta_1^2+1}\sqrt{L_2/L_1}}{\eta_2(\eta_1^2+1)+\iota^2\eta_1}$$

Careful observation of equation 4 will show that there is a relation between ι, η_1, and η_2 that will give still greater amplification. In other words, in a radio-frequency transformer should the primary have one turn or ten? Should the coefficient of coupling be large or small? Should the secondary circuit have as small a resistant as possible? Let us see.

Differentiating E/e_g with respect to ι, and setting the derivative equal to zero, we have the relation between the three quantities that will determine their best values. Performing the above operation we obtain

$$(5)\quad \iota^2 = \frac{\eta_2}{\eta_1}(\eta_1^2+1) \quad \text{if} \quad \eta_1^2 \gg 1$$

$$(5A)\quad \iota^2 = \eta_1 \eta_2$$

Substituting equation (5) in equation (4) we find that the voltage amplification is

$$(6)\quad \frac{E}{e_g} = \frac{\mu \sqrt{L_2/L_1}}{2\sqrt{\eta_1 \eta_2}}$$

Equation (6) is the maximum voltage amplification obtainable with a tuned-radio-frequency transformer after C_2 has been adjusted to its best position, and the proper relation has been obtained between ι, η and η_2. It might be added that this voltage amplification gives by equation (6) is only obtainable at one definite frequency because η_1 is variable, while η_2 and ι do not appreciably vary with frequency. (Note: The reason that ι and η_2 do not vary is that the former is geometric ratio, while in the latter R^2 goes up as the frequency increases; so that in a well-designed coil $R_2/L_2\ \omega = \eta_2$ remains almost constant.)

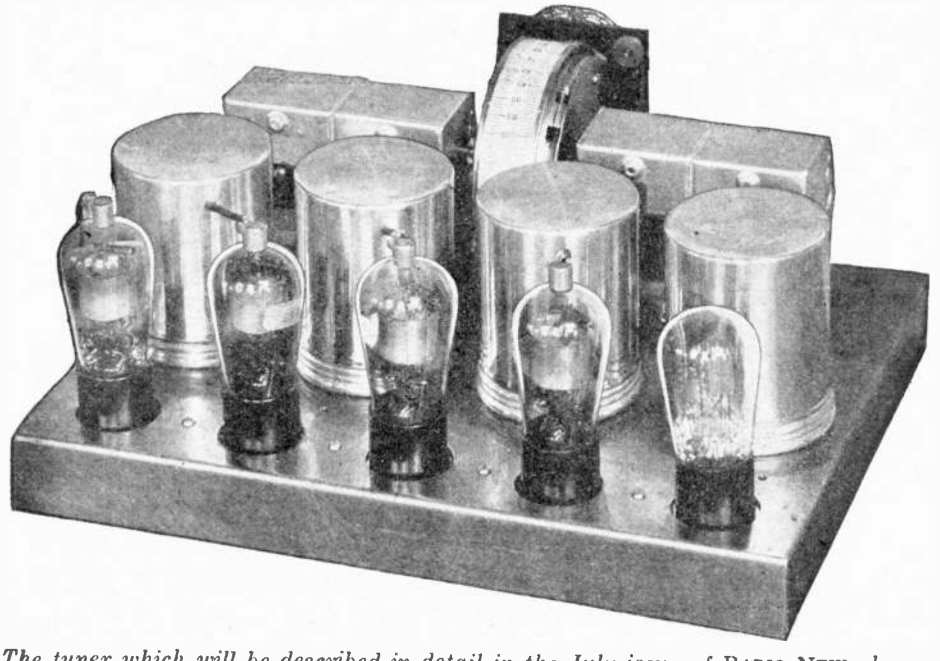
However, if the design relations given in equation (5) or (5A) are satisfied for the *middle* of the spectrum over which the transformer is to operate, almost even amplification will result. Thus, for maximum amplification, we must make $\iota^2 = \eta_1\ \eta_2$.

In designing the transformer, η_2 is made as small as possible by using a high-grade condenser and a coil whose radio-frequency is as low as possible. This being done, η_2 is fixed. Having done this, the relation alone gives the primary inductance L, for any coefficient of coupling; for

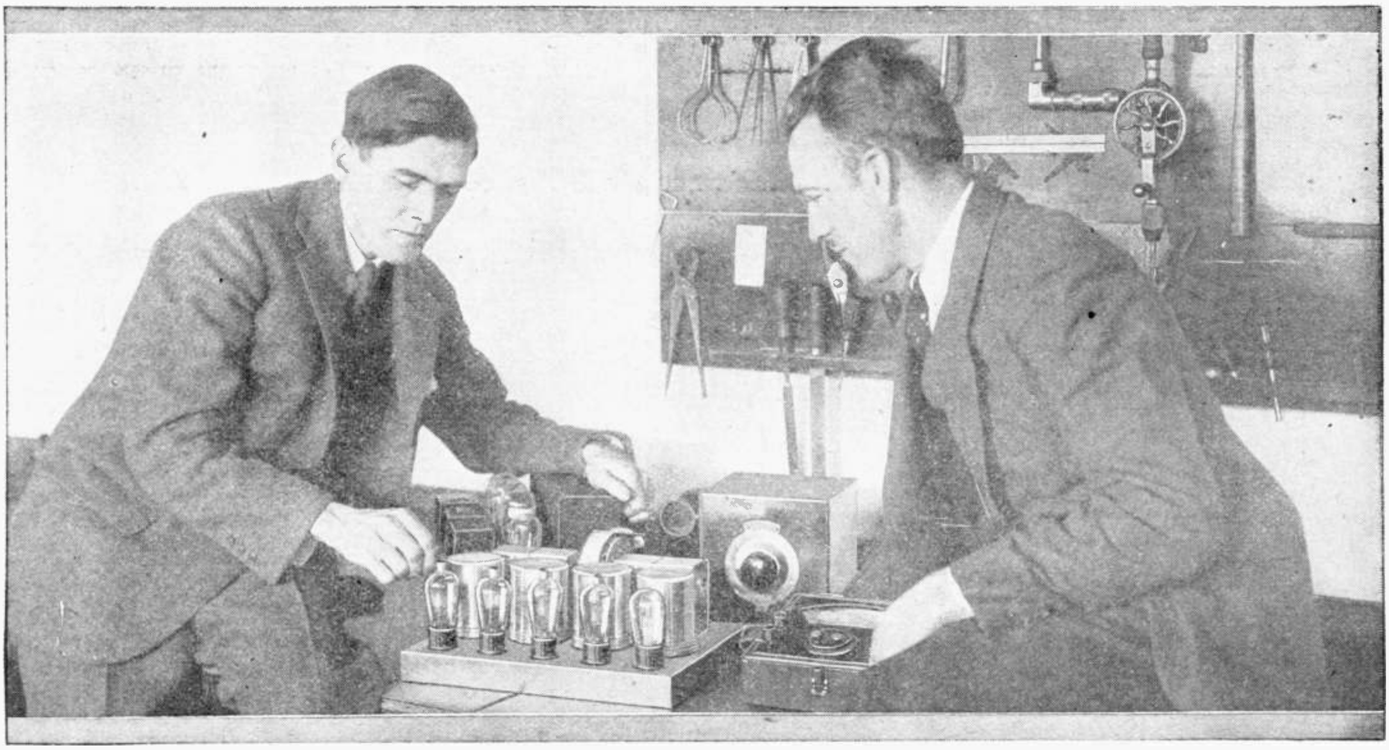
$$(7)\quad L_1 = \frac{\eta_2 R_p}{\iota^2 \omega}$$

It will be noted that, when ι is large,

(*Continued on page* 62)



The tuner which will be described in detail in the July issue of RADIO NEWS *has an untuned antenna coupling stage, followed by four transformers of the type whose design is dealt with in this article. The four tuning condensers are ganged and operated from a single dial. The shield cans shown hold each a transformer, with a choke coil and by-pass condenser.*



The Velvetone-29

A New Five-Tube A. C. Screen-Grid Tuner of Exceptional Design

By James Millen and Glenn Browning

PROBABLY no industry in the history of our country has made such rapid progress as the art of radio reception and transmission. This has been largely due to the fact that the American public has generally accepted this new form of entertainment which brings the world of sound into the home. In fact, radio has become a major feature of a pleasant evening at home.

It seems only yesterday that we were satisfied if something in the nature of speech or music came out of the loud speaker; today, the sound emitted from the receiver must closely approximate an exact reproduction of the original, otherwise our ears immediately sense the distortion. When one stops to think of the changes that the sound has to undergo from the time it strikes the microphone at the transmitting studio, until the time it is emitted from the radio speaker, one wonders how it is possible to get natural reproduction. The microphone changes the sound waves into electrical currents, which must be amplified, and then radiated through space. Our receiver then picks up a minute fraction of this energy, amplifies it, unscrambles the speech or music frequencies, and finally the loud speaker emits sound which is a replica of the original. The receiver, if it is to perform faithfully its part in these transformations, must not only have the component parts carefully designed, but each part must fit into the scheme of things in such a way that the quality of the received signals is not distorted.

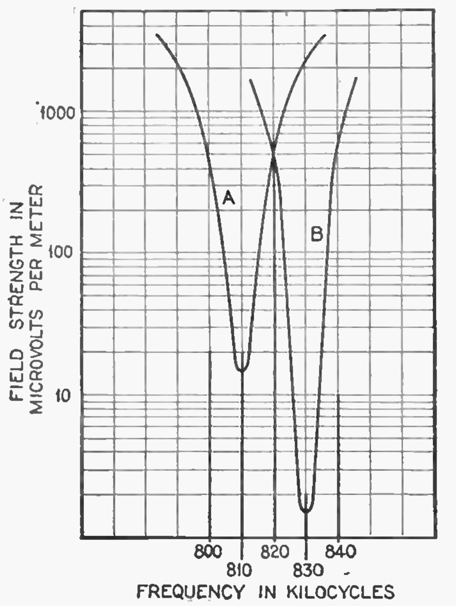


FIG. 1. *The curves indicated in the above chart show the relative selectivity and sensitivity of two different receivers.*

This quality of received signal is probably the first requisite in every broadcast receiver. However, due to the increase in number and in power of the transmitting stations, a receiver must be selective as well. That is, it must possess the ability to respond to any one of some 80 or more channels on which broadcasting occurs, to the exclusion of programs being broadcast on channels adjacent to the one tuned in. This means that a number of tuned circuits must be employed in the design of the tuner device. In fact, if the receiver is to combine distance-getting ability together with selectivity and quality, three or four tuned circuits become necessary. This will readily be appreciated by the following illustration.

Assume that the field strength of various stations is as indicated in Fig. 1; that is, a local station broadcasting on 820 kc. has a signal strength of 500 microvolts per meter, while a semi-distant station on 830 kc. has a signal strength of about 2 microvolts per meter, etc. The receiver whose selectivity and sensitivity is represented by curve "A" would be able to receive the station transmitting on 810 kc. without interference from the local, but would not be able to receive the broadcast station on 380 kc., as the receiver does not have sufficient gain. However, if the

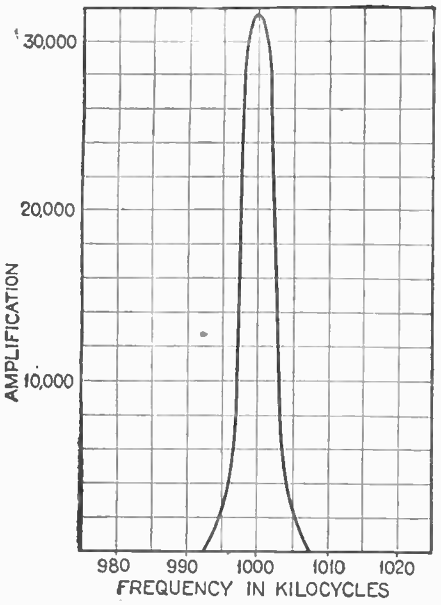


Fig. 2. *This curve shows the selectivity effect of four tuned stages, each stage tuned alike*

sensitivity was increased without adding selectivity, so that stations with a field strength of 2 microvolts per meter could be heard, this would be equivalent to lowering Curve "A" as a whole, and then interference would result.

On the other hand, the receiver with tuned circuits, whose sensitivity and selectivity is represented by Curve "B," would be able to bring in any of the stations at will. Thus, it is apparent from the comparison that a set which may seem selective would, if the sensitivity was increased, actually be quite broadly tuned.

The writer has heard the question asked many times, "How can you get a radio frequency amplifier to tune sharply when you use the screen-grid tube?" The fact is that this tube will tune more sharply for a given signal strength than will the 227 or 201A; but, because the signal strength increases considerably, the *apparent* selectivity is lessened.

However, there is a definite limit to the sharpness of tuning unless the shape of the resonance curve is modified, for the high notes would not be amplified as much as the lower ones. This can readily be observed by reference to Fig. 1. In the case of receiver "B," a 5,000-cycle note would be amplified only about one-third as much as a 100-cycle tone. Inasmuch as the ear responds as the logarithm of the intensity, the noticeable difference to the above distortion would be in the ratio of 1.47 to 1, which in all probability would not be at all objectionable.

In the design of the kit set to be described, the questions of selectivity and quality as well as distant reception have been carefully considered. Four tuned circuits have been used for the purpose of selectivity, and the tuning very slightly staggered so as to modify the resonance curve, giving it a flatter top with steep sides. This is shown in Figs. 2 and 3. Fig. 2 gives the tuning curve for the four tuned circuits, each circuit being exactly in tune with the previous one, while Fig. 3 indicates the effect of slightly staggering the tuning of the stages. It will be noted in the case where the stages are staggered, that the sides of the curve are more abrupt, and that the top is flatter; the amplification being less than is obtained with perfect alignment. In this manner the question of quality reception, as far as the tuner is concerned, is taken care of.

There are two sources of distortion introduced in the detection of signals by the detector. One might be called "frequency distortion," which is due to the detector being more efficient in rectifying, say, 2,000 cycles than it is in rectfying 200 cycles. This occurs in the case where a grid condenser and a large value grid leak is used, and can be practically eliminated by using either a grid leak of a megohm or less, or by using grid bias detection. The second source of distortion is introduced by overloading the detector.

If only one stage of audio amplification is used after the detector, grid bias detection is preferable, while if two stages are used, as far as the writer has been able to determine, there seems to be little difference which system is used, for in this case the last or power stage would seem to overload before the detector. The grid leak-condenser method has the advantage of considerably more signal strength, while the grid bias method tends to make the receiver tune somewhat sharper. Although the grid bias method is shown in the schematic diagram of the kit set, the set builder can use his own preference as to which he should employ.

In using four stages of amplification with the a.c. screen-grid tube, the problem of careful shielding was encountered. It was found, after a great deal of experimenting, that if the coils were shielded, condensers and tubes could be left outside the shielding, providing the leads to the tubes and condensers were short. Of course it was necessary to choose a condenser gang which had little capacity between the stator plates. It was also necessary to confine the radio frequency current flowing in each particular stage. This was done by placing the by-pass condenser tube, inside the shield which contained the and r.f. choke, in the plate circuit of each coil.

The problem of the size of tuning coils to use, when it was necessary to shield, was determined by the following method.

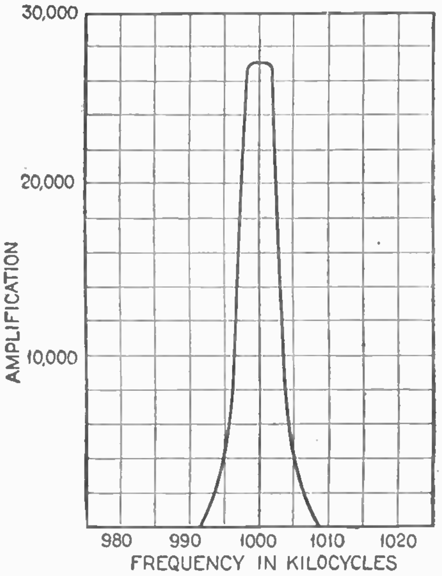


Fig. 3. *Here the tuning has been slightly staggered to obtain a flatter peak—hence less side-band cutting*

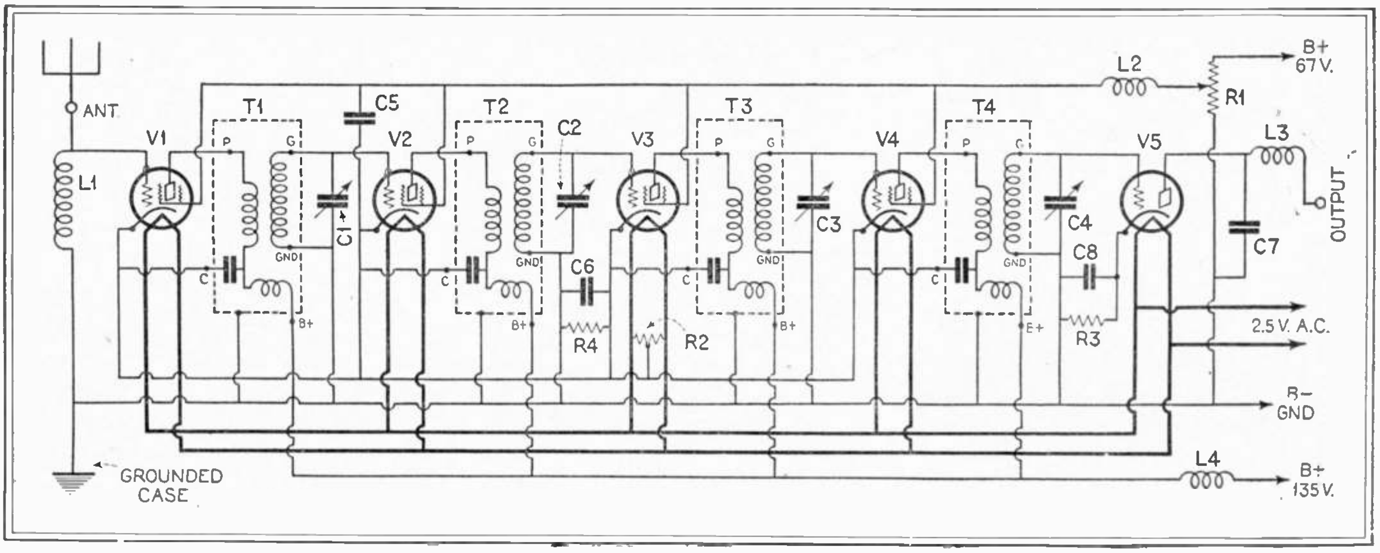


Fig. 4. *The circuit of the Velvetone a.c. screen-grid receiver*

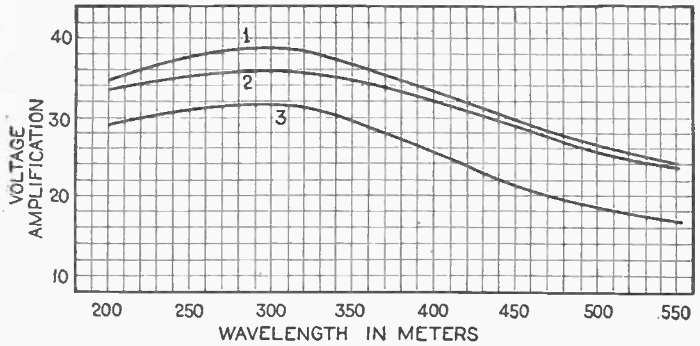


Fig. 5. *These curves are plotted to show the change of voltage amplification of the 1¼" coil, inside and outside of shield cans*

Assuming the size for the shields to be as large as physically practicable, we then measured the amplification of different sizes of coils when placed inside of the shields. It was found that a coil of 1¼" diameter was considerably the best under these conditions; though of course, with no shielding, two or three-inch diameter coils were somewhat superior.

The reader may be interested to note the change of amplification of the 1¼" coils inside and outside the shields. This is shown in Fig. 5.

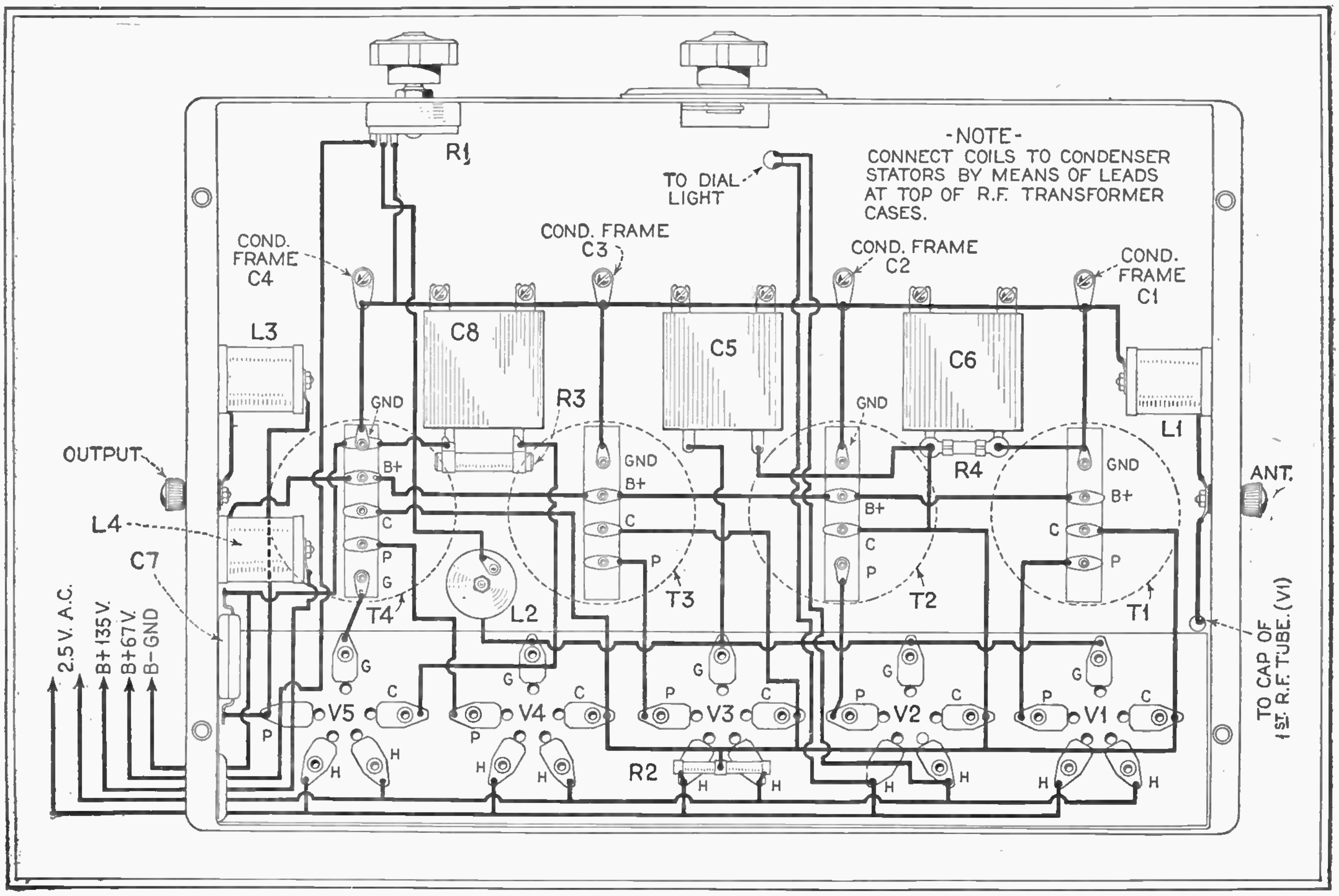
In the course of our experiments, steel shields were tried and Curve 3, Fig. 5, shows the result. It will be seen that the loss due to steel shielding is very much greater on the long wavelengths than on the shorter ones. This was carefully checked and certainly appears to be the case; the possible explanation being that the longer wavelengths (lower frequencies) penetrate further into the shield than do the shorter wavelengths.

It was thought advisable to make a single control kit, and therefore an untuned antenna system was used consisting of a radio frequency choke coil connected in the circuit as shown in Fig. 4. This system has an added advantage, besides the single control feature, in that the amplification of the radio frequency transformers falls off slightly on the long wavelengths, while the choke coil antenna system is more efficient on the long waves. Thus the combination gives a more even gain over the broadcast range than would otherwise be the case.

The actual construction of the four-stage tuned radio frequency kit set is quite easy, as the National Company supplies the base with the sockets in place, and the coils are obtainable in sets of four, all matched. The leads are brought out from the coils to a small terminal strip mounted on the bottom of each shield. To facilitate wiring, the control grid lead is brought out in two places—one for connection to cap of the UY-224 and the other for connection to the stator plates of the variable tuning condenser.

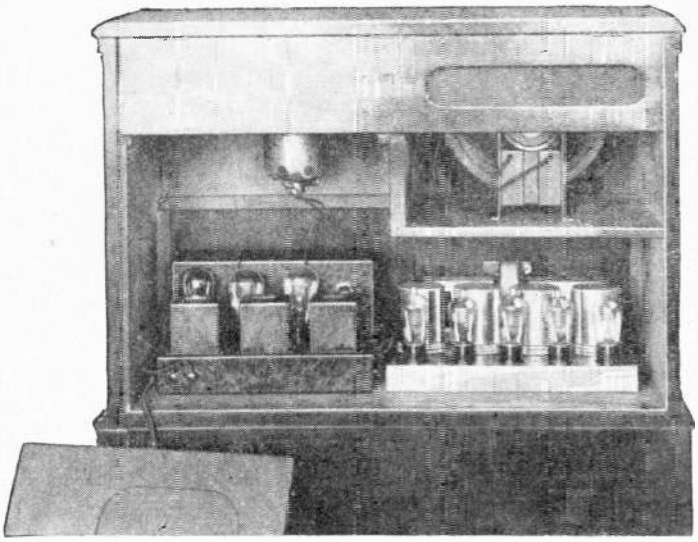
The condensers used with the kit have small trimmer condensers built in each one, the purpose of these being to line up the condensers and compensate for any capacity in the wiring. Once the condensers are lined up at minimum capacity, they are so matched that they will turn within 1 per cent over the broadcast band. This accuracy in matching allows for about the right amount of staggering in the combined stages, provided that the error is not accumulative. To take care of this, the coils and the condensers are both numbered, so that the right coil is associated with the correct condenser. For convenience, one of the rotor plates in each condenser is slotted into sectors which may be adjusted by the constructor, should the occasion arise.

In wiring up the set, it is advisable to wire the filament circuit first. Number 16 guage insulated wire, twisted together, should be used for this purpose. Do not use too small wire, for the filaments of the five tubes combined take a total current of seven amperes. The center tap resistance should be connected to the second screen-grid tube, as shown in the schematic diagram, and the center of this re-

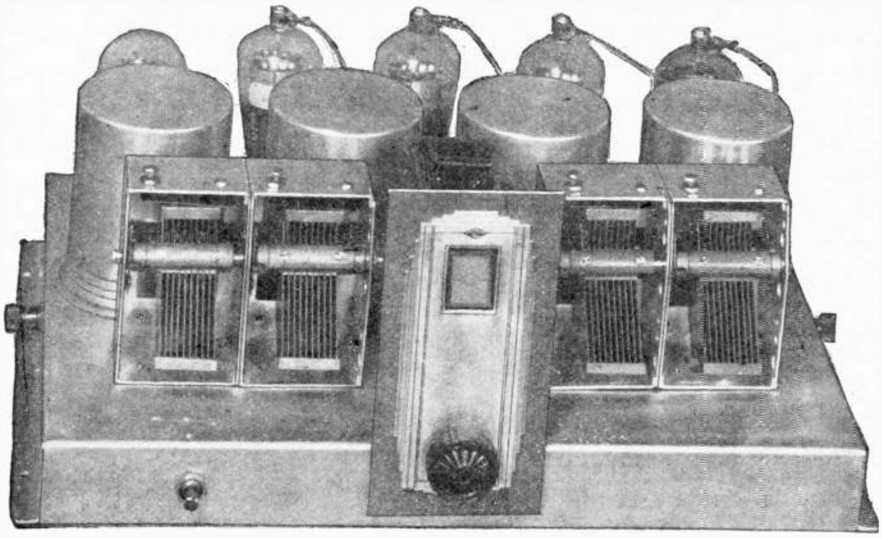


As this picture wiring diagram shows, all the wiring, with the exception of the leads to the caps of the screen-grid tubes, is made underneath the base sistance run to the cathodes of all the screen-grid tubes. Instead of using the shield as a ground, it is better actually to run a piece of bare wire to the various ground connections. This eliminates the possibility of a high resistance joint which might make the receiver tune broadly; or, as in some cases, such joints have been the cause of sufficient inter-coupling to bring about set oscillation. This "ground" wire should be connected to the chassis in several different places.

It will seem that even though one end of the coil is connected to the shield, a wire is also brought out so that the connection may be made to the ground terminals of each condenser. The by-pass condensers, in the shield compartments that hold the coils, have a connection coming out through the shield, marked "Cathode." This allows the by-passed radio frequency current to return without going through the resistance used to obtain the "C" bias.



A rear view of the console cabinet housing the Velvetone tuner, "245" power amplifier, dynamic loud speaker and phonograph turntable



A front view of the chassis ,showing the extremely simple assembly

These leads should be run as directly as possible to cathode of the tube associated with the transformer. The radio frequency chokes, external by-pass condensers, and grid biasing resistors are located as shown in the layout of parts.

It will be noted that the mechanical design of the set is such that all the important grid and plate leads are exceptionally short.

If grid bias detection is used, as indicated, the set builder should experiment somewhat with the amount of "C" battery for best results. Usually, with 45 volts on the plate of the detector, about six volts "C" battery is correct. However, this depends somewhat on the characteristics of the 227 tube used as a detector. If the constructor desires to use a grid leak and condenser for detection, the condenser (having a value of .00025 mfd.) should be connected between the grid and the tuned circuit, while the grid leak, having a value of about one megohm, should be connected between the grid and the cathode of the detector tube.

The volume control chosen is a potentiometer of 10,000 ohms, connected between the minus "B" and the plus "B" 67 volts. The variable arm goes to the screen grid of the tubes through the radio frequency choke coil. In this manner the potential on the screen grids may be varied over a range of from 0 to 67 volts. This type of volume control has the advantage of being completely out of any circuit where alternating current is flowing, and consequently simply regulates the amount of amplification of the screen-grid tubes. In most potentiometers the shaft is connected electrically with the movable arm so that it is necessary to use an insulating bushing where the volume control comes through the metal base.

This kit set may be used with any radio amplifier system the set builder may prefer. The writer has used the National Velvetone amplifier and power supply, which was described in the June, 1929, issue of Radio News. This amplifier has the correct voltage taps for the power supply and also has a separate transformer winding which will supply the filament current for the five heater type tubes used in the tuner. It is essential that a separate filament winding be used to supply the filaments of the tubes in the tuner. This audio amplifier consists of one stage of transformer-coupled audio amplification using a 227 tube, follower by a stage of push-pull amplification employing the new 245 tubes. It is not essential to use two stages of audio amplification, for if "C" bias detection is used, the output of the detector may be put into the primary of an audio transformer,

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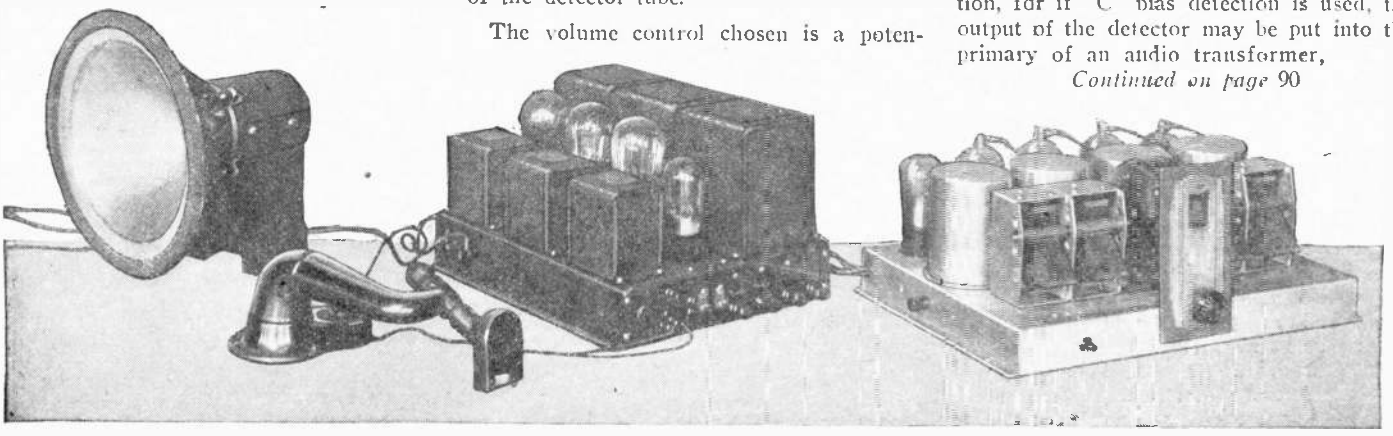


The elements of a complete radio-phonograph combination

The "Velvetone" 245 Push-Pull Amplifier

The Latest Development in Power Tubes Utilized in an Audio Channel and Power Unit Adaptable to Many Purposes

By James Millen

DURING the past four years, since a unit combining an audio amplifier with a socket-power current supply was first described in a radio magazine, the fundamental soundness of such design has become quite firmly established; and today any number of well-known manufacturers are marketing combination amplifier-power supply devices for both radio and phonograph use.

In the past, however, manufacturers as well as experimenters have felt that the alteration of the amplifier's design from, perhaps, a 171A power stage to one employing such tubes as the 210 or, more recently, the 250 entailed too great an outlay for the bulkier and more costly equipment necessarily required to power such tubes.

The new UX-245 power tube with its high power output at low plate voltages now makes possible the design of much more compact and lower-priced "B" power-supply units and amplifiers of this character; and this development will no doubt become, during the coming season, an important factor in stimulating the use of such amplifiers.

But why the combination of audio amplifier and power supply? The question of separating the tuner unit of a radio receiver from the audio "channel" has been argued pro and con by designers, engineers and experimenters; and it is not the intention of the author to pass judgment on such a debatable issue. Suffice it to point out that the demand for combination amplifier-power supply units exists to an overwhelming degree, and this article is intended to describe to the reader the outstanding and important features of commercial units which are now available, together with those of one that can be built at home.

The uses of these power amplifier-power supply devices are many. To the experimenter they offer the important advantage of having on hand a standard audio channel to which can be attached a radio tuner unit of any type with which he may be experimenting at the time. These power packs provide a ready source of plate potential for the tubes external to them, such as those which are used ı the tuner. A combination of audio channel and power-supply unit also lends itself admirably to the all-electric reproduction of phonograph records, with the assurance that the tone quality obtained will be far superior to that obtained from the old-time phonographs and will be on a par with that of electric phonographs of commercial types which are now available. (This, of course, necessitates that an electric pick-up of merit and repute should be used with it). Then, for the fellow who wants to build an outfit consisting of both radio and phonograph units, there is nothing more suitable than just such a combination; for thereby he can, with the aid of a switch, make use of the audio amplifier's power supply for either radio or phonograph use.

SINCE 1925, when he developed and described what was perhaps the first combination of an amplifier and power pack available to the radio public, Mr. Millen has introduced many carefully-engineered assemblies to the readers of RADIO NEWS *and other periodicals. He has been associated for some years with the National Company, to the general management of which he has worked his way, and has been the leader in its engineering work.*

There are three major points, not always apparent, but which must be simultaneously met in the design of a combination amplifier-power supply: the arrangement of the various parts in such apparatus must always meet these three conditions. First, the locations of the various audio and power transformers, relative to each other, must be such to preclude any possibility of stray-field linkage; which would result in either A.C. hum in the output or distortion. Generally, most trouble is encountered in finding the proper location for the first audio transformer; as any A.C. field from the power or filament transformer which links with the windings of this input transformer results in a hum, which is passed through the entire amplifier and thus becomes quite pronounced in the output.

The second and third points which must be given due consideration in locating the various parts are simplicity of wiring and compactness of the completed unit. In the case of the National "Velvetone" amplifier illustrated here, the first condition was met by so placing the various transformers in their containers as to prevent undesirable electromagnetic intearction. Just how successful this procedure turned out to be is illustrated by the entire absence of A.C. hum in the output. As to simplicity of wiring and compactness of design let Figs. A and B speak for themselves.

With the advent of the new UX-245 power tube it now becomes possible to reduce very materially the cost and size of a combination amplifier-power supply, because of the high power output obtainable from this new tube with a low plate voltage. The following table, comparing some of the more important characteristics of the UX-245 with those of earlier types of power tubes, should prove interesting.

Tube	*"B" Plate Voltage*	*Maximum Undistorted Output (Milliwatts)*
112A	90	30
	135	120
	180	300
171A	90	130
	135	330
	180	700
210	250	340
	350	925
	425	1540
250	250	900
	350	2300
	450	4600
245	150	400
	200	900
	250	1600

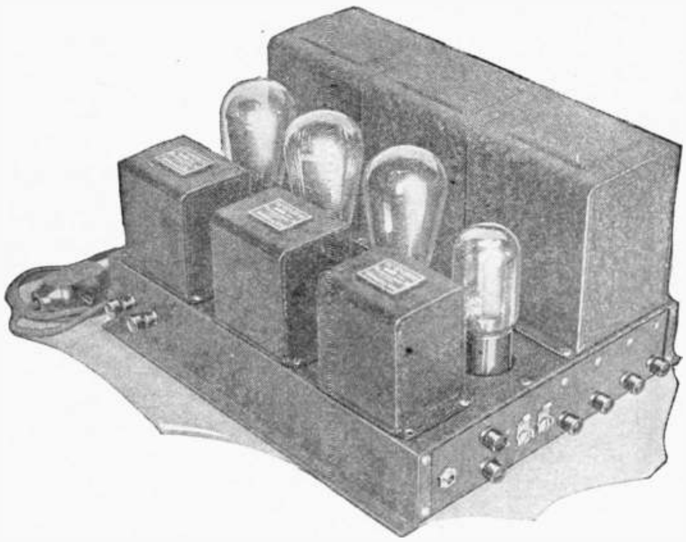


FIG. A. *A front view of the "Velvetone" amplifier assembled. The power transformer, filter chokes and large Mershon condenser are in the rear cases; the three audio transformers in front. The terminals at the side are connected to other apparatus as shown in* FIG. 2.

The advantages of the new tube which this table shows are evident. Note that the 210 tube, with 250 volts on the plate, provides an undistorted output of 340 milliwatts; while the 245 with the same plate voltage offers a maxibum of 1600, almost *five times as much.* Compared to the 250 tube, the 245 provides a little less than twice as much undistorted output in milliwatts when operating at a plate voltage of 250. Also, it will be seen from the above table, the 245 with but 250 volts on the plate has a greater power output than the 210 with 425!

Some of the most important advantages resulting from the use of this low plate voltage are the reduction in cost, improved performance and freedom from condenser trouble made possible in the power-supply unit by the use of a Mershon electrolytic condenser in place of the paper condenser necessary at the higher voltages. This type of high-capacity condenser is suited to use in filter circuits supplying under 350 volts and, as the maximum voltage required for the UX-245 is 300 (250 plate plus 50 grid) we are able to operate with a considerable margin of safety.

The UX-245 was designed especially for A.C. operation and, as a result, has a husky low-voltage, high-current, oxide-coated filament with a high "heat-inertia coefficient;" so that it is not adversely affected by ordinary line-voltage fluctuation.

Although the filament voltage is 2.5 (which is the same as that required for the heaters of the UY-227 and the new UY-224) a separate filament winding is necessary for the power tubes. This is to obtain the grid-biasing voltage in the most satisfactory manner and without putting the same high bias on the heaters of the UY tubes; which would result in increased hum and possibly, in some cases, insulation break-down between the UY cathode and heaters.

THE AUDIO TRANSFORMERS

The audio transformers used have cores of the new high-permeability nickel steel; this, in connection with the use of a special type of split-secondary winding, results in a frequency-characteristic which is essentially a straight line over the entire range of audio frequencies now being transmitted by the better broadcast stations. The push-pull transformer has two independent secondaries wound in opposite directions and placed side by side, in order to secure truly balanced performance.

POWER SUPPLY NOTES

Aside from the use of the new triple-section high-capacity Mershon filter condenser (which is made possible, as pointed out above, by the relatively low plate-voltage requirements of the new power tube) there are several circuit features worth mentioning. Perhaps the most noticeable, from the circuit diagram, is the use of separate filament and plate transformers; which makes possible a reduction in hum, compare dwith the use of a single transformer for this purpose. Both the plate and filament transformers are wound with wire much heavier than generally customary, in order to supply "A" and "B" voltages for any R.F. amplifier-tuner with which the amplifier may at any time be used.

From the transformers we pass to the UX-280 rectifier, which has recently been improved in design and re-rated for use with transformer-secondary voltages as high as 350. In this instance, the secondary voltage on each side is but 300; so that the tube is being conservatively operated.

Because of the high capacity of the

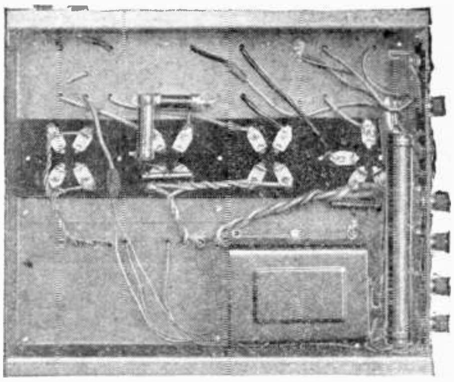


FIG. B. *A bottom view of the "Velvetone" chassis showing the voltage-divider and by-passes at the right*

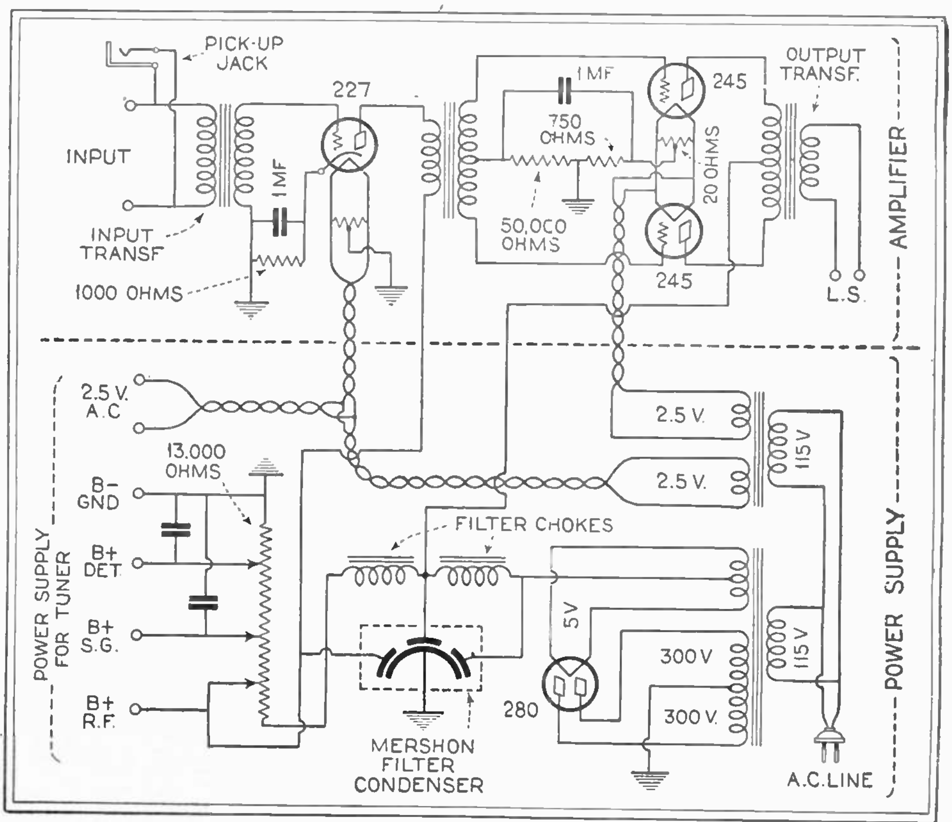


FIG. 1. *The "Velvetone" provides 2½-volt filament current for a receiver, as well as for its own tubes, all of which operate on this supply. Note the system of by-passing all stages in this unit.*

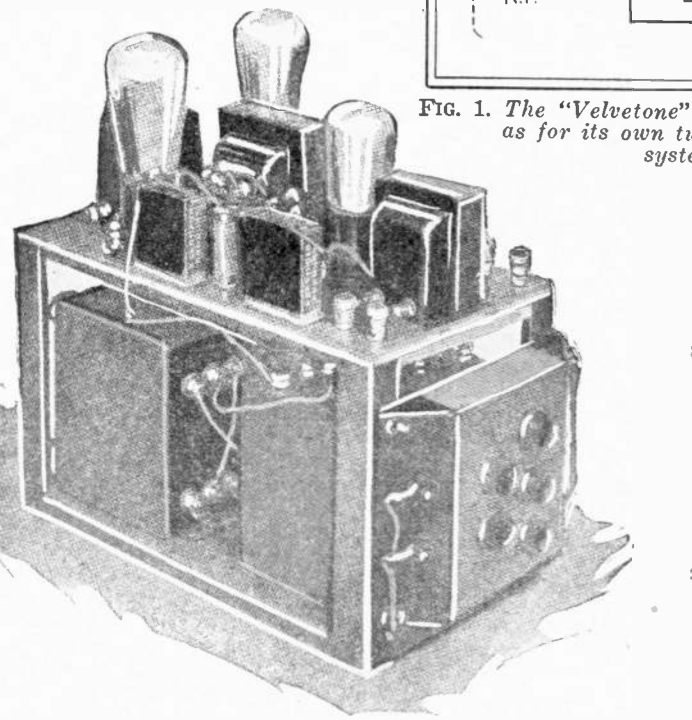


FIG. E. *The double-deck amplifier and power pack at the left was designed in the* RADIO NEWS *Laboratory for home construction. The two decks may be mounted separately*

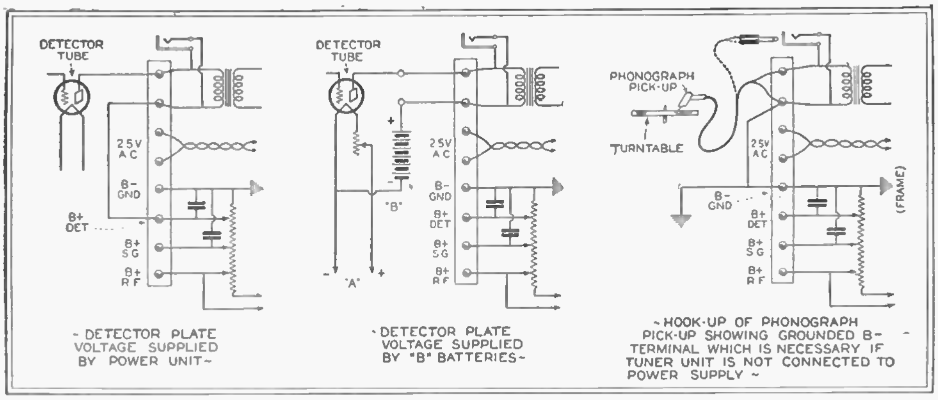


FIG. 2. *The "Velvetone" is connected to an A.C. tuning unit externally, as at the left; to a D.C. tuner as in the center diagram; while the connection at the right gives phonograph reproduction of a high quality with volume of any desired amount. It will operate three or more loud speakers.*

Mershon condenser, a single filter section is ample for the push-pull stage. Another section is then added for the first-stage plate supply as well as the external voltage taps (all of which should be operated as near hum-free as possible, if there is to be no hum in the loud speaker). A circuit novelty which works out exceedingly well is interposed at this point; it is the manner of connecting the third section of the Mershon condenser so that it provides exceedingly effective by-passing and tank-capacity service for the first audio stage, in addition to its filtering action. Thus, both the push-pull stage and the input stage have their own independent tank condensers; this refinement is found in few amplifiers, but is one of the many little points that must be considered where the best possible tone quality is to be attained. The remaining features of the power system are the output potentiometer (of an adjustable type) which makes it readily possible to secure accurate voltage adjustment for the detector and radio-frequency amplifier without danger of applying excessive voltages to the various tubes; yet, at the same time, there is certainty that these voltages, when once set, will remain at the selected values.

Fig. 2 shows three ways in which the combination unit may be used. If it is desired to connect to it a tuner unit which has no plate-voltage source of its own, then these various voltages may be obtained from the taps brought out on the terminal board of the power unit. At the left such a circuit of the detector table is completed by means of a connection between one of the input ter-

(*Continued on page* 71)

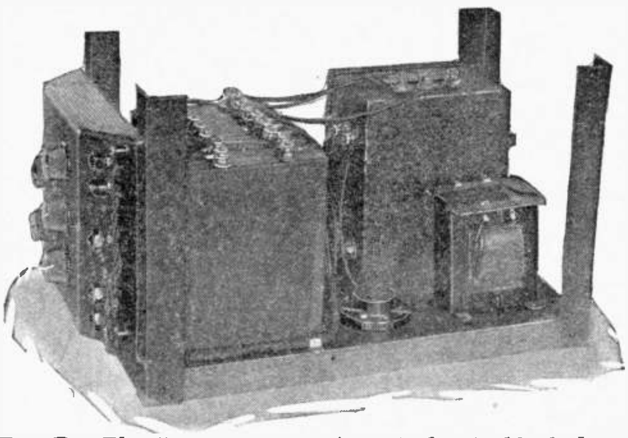


FIG. D, *The "B" power section of the double-deck unit illustrated opposite.*

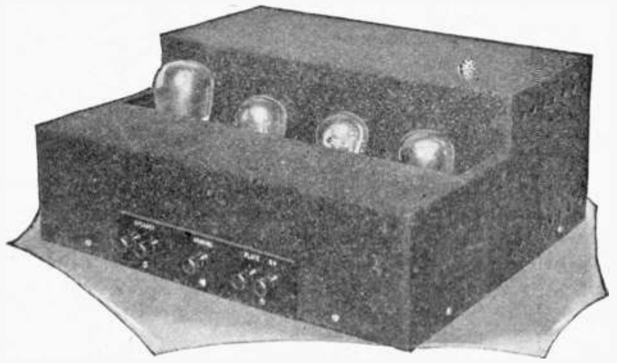


FIG. C. *Another of the commercial amplifiers and power units now being placed on the market for the new "intermediate" 245 tube. This is of Ferranti make.*

Ten Instructions for the "DX" Fan

(1) Good reception begins with the interception of ample signal strength. Therefore, make sure of good aerial and ground connections. Joints should be soldered, or at least taped. A suitable socket antenna plug will sometimes prove more efficient than one outside antenna, particularly in poor radio localities. It may be employed as a "booster," in addition to the usual antenna.

(2) Reception can be no better than the tubes employed. Tubes, contrary to general opinion, do not last forever; even if they light, that is no indication of their goodness. When tubes have been in use more than a year, they should be replaced with fresh tubes. Only tubes of a reliable brand should be used. Cheap tubes are most expensive in the end.

(3) Proper "A," "B" and "C" voltages should be applied. In the case of batteries, this may be done by voltage taps. In the case of radio power units, this may be done by employing efficient variable resistors in obtaining precise voltages for all purposes.

(4) The grid leak in the detector circuit should be adjusted for best results. While the 2-megohm value may be satisfactory for powerful local signals, this resistance value is sometimes too low for weak DX signals. Either a collection of grid leaks of various values should be on hand ,or a suitable variable grid leak should be employed, if you would enjoy DX results.

(5) Regeneration is practically essential to real DX results. It can be secured in various ways, for practically every radio-frequency circuit has some form of stabilizer to prevent regeneration, and this can be altered when in search of DX, so as to permit of regeneration or approach to maximum sensitivity.

(6) A sensitive loud speaker should be employed, or, better still, a pair of head-phones, plugged into the first audio stage. **Many loud speakers today are relatively insensitive** because they are designated to operate on powerful local signals without blasting.

(7) It is well to change tubes around to determine the best tube for each position in the radio set. There is sufficient variation in most tubes to make some better for one purpose than for another.

(8) If you are troubled by excessive background noises or microphone interference, the cause is generally traceable to the detector tube, which should be changed.

(9) By-pass condensers of 1 or 2 mf., connected between "B—" and the various "B+" terminals of the radio set, will improve sensitivity and tone quality of weak signals.

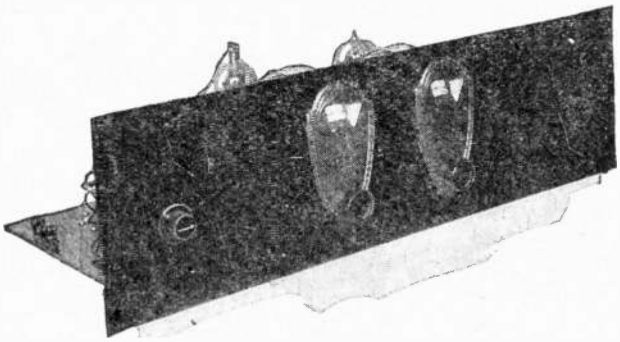
(10) And in the final analysis, DX is largely a matter of patience and skill; for some fellows can hear* Hong Kong on a crystal detector while others cannot cover 500 miles with an eight-tube superheterodyne.

—*Clarostat Engineering Bulletin.*

* Those who *really* do so are, as a rule, in Hong Kong.—EDITOR.

How to Build the New A.C. Screen-Grid "Everyman" Tuner

By Zeh Bouck



The attractive panel appearance of the "Everyman" may be seen at the left, as it appears ready to slip into a suitable console or cabinet.

ONE of the most efficient receivers which has been presented to the constructional fan (and to the average broadcast fan through the efforts of the custom set builder) was the Everyman Five, an exemplification of well-established engineering principles, designed by the radio technicians of the *New York Sun.* The receiver was introduced originally as a battery-operated set, which necessarily limited its popularity in this era of A.C. receivers. However, as a veteran critic of broadcast conditions, the writer has no hesitancy in describing this receiver as almost ideal; its qualifications of relative perfection being simplicity of construction, reasonable cost, flexibility in adaptation to audio channels, and selectivity and sensitivity in the correct degrees.

Appreciating the limitations of the battery-type receiver, he has redesigned the set for Arcturus A.C. tubes, and the resulting

WE describe here the latest of a series of developments of "Everyman" receivers under the auspices of the radio editors of the New York Sun, *and in which some of the best engineering brains of the country have cooperated. Mr. Bouck, who has been intimately associated with the progress made in all electric receivers, speaks with authority on the subject; and his contribution is hereby commended to all our readers.*—THE EDITORS.

equipment is presented herewith to the readers of RADIO NEWS, in the form of an R.F. tuning unit, complete in itself, and adapted excellently for use with an external amplifier of any desired type. A push-pull audio channel, adapted to operation from the same filament transformer as the tuner, is also shown.

The characteristics of the A.C. Screen-Grid "Everyman" tuning unit are similar to those of the D.C. model, with the exception of its noticeably increased sensitivity—due to the extra amplification effected by the use of an Arcturus A.C. 22 screen-grid tube, the characteristics of which are superior to those of the conventional D.C. four-element tube.

In the A.C. Screen-Grid "Everyman" unit, both selectivity and sensitivity have been refined and emphasized to the last degree compatible with quality; and in this set these characteristics are easily and conveniently controlled. Without recourse to

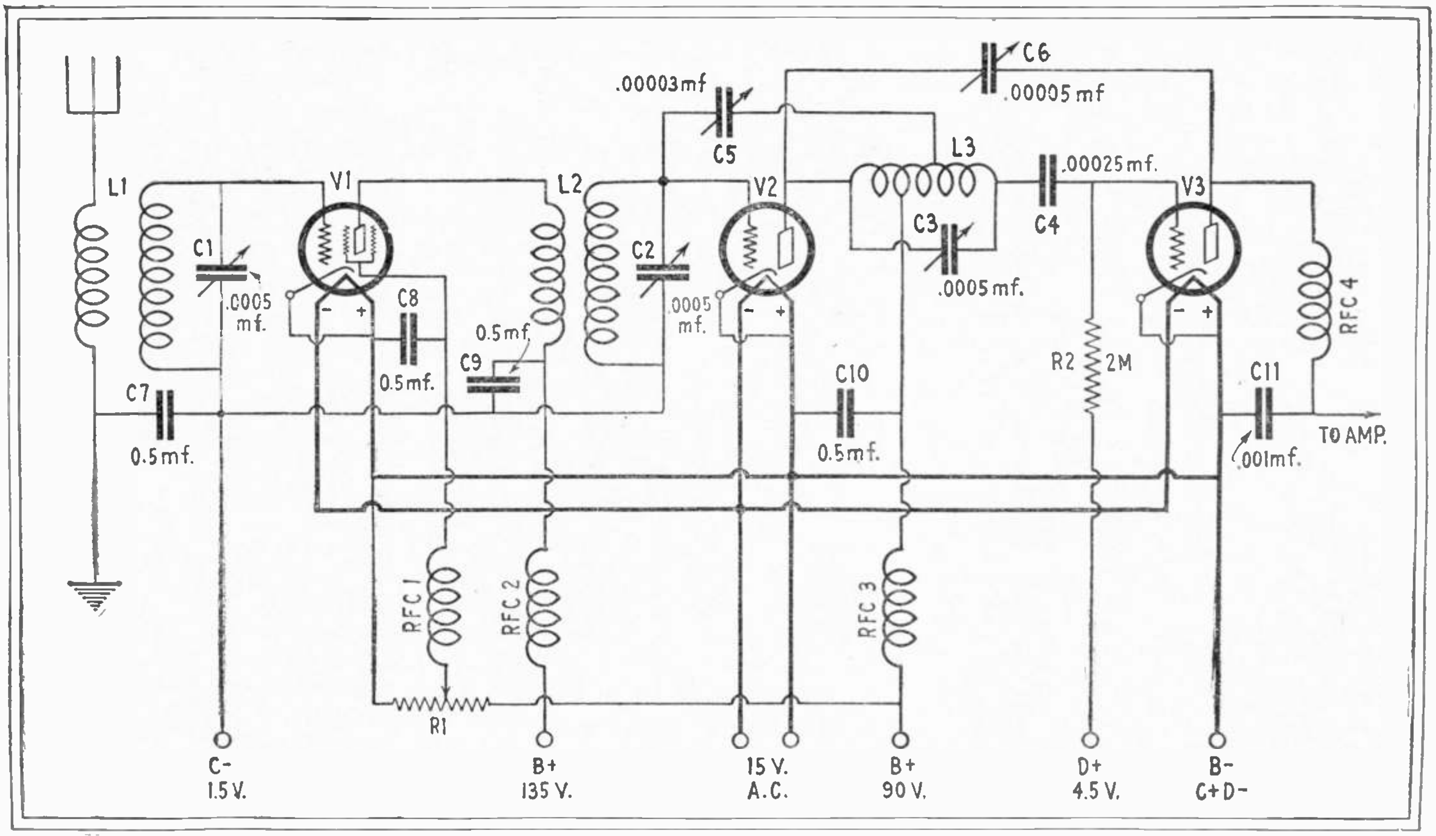


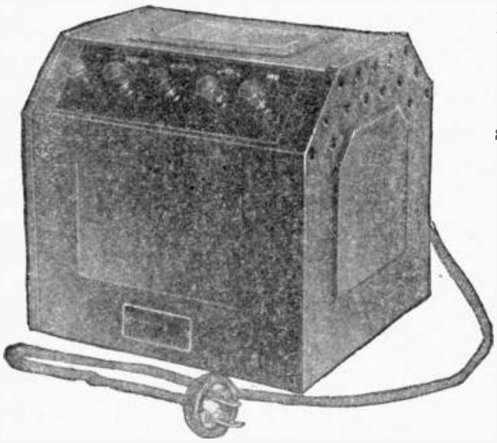
Fig. 1

The "Everyman" Tuner shown here, using three 15-volt A.C. tubes, the first in a screen-grid stage, is a complete receiver. With a suitable audio channel, such as that on page 1104, it will operate any speaker selected, and give results of high quality.

regeneration, the sensitivity of the receiver is such that practically all stations, both local and distant, contributing to the average evening's entertainment, can be tuned in on a short indoor antenna. The noise level, under such conditions, is maintained at a satisfactory minimum, and reception comes through unimpaired by background. But when regeneration is introduced, with a turn of the right-hand knob, the sensitivity of the receiver is noticeably increased; and the ratio of noise level to signal strength is the only limit to reception.

FIFTEEN VOLT TUBES

The A.C. Screen-Grid "Everyman" tuner is built around the Arcturus line of 15-volt tubes; these are of the heater-cathode type, yet plug into the standard UX four-prong



socket. The cathode construction renders them practically humless, and the use of a carbon heater insures a long life measured in thousands of hours.

The schematic diagram of the R.F. and detector stages of the unit is Fig. 1, and the layout of the parts is given in Fig. 2, which may be compared with the reproduced photographs. The first tube (glancing from left to right) is the screen-grid amplifier V1. The second tube V2 is included in a somewhat conventional radio-frequency amplifying circuit and is of the familiar three-element type. The third tube in the R.F. section of the receiver, V3, is the detector, arranged for grid rectification in Fig. 1.

The circuit is stabilized by a semi-permanent adjustment of the duplex Clarostat R1, which controls amplification by varying the bias on the screen-grid of V1, and by the .00003-mf. balancing condenser C5. When correctly adjusted, the circuit is stable over the entire tuning range with unusual gain characteristics.

Stray coupling effects are reduced to a minimum, without recourse to shielding, by the spacing of the coils, and by the generous use of the radio-frequency choke coils RFC 1-2-3-4, and the by-pass condensers.

THE RADIO-FREQUENCY UNIT

In this article, as will be seen, only the radio-frequency section of the receiver is reconsidered and illustrated in detail. As this receiver will be built almost exclusively by experts and by custom set builders for the broadcast enthusiast, the choice of the audio amplifier is left to individual preference, which will be governed principally by the power desired in the output circuit.

It is in the radio-frequency circuit that the "Everyman Five" differs from the conventional receiver and exhibits its distinct superiorities. The output of the detector can be coupled to any adequate audio frequency amplifier. A preferred design for the audio amplifier will be indicated later on.

Fig. C

A special National "A and B" power unit, designed to powerize the "Everyman" Five.

LIST OF PARTS

The following parts are required to build the A.C. Screen-Grid "Everyman" tuner illustrated here.

One Set Twin Coupler "Everyman Five" coils (L1, L2, L3);
One National "Everyman Five" assembly, consisting of two drum dials and three .0005-mf. variable condensers mounted and coupled (C1, C2, C3);
One .00005-mf. Camfield midget regeneration condenser (C6);
One .00003-mf. Camfield midget balancing condenser (C5);
One Muter 2-megohm grid-leak and mounting (R2);
Three Eby UX sockets;
One Muter grid condenser, .00025-mf. (C4);
Four Muter by-pass condensers, ½-mf. (C7, C8, C9, C10);
Four Muter R.F. choke coils, 85-millihenry RFC, 1, 2, 3, 4);
One bakelite panel, 7x24 inches;
One Yaxley 7-wire cable and plug;
One sub-panel or baseboard, 7x23 inches;
One Duplex Clarostat (R1);

It is recommended that the inductance coils be bought ready-made. However, they may be wound at home, if desired, to the following specifications: There are four distinct coil units: as in L1. The antenna primary and its secondary are separate. The R.F. transformer L2, consisting of primary and secondary, is on one form, as also the coupling coil L3.

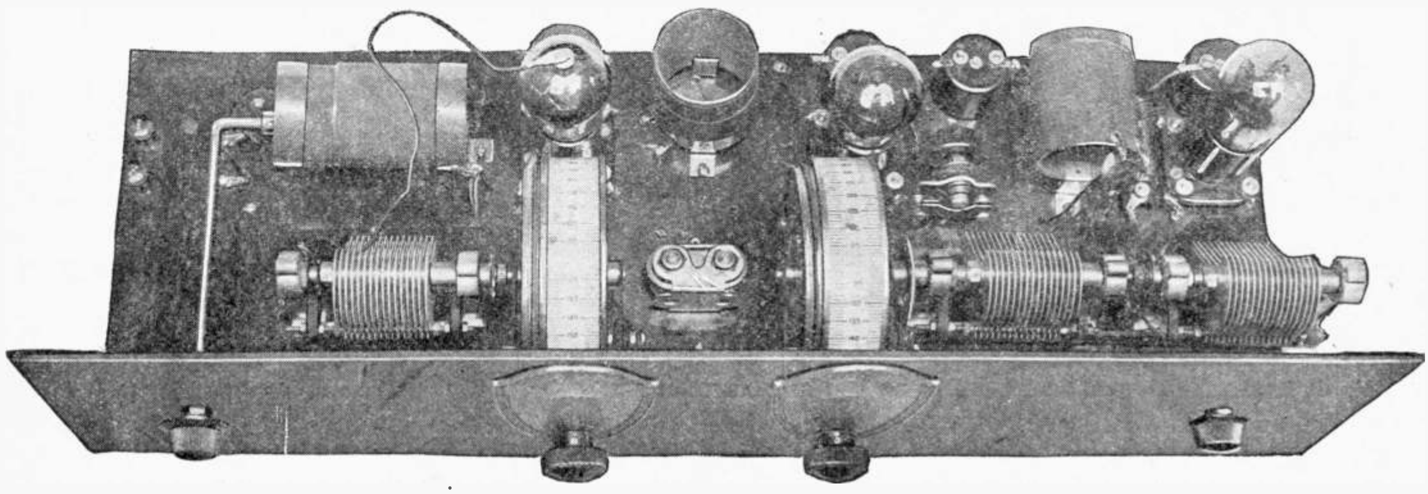
All coils are wound on bakelite tubes having an inside diameter of 2 inches; the antenna primary is wound with 18 turns of No. 22 D.S.C. wire, and its secondary with 70 turns of the same. L2 also is wound with 70 turns of No. 22 D.S.C. wire, brought out to lugs on each end of the coil, for the secondary; while the primary is wound over the secondary, in the same direction, with 40 turns of No. 24 D.S.C. wire. The coupler L3 is wound with 70 turns of No. 22 D.S.C., and is tapped at the 21st and 49th turns.

ASSEMBLY

The constructional details of the receiver are sufficiently indicated in the wiring diagram (Fig 1) and layout (Fig. 2) as well as the pictures of the completed receiver. However, there are one or two points worthy of special emphasis.

The following procedure should be observed in wiring the coils: referring to Fig. 2, when the adjustable primary of L1 is closely coupled to the secondary, its terminal nearest the latter is connected to ground — the other end, of course, being wired to the aerial post. The top end of the primary of L2 (the end of the primary terminating at about the middle of the coil) is connected to the plate of the first R.F. tube V1. The lower terminal of the primary is wired to the choke coil RFC2. The lower end of the secondary (the terminal nearest the low or battery end of the primary) is wired, as indicated, to the "C—1.5" terminal of the receiver. The other end of the secondary goes to the grid of the second tube V2. Then L3 is connected as shown in the wiring diagram. As it is symmetrically tapped, only the relative positions of the taps are important and these are indicated in Fig. 1.

In wiring the unit, care should be taken to wire all "F+" terminals together. The



The placement of parts in the "Everyman" Tuner illustrated above is such that every component is given ample room, and interstage coupling is limited to the minimum without shielding. The receiver is especially adapted to use with a separate amplifier.

cathodes of the tubes are common, with the heater terminal plugging into the "+" prong of the socket. As already stated, the tubes used in the R.F. section of the "Everyman Screen-Grid Five" are all of the Arcturus fifteen-volt type. The first tube is a screen-grid A-C22, the second an amplifying tube, A-C48, and the third the detector tube type A-C26.

These tubes require 15-volt A.C. filament or, rather, heater potential, which is supplied from any suitable step-down transformer, such as the Thordarson type 121.

SPECIAL POWER SUPPLY

The National Company has designed for the "Everyman Five," a special combination "A and B" supply (Fig. C) that incorporates a step-down transformer with a 15-volt secondary for these tubes. Using this power supply, it is necessary only to obtain the "C" and "D" potentials from external sources; these are most conveniently furnished by means of dry cells. The required voltages are 1.5 and 4.5 volts as indicated in Fig. 1. Any combination of supply sources, however, that will furnish the required potentials will be satisfactory.

The designation of the "D" voltage in the detector tube is self-explanatory to those familar with grid-rectifying circuits employing this 26-type 15-volt tube. It is merely a simple method of placing on the grid of the detector tube the necessary positive voltage which is secured, in battery-operated sets, by bringing the grid return down to the "+" side of the A battery. The "D" battery is merely a 4.5-volt "C" battery turned around.

OPERATION

The main consideration involved in making the preliminary adjustments on this receiver is the stabilization of the radio-frequency amplifier; this is obtained by the correct adjustment of both the balancing condenser C5 and the duplex Clarostat R1. Adjustments should be made on these controls when the receiver is tuned to a broadcast station in the neighborhood of three hundred meters. The circuit should be so balanced, by adjustments on R1, that it will oscillate when the .00003-mf. balancing condenser is moved in either direction from the stable adjustment. The regeneration condenser C6 should be at minimum capacity during these adjustments.

If the line voltage and the step-down transformer are correctly balanced, the tubes will heat to normal operation in exactly thirty seconds after the current is turned on. This condition will obtain when fifteen volts is applied to the heaters of the tubes; and it is at this voltage that the tubes are characterized by a life well in excess of two thousand hours. If the tubes heat to normal operation in less than 30 seconds, it is an indication that too much voltage is being applied to them. This should be reduced by putting a low-range power Clarostat or other voltage regulator in series with the line to the primary of the filament-lighting transformer, and adjusting until the proper time-lag is secured.

A PUSH-PULL AMPLIFIER

The diagram of Fig. 1A shows an audio amplifying system capable of delivering a large undistorted power output from any adequate input, such as will be obtained from the detector of the A.C. Screen-Grid "Everyman" tuner. This amplifier is conventional, but represents an arrangement that is practically perfect within reasonable operating limits. It consists of a standard push-pull power stage preceded by one straight transformer-coupled stage.

Fifteen-volt tubes are used in this amplifier also; thus making it possible to operate the heaters of the entire receiver from a single A.C. transformer. An A-C48 type tube is used in the first audio stage and two type 40 power tubes in the push-pull stage. Transformers recommended are the Amertran De Luxe or the Ferranti, designed for use with the 171 type of tubes. The output transformer should be, of course, adapted to

(*Continued on page 90*)

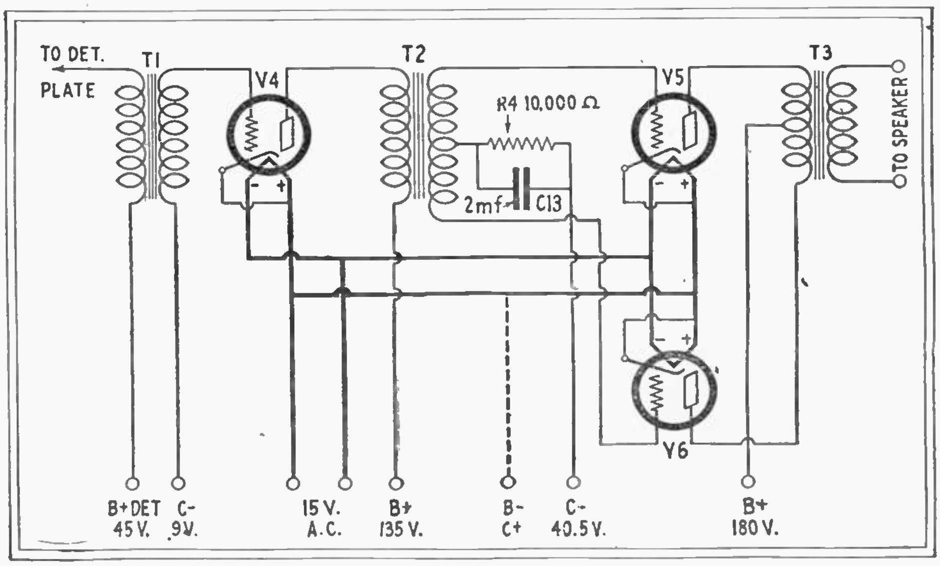


Fig. 1A

The audio amplifier diagrammed schematically here is especially well adapted for use with the A.C. Screen-Grid 'Everyman' Tuner; as it also utilizes 15-volt tubes throughout. The output is equivalent to that of 171-type tubes in push-pull.

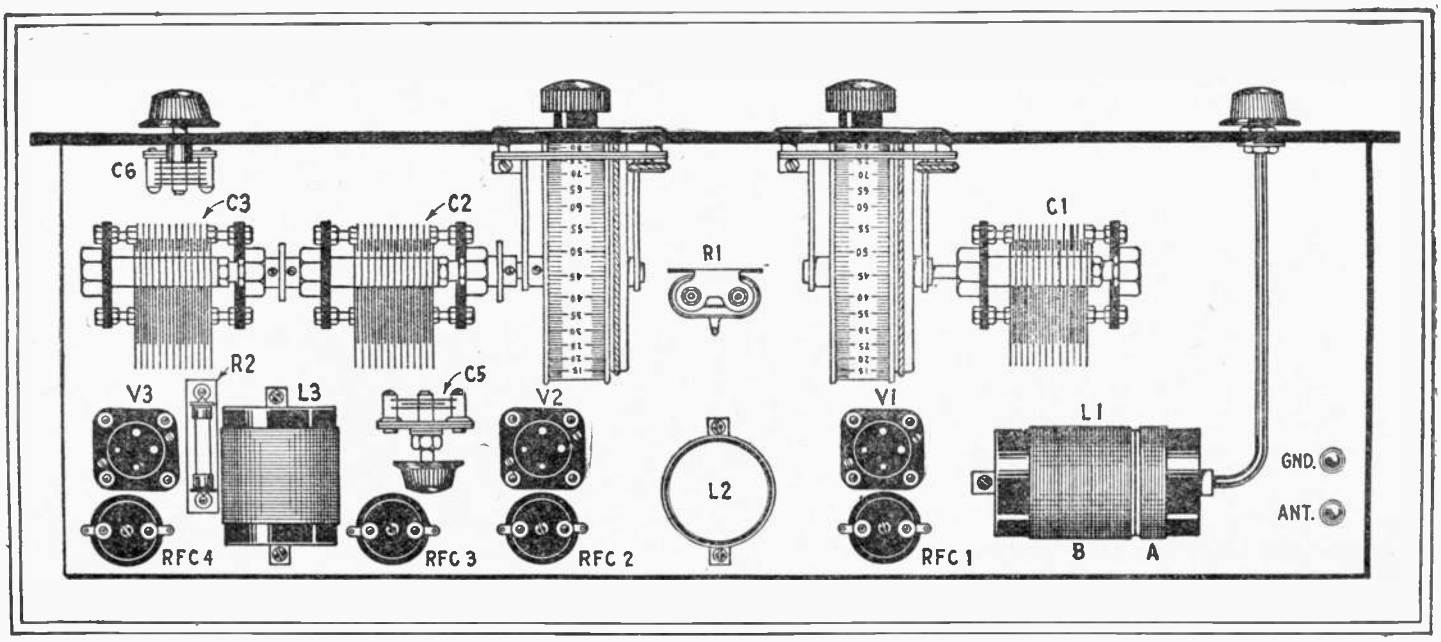


Fig. 2

The layout of parts for the "Everyman" shown here, in combination with the photograph on the preceding page and the schematic diagram (Fig. 1) will give sufficient details for construction; as placement is not critical if care is used to mount the coils at right angles.

The "Explorer Electric Eight"

A Single-Control Socket-Powered Receiver of Unsurpassed Tone Quality and Extraordinary Amplification

By John B. Brennan, Jr.

TO those who have observed the trend of modern receiver design, it is a significant fact that practically all the receivers now in popular use, and being manufactured on any considerable scale, employ a type of circuit that has been known to experimenters for a long time. Rarely is it found that a manufacturer has incorporated a so-called "trick circuit" in the receiver which he produces. The reason is not difficult to find; aside from the fact that conservatively designed receivers are easier to produce from an economical standpoint, they are exceedingly simple to operate, with an assurance of maximum satisfaction in performance, for an unskilled user.

It behooves the professional set-builder and experimenter, then, to benefit by the experience which the manufacturer has gained through years of labor and expense.

It has become an accepted fact that a person can build a better radio receiver than he can buy, and for less money, too. Without going into the economical features of such a discussion, this assertion can be borne out by the fact that a prospective radio set-builder, by virtue of the choice which he can exercise, may select well-nigh perfect units of radio apparatus, put them together in a receiver, and when he has completed the job, rest assured that his product is, in all respects save possibly a few details of finish, superior to a manufactured job. Included in a cabinet which he has selected to harmonize with his decorative scheme, the receiver's appearance is in no way affected by its "works."

MODERNIZING A STANDARD CIRCUIT

With this idea in mind, the writer set about selecting a suitable circuit for an instrument that would have, when completed, all those elements of good sensitivity, fine selectivity and irreproachable tone quality which go to make up the receiver de luxe.

Essentially the circuit employed in the receiver described here is the same as one used six or eight years ago. Yet it differs in particular from the original in that advantage has been taken of all the more worth-while improvements which have been developed within the past three years.

MR. BRENNAN, the designer of this set, who is well known to most radio set builders by his articles, was for some years the technical editor of Radio Broadcast, *and has recently accepted a similar post on* RADIO NEWS. *He describes here a receiver comparable with the highest (not the ordinary) type of commercial product, and above all one of the highest fidelity as a reproducer. Its amplification is all (and more) that can be utilized in ordinary radio locations.*

To bring home to the reader in a completely convincing manner the similarity and differences between the original and the improved tuned-radio-frequency circuits, it is necessary to digress for a moment and recount briefly the essential details of both.

The original tuned-radio-frequency circuit consisted, mainly, of a number of tuned radio-frequency amplifiers, usually three in number, and each tuned by its own tuning condenser. To such a tuning unit was added some form of accepted audio-frequency amplifier. Customarily, all this apparatus was strewn out on a baseboard, with its coil units arranged at all sorts of queer angles, to get away from interstage coupling. The panel was a veritable monstrosity, looking complicated enough to scare away the uninitiated with its many dials, tap switches and rheostats. In those days it was common enough, considering the tubes available, to build a set having a separate rheostat for each tube used. Wiring was considered an art for appearance sake, and much shiny bus bar with many perfect right-angle bends was the order of the day. While all this looked nice, it did not add materially to the efficiency of the apparatus or cause it to function suitably as a receiver.

In the audio end, small-sized, poorly-made transformers or impedance units served to amplify the received signal; but little or no attention was given to the all-important matter of tone-quality reproduction. In the case of resistance-coupled amplifiers, it was not unusual to employ flimsy paper-made resistance units with condensers of not too-efficient characteristics. Yet in spite of all this, we managed somehow to build receivers which worked, and in some cases worked extremely well.

Down through the years the parts manufacturers have, by careful, consistent research and investigation, each in his own field of endeavor, developed units which are undoubtedly more improved and perfected, both electrically and mechanically, than

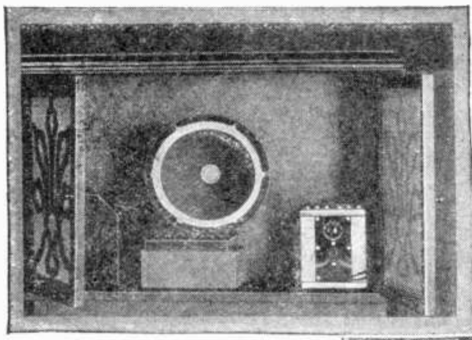


Fig. B
Behind the baffle necessary for low-note reproduction, we have the dynamic speaker and two power supply units, "A" at the right and "B" at the left.

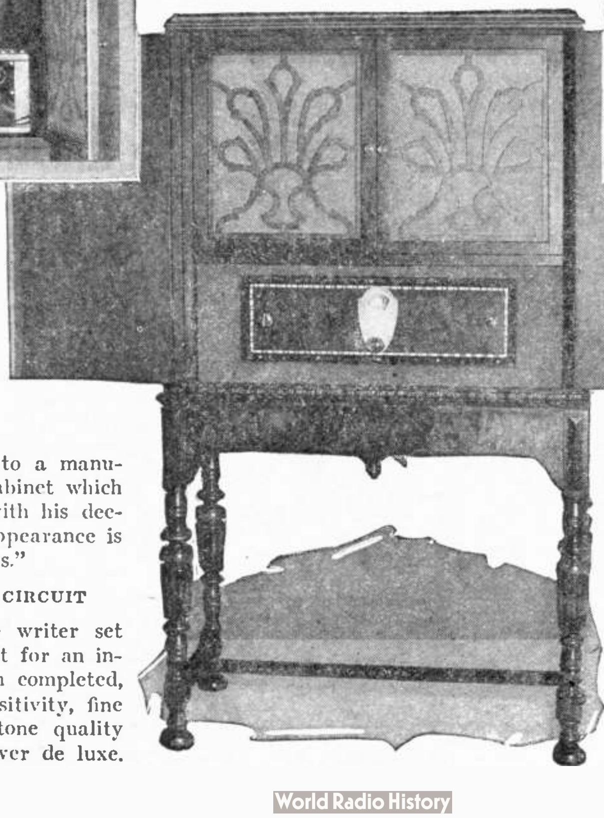


Fig. A
The "Explorer Electric Eight" in its parlor clothes, with the console doors opened. The upper grilles are closed over the speaker baffle; their light silk lends decoration without obstruction.

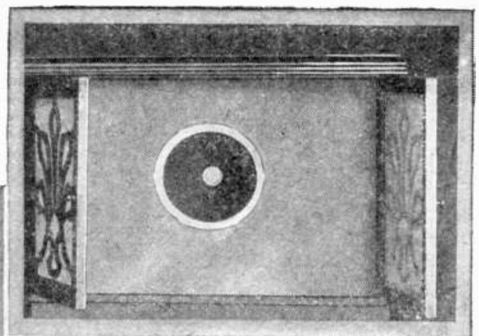


Fig. C
The dynamic cone only is to be seen through the Celotex baffle. Top, bottom and sides of the speaker compartment are lined with the same sound-proof material.

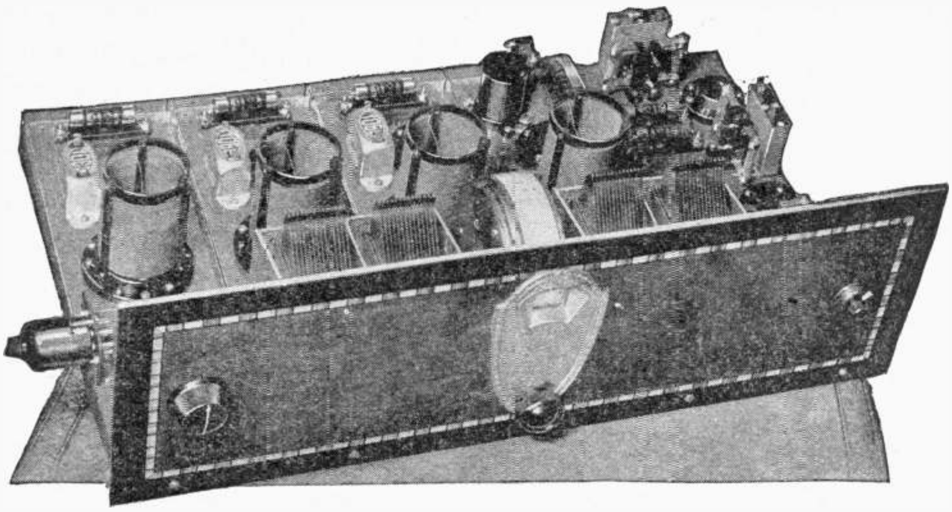


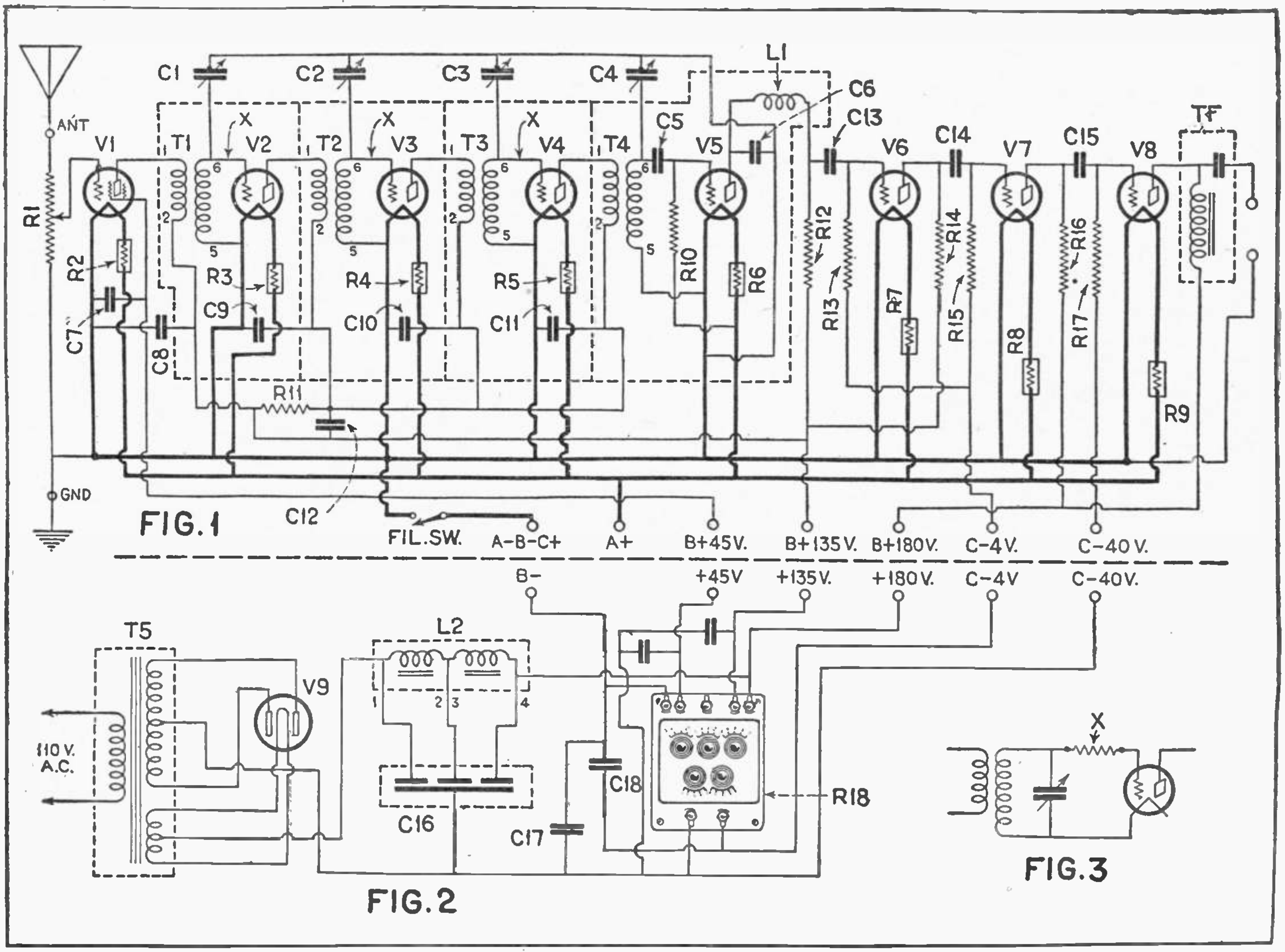
Fig. D
The "Explorer" from the front, with shields removed to show its compact layout.

their predecessors. It is natural to suppose, then, that if these improved units were put together in what was formerly considered a good circuit, the results should be far better than the sets we were accustomed to use a number of years ago. This is precisely what the writer has done and this article describes to you the construction of such a modernized receiver.

THE NEW DESIGN

The receiver described here is similar to the original type of multi-stage receivers in that coils, condensers, sockets, tubes, an audio amplifier, etc., are employed; but there the general similarity stops. Take the condensers, for instance; instead of having three or four separate condensers, each mounted on the panel and controlled separately by its own dial, the new receiver has two ganged units controlled by one master dial. The coil units are efficiency themselves (being twice matched at both the high and low ends of the frequency range) and are selected for use with the particular type of tube to be used. Each radio-frequency stage is completely shielded with metal cans not only for the purpose of isolating one electromagnetically from the other, but also to shield the entire circuit from external influences. This, for instance, prevents the coil units and associated wiring from picking up signals from a station directly without the aid of an antenna. By some, such a feat is considered an indication of the efficiency of the receiver as a whole; but to those who know and understand the true state of affairs, this is purely an indication that the receiver is operating below par and with the aid of remedying apparatus could be improved.

Intercoupling between R.F. stages can be caused in a number of ways but the two most important are direct electromagnetic coupling between the coil units themselves (when, as is usually the case, they are situated too close to each other) and coupling of the R.F. currents which course through the various battery wires. The coupling in the latter case is due to the closeness and parallel path of two or more wires of sep-



The complete circuit of the receiver proper, above the dotted line, is Fig. 1; that of the "B" unit Fig. 2. The "A" unit is connected across the filament terminals and to "B—" in the usual way. The "X"s in Fig. 1 may require inserted resistors, as shown in Fig. 3.

arate radio-frequency circuits; the actual disturbance being caused by one of the wires being located in and cutting the magnetic field which surrounds an adjacent wire.

The proper use of shield cans will eliminate quite effectively intercoupling between the coil units of the several stages. In the case of intercoupling due to parallel wires, the remedy lies in separating the wires, so that they do not run parallel but rather at right angles to each other. Not always is this possible and it is better to eliminate the trouble than merely to apply a remedy. The elimination process consists of keeping the R.F. currents out of those wires which are causing the disturbance. Since, usually, it is found that these offending wires are the "B"-voltage leads to the plates of the radio-frequency amplifier tubes, it is quite a simple job to include in the circuit suitable components to prevent these currents from coursing through these wires and shunt them to their destination by a more direct and less troublesome path. R.F. choke coils and by-pass condensers are the pieces of apparatus which accomplish this work; the chokes prevent R.F. currents from coursing through the long "B" battery leads, while the by-pass condensers shunt them by a short route to the "—" side of the A supply line.

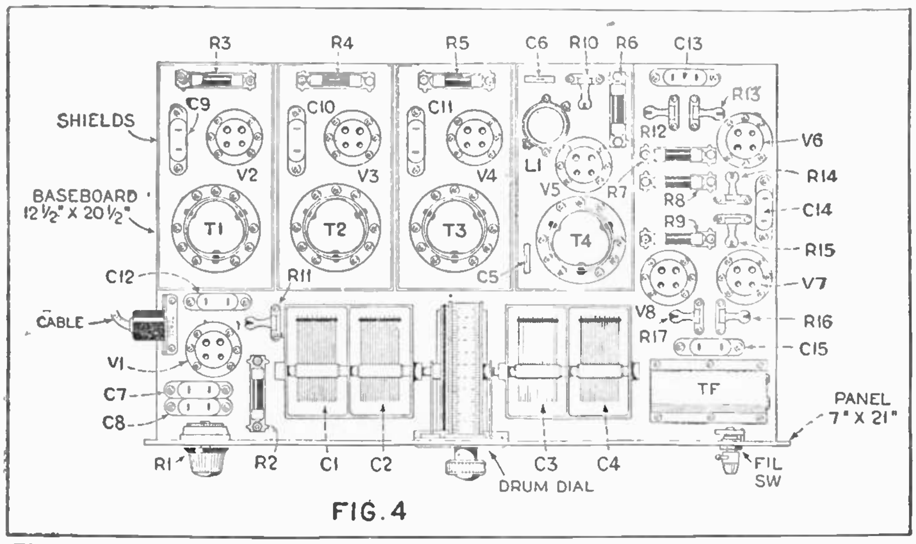
MULTIPLE TUNING

In present-day manufacture the tendency is more and more toward single-control receivers and, naturally, with the addition of each tuned stage of radio-frequency amplification the job of accurately tuning all of the circuits to the same wavelength becomes increasingly difficult. In receivers where the antenna is connected directly to the first tuned stage (either by an inductive or a capacitative coupling) it is well-nigh impossible to make all the tuned circuits peak accurately at the same wavelength; because the first tuned circuit is not working under the conditions which exist in the other associated tuned circuits. A simple expedient is to tune separately the antenna circuit, but then we get away from the single-control feature.

Lately it has become the accepted practice to employ in advance of the tuned stages a tube which functions as a coupling medium between the antenna-ground system and the tuned circuits of the receiver. The writer has employed it in many receivers with excellent success, and it is again used here. To do away with the necessity of employing an untuned coil as a coupling medium between the tube and the antenna, there is here inserted a simple resistance which, at the same time, serves most excellently as the volume control of the receiver. The tube employed is of the 222 type (screen-grid) and, besides serving as a coupling medium, provides also a certain amount of signal amplification which would not be obtained if an ordinary 201A-type tube were used.

Briefly explained, the tuner section of the receiver described here consists of one stage of untuned radio-frequency amplification, employed as the coupling stage, and four tuned stages, three of which are amplifiers and the fourth a non-regenerative detector. Each of the tuned stages, including the detector, is housed in a shield can, with the exception of its variable condenser. In the audio amplifier, separate parts are used to make up a single stage of resistance amplification. That is to say, separate plate and grid resistors are mounted in their individual mountings and separate fixed condensers are employed to couple the several tube circuits together. Although the chances are exceedingly slim that any of these units will go bad during operation, the provision is made; so that, if for any reason, it is desired to make a substitution (for example, let us say, of a coupling condenser) this may be done without having to discard an entire coupling unit, as would have been the case if the old-time units had been employed.

To protect the windings of the loud speaker from burn-out, a tone filter has been located between the plate of the power amplifier tube and the loud speaker itself; which, by the way, must be a good one if



The layout diagram above, when compared with the list of components on page 1139, and the photographic illustrations, will clearly identify each part.

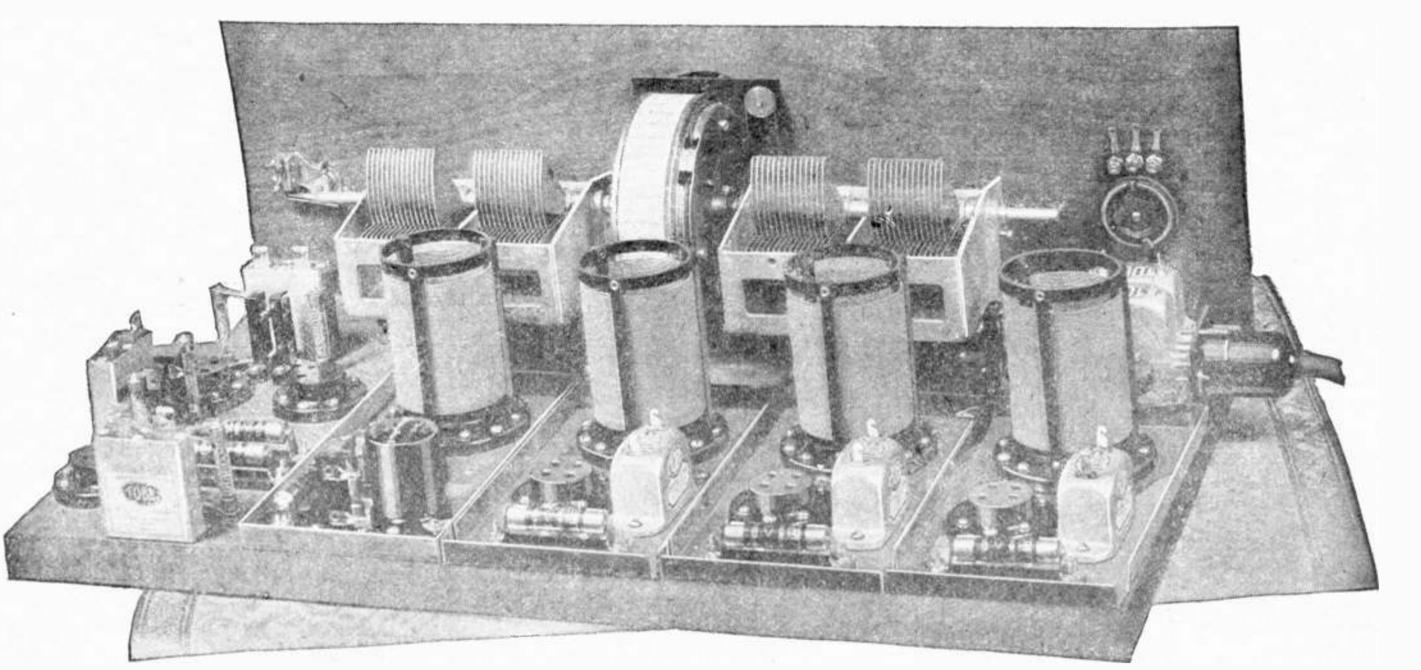


Fig. E

This rear view of the "Explorer Electric Eight," without its shielding, indicates the simplicity and ease of its construction.

we are to realize the highest order of tone quality of which this receiver is capable.

Throughout the receiver, each of the tubes has its filament automatically controlled and adjusted to the correct voltage and current requirements, by the use of a suitable Amperite.

SELECTION OF POWER TUBE

The line drawings accompanying clearly illustrate the several features explained here. As indicated and illustrated, the receiver was first constructed to employ a 171A-type tube in the power amplifier stage of the audio-frequency amplifier, and to protect the cone loud speaker a National tone filter was employed between the power stage and the speaker.

in the circuit, to provide the correct grid-bias voltage for the new tube. In the diagram (Fig. 7) wherein these changes are indicated, a table of values for various grid-bias resistors is given. The value to be used depends on that of the plate voltage which is applied to the plate of the 245 tube. Naturally, since this power tube requires a higher value of plate voltage than can be supplied by the "B" unit originally intended for the 171A tube, there are a number of changes which must be made if the builder desires to employ the 245 power tube. Additional information on this subject will be included in the latter part of this article.

ASSEMBLY AND WIRING

First, lay out the panel as shown in Fig.

In wiring the receiver it is well to follow out a system. First, wire all the filament circuits; then wire all the grid circuits; then wire all the plate circuits and, finally, complete the wiring by finishing all the miscellaneous circuits such as by-pass condensers, etc. The wire used should be flexible and well insulated. This is especially true of the wiring which is to be done inside the shield cans; for there must not be any possibility of short circuits between the wiring and the metal cans. The wire used exclusively by the author was Corwico solid and stranded "Braidite." This is very easy to handle, because the insulation can be slipped back on the wire; whereas it is necessary with other wires to actually strip the insulation from the end of the wire.

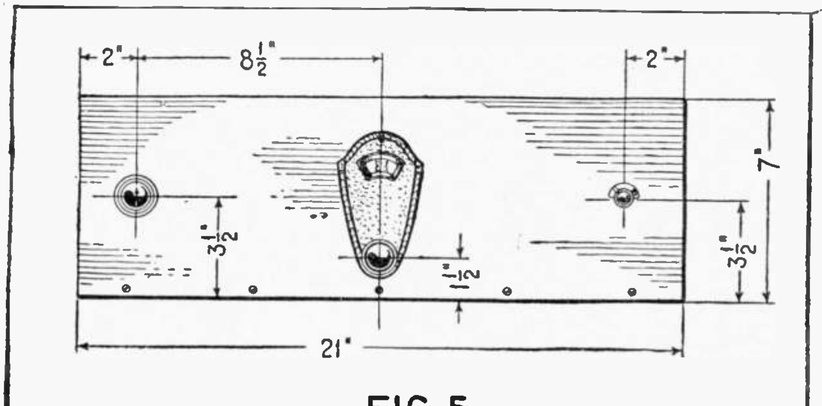


FIG.5

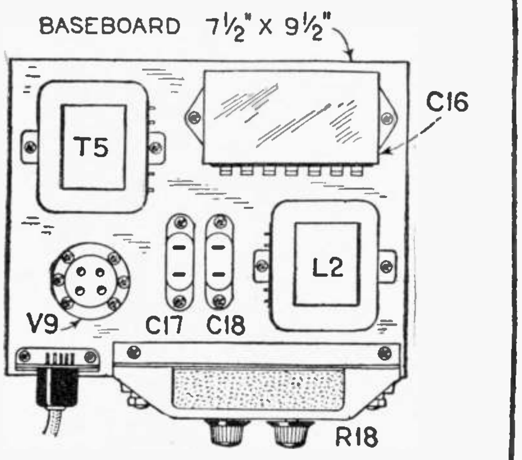


FIG.6

Above, the panel layout of the "Explorer" receiver; at the right, the layout of parts for the "B" supply unit diagrammed in Fig. 2.

Since these drawings were made, the original receiver has been altered in several ways. First, it was desired to operate one of the new dynamic loud speakers (in particular the S-M 850) out of the new 2½-volt intermediate power tube, the UX-245. Therefore, since the S-M 850 was already equipped with a suitable speaker coupling transformer, the tone filter unit was eliminated from the receiver. Secondly, to power the 245 tube filament direct from an A.C. source, the filament regulator connected to the power stage socket was removed, together with the regular D.C. filament leads to the socket; and a pair of twisted wires was run to suitable binding posts for connection to the 2.5-volt terminals of a filament transformer. Thirdly, a grid-bias resistor and by-pass condenser were included

5, and then drill. Mount the volume control R1 and also the dial and the filament switch in their places. Next, fasten the panel to the baseboard and then place the two tuning-condenser units in place, so that the shafts fit into the hole in the center of the dial. Then bend and drill a pair of brass brackets for each of the condenser units, so that they are supported from the baseboard. The builder will have to determine for himself the correct height of these brackets since their dimensions depend largely upon the thickness of the baseboard employed.

Next lay out on the baseboard the bottoms of the shield cans and put in place the apparatus which is to be placed in them, in accordance with the base layout, Fig. 4. When you are certain that the layout positions have been determined for all this apparatus, then it may be fastened in place. Follow the same procedure with the audio-amplifier apparatus.

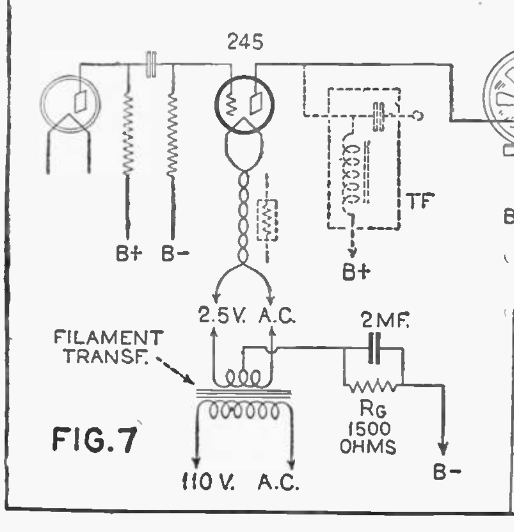


FIG.7

B	RG
150	1200 OHMS
200	1400 OHMS
250	1500 OHMS

To use a tube of the new 245 type in the last stage, the circuit must be changed as above. The dotted lines show the previous arrangement. The value of Rg, the resistor which furnishes grid bias for this tube, will be found in the column at the right of the diagram, opposite the value B of the plate voltage applied.

Secondly, by virtue of a good coating of tin on all of the wires, it is made extremely simple to make soldered connections between these and other parts of the circuit. Thirdly, because the wire is flexible, the various long battery leads may be bunched together to form a neat cable.

OPERATING NOTES

The tubes used in the receiver are as follows: R.F. coupling stage, a CeCo "RF22" tube; first, second and third R.F. stages, CeCo "AX" tubes; detector stage, CeCo "H" tube; first and second audio stages, CeCo "G" tubes; third or power audio stage, CeCo "J71" tube or "245" intermediate amplifier tube. The 2,500-ohm "Powerohm" R11 should be inserted in its mount. This resistor is used to "drop" the 135 volts which is supplied to the plate of the R.F. 22 coupling tube to about 90 or 100 volts for the plates of the three tuned-stage R.F. tubes. If all the tuned stages are found to oscillate upon operation of the receiver, it may be necessary to increase the value of this resistor to about 3,500 ohms. If it is found that only one or two of the tuned stages oscillate, then a 300-ohm "grid suppressor" may be inserted into each circuit at the point marked "X" in the circuit diagram, Fig. 1, as further illustrated in Fig. 3. These "grid suppressors" are wire-wound resistors manufactured in a form convenient to use. The resistance wire is wound on a core covered with insulating material, and the whole is cased in cambric cloth. Eyelets are located at the ends of the wire, for ease of connection.

Figs. 2 and 6 are the circuit diagram and base layout, respectively, of a suitable "B"

(Contined on page 88)

Operation on 32 Volts

Editor, Radio News:

I am a service man in my spare time, during the evenings and week-ends. I find this work interesting and the compensation is good. I was certainly pleased to see your columns for the service man in the last issue, and I hope that this service will be continued.

Several of my customers are using Delco and similar electric-light plants supplying 32 volts. I have been asked a number of times whether this current could be used for the sets. Of course, I answered that it was not suitable for the plate supply, but I thought that the filaments of the tubes could be operated from this source if the correct arrangement were used for the reduction of the voltage. I wonder if you could design such a unit for me or tell me where I could obtain such information.

J. J. O'Brien,
Bluefield, West Virginia.

"The Service Man" department will be continued if dealers and service men show sufficient interest. If you have any hints which are likely to help others who repair sets, we would suggest that you type or write them briefly in ink and send them in, along with any diagrams that you think would help to illustrate your point. If you have any problems, we will be glad to assist you if it is possible for us to do this; but in any case, your interest in this department, as shown by the number of letters received, will be appreciated.

A diagram of a 32-volt filament supply which will usually operate satisfactorily from a farm-lighting plant is shown here (Fig. 1). The current supplied by these units is, usually, sufficiently constant so that very little filtering is necessary. However, in order to keep noise level at a minimum, it is advisable to use a filter of some kind; and, for this purpose, you will find that a choke and two filter condensers are used. The choke will have to be made in such a manner that it will carry three amperes or more at 32 volts, without overheating. In case you cannot obtain a suitable coil, the choke may be omitted and a single 4-mf. filter condenser or larger size may be used for the filter. This method is not as efficient as the first; but it will often operate satisfactorily, especially in the larger installations.

The remainder of the unit consists of the voltage-reducing device, made up of resistors. The first resistor R1 and the second R2 are fixed resistors, the values of which are determined by the type and number of tubes used in the set. If 5-volt tubes are employed, a resistor of 12.5 ohms and a current-capacity of about 60 watts will be suitable for sets using up to 1 ampere. Between 1 and 1.5 amperes, the resistor should have a value of 10 ohms and a capacity of 60 watts; while sets drawing up to 3 amperes should use a resistor with a higher current rating such as 125 watts. The Ward-Leonard type PEB-6.4 resistor is suitable in this case. The resistance value is 6.4 ohms.

For resistor R2, the value is also dependent on the number of tubes used. A current rating of 60 watts will be sufficient for all purposes. A table of resistances follows:

Current drain amperes	*R1 Resistance ohms*	*Rating watts*	*R2 Resistance ohms*	*Rating watts*
.75	12.5	60	5	60
1.00	12.5	60	7	60
1.25	10.	60	5	60
1.50	10.	60	7	60
1.75	6.4	120	3	60
2.00	6.4	120	3.5	60
2.25	6.4	120	4.25	60
2.50	6.4	120	5	60
2.75	6.4	120	6	60
3.00	6.4	120	7	60

The current drain of the set should be figured from the number and the type of the tubes used, and the corresponding resistors for R1 and R2 should be used.

R3 and R4 are rheostats of about 6 ohms. They should be made with wire sufficiently heavy to carry 3 amperes without overheating. If 199-type tubes are used, resistor R1 should have a value of 45 ohms and R2 one of 7 ohms. R3 and R4 in this case should have a value of about 20 ohms. In constructing the unit, the two resistors R1 and R2 should be mounted in such a way that they will be well ventilated, so that there will be no danger of overheating. R3 and R4 are adjusted with the set in operation and a voltmeter is used to determine the correct setting. Two 5-ampere fuses should be connected in the circuit and, in some cases, it is advisable to place a one-microfarad condenser in the ground lead of the receiver, to prevent a short circuit in the power-supply unit. The condenser is merely connected between the set and the ground. Its use will not affect the operation of the set.

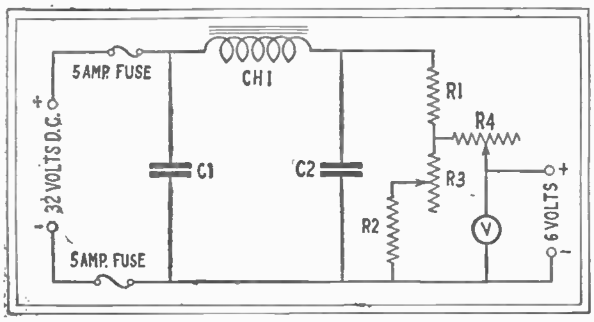


Fig. 1
Many homes in rural and suburban districts have 32-volt light plants. The current, properly filtered, may be used with D.C. tubes and suitable resistors.

MEASURING CONTINENTAL MOVEMENTS

THE theory that the continents are not fixed in position, but are very gradually drifting over the earth's surface, has met with much favor among scientists in late years. The Washington Naval Observatory is co-operating in a series of world-wide measurements which will determine more accurately than ever before the exact relative positions of geographical stations. Radio, being almost instantaneous, affords the means of synchronizing the clocks which will determine exactly the differences in time, and consequently in longitude.

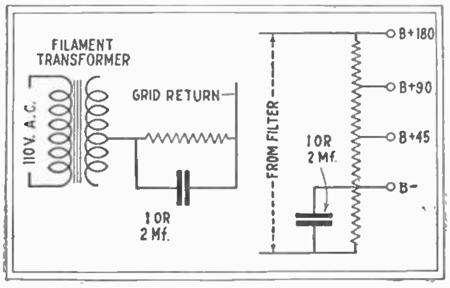


Fig. 2
Adequate by-pass condensers of sufficient capacity must be used in the filament returns of A.F. tubes which depend on resistors to provide grid bias or quality will suffer.

Adequate By-Passing Needed to Give Quality

Editor, Radio News:

In servicing many of the commercial and home-made A.C. receivers, I have found that the resistors used for the "C" bias are not by-passed. To me this seems a very important point, and I have often found that the quality and the all-round results were improved by placing a condenser at this point. The reason why this is so important is the fact that the audio-frequency currents must pass through this part of the circuit; and the resistor offers a very appreciable opposition to the flow of these audio currents. The resistor used for the grid bias is usually one with a value between 1,000 and 2,000 ohms. Naturally, this is sufficient to reduce the volume, and it also causes some distortion. I have found that a condenser of about 1-mf. capacity is sufficient to overcome all the difficulties caused in this way.

There are two ways in which the condenser may be connected, depending on the method of obtaining the bias. One arrangement uses a resistor in the lead from the center tap of the filament transformer, or from the center of a tapped resistor across the filament winding; and in this case the condenser is merely connected across the series resistor. The other common method is to use part of the voltage-divider in the "B" power unit to obtain the necessary voltage drop. In this case the condenser is connected between the "B—" and the "C—" lead or the negative lead from the rectifier in the "B" power unit. The results in either case are the same, except that the need for the condenser is usually greater in the former arrangement.

I have found that the use of a condenser at this point often reduced the tendency of an audio-frequency amplifier to "motorboat" and, in some cases, it has been a complete cure for this trouble.

John Bender,
Detroit, Michigan.

Radio Service Course

THE first radio course for service men has just been compiled by the Radio Division of the National Electrical Manufacturers Association, in co-operation with the Radio Institute of America, as the answer of national set manufacturers to the increasing demand for fuller information on service problems.

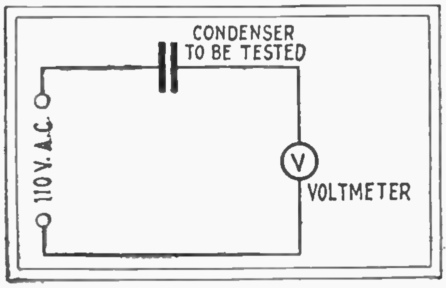


Fig. 3
The reading increases with the capacity.

The course comprises four text books; while, during the course, there are offered four examination papers which may be submitted to the Radio Institute of America for correction and rating.

Technical language has been avoided as much as possible; but fundamental principles, receiving circuits and circuit diagrams, receiving-set components, definitions and ethics of servicing have been treated in sufficient detail to give the radio dealer and his service men an accurate understanding of the essential information required in practical service work.

"What's the Job Worth?"

Editor, Radio News:

I would like to see published in your magazine an average-charge scale for various operations performed on radios. Of course, I realize that this cannot be given except in a very general way; but, if the service man had some sort of flat-rate scale to go by, it would be a great help in satisfying his customer that he was getting value received; as well as a salve for his own conscience after charging his customer a dollar for soldering one little connection after spending probably ten or fifteen minutes finding it.

These days a rate per hour is hardly fair to the man who has quite a bit of money invested in expensive testing equipment with which he can locate and fix most of the common troubles in a very few minutes. It would seem that if, by modern methods, he locates a high-resistance connection in the grid lead to the detector in thirty minutes, he is entitled to the same amount of money as the man who spends hours finding it by the old trial-and-error methods and charges his customer a dollar and a half an hour for it.

If you can possibly thrash out a satisfactory solution to this problem, I am sure that we would all appreciate it.

Gordon E. Lockerd,
Portales, New Mexico.

There is no doubt that this is one of the most important questions facing the service man, who is interested in radio, not as a hobby, but as a means of making a living. He is entitled to be paid, not only for his investment in a testing equipment, but for what the French call *savoir faire*—the knowing how to do things. We may remember the old and impressive (if possibly exaggerated) story of the oculist who justified his high charge for an operation by saying that he had spoiled a peck of eyes learning how to do it. The set owner should be willing to pay for expert knowledge applied to the improvement of his set, but hardly for experiments with it. It is impossible to determine on a standard flat rate for servicing work which would be universally applicable. The cost of doing business varies considerably in the different parts of the country, and even as between locations in the same district. However, anywhere that there are a number of service men doing business in the same city, a get-together movement on their part will be of undoubted value in promoting a better understanding of business problems and a greater insistence on obtaining a fair price for their services, investment in equipment and education considered. Other trades have long since learned that lesson; but to a large extent the radio service men of the country have just "happened" to get into the business. We will be glad to chronicle the organization of local service men's clubs, and such a tariff of minimum charges as they determine to be adequate for their location conditions —as a guide to others.

Measuring Large Condensers

Editor, Radio News:

In assembling "B" power units and other power devices, one often encounters condenser blocks that are not marked with their capacity. The capacity of such condensers may be measured approximately by the following method (Fig. 3).

Only the 110-volt 60-cycle current found in standard lighting circuits, and a "B" battery voltmeter of the plunger or solenoid type are required. The lighting voltage may usually be relied upon to be fairly constant, and the frequency is kept sufficiently accurate for this purpose. The voltmeter should have a range of about 0-50 volts; this type of meter can be obtained very cheaply. Since the plunger meter is not polarized, an easy way to recognize the correct type of meter is to connect it across a "B" battery and then reverse the leads. In the plunger-type meter, the deflection is always upward on the scale, regardless of the direction of the current flow. In the polarized meter, the needle will move off the scale when the connections are reversed; such a meter cannot be used.

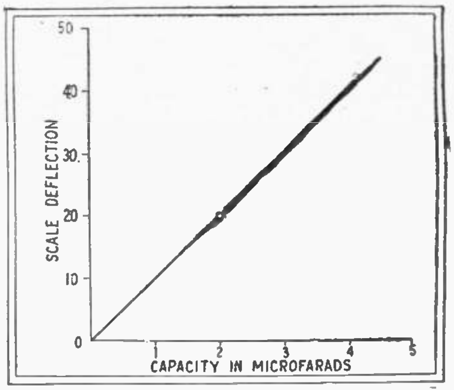


Fig. 4
By charting the meter reading with a condenser of known capacity, a scale like this is made.

To measure the capacity of a condenser, connect the condenser and voltmeter *in series* to the line and note the deflection. The calibration of the meter is accomplished by connecting a condenser of known capacity in the circuit and plotting a curve as shown in the graph above (Fig. 4). Only one point is necessary, as the curve will be a straight line determined by the origin and the point found. The approximate capacity of any condenser of sufficient capacity can then be determined by referring to the curve.

Paul Wimberley,
New Braunfels, Texas.

This method of approximating capacities is satisfactory, if the condenser is in good condition. If the condenser is short-circuited, a low-voltage meter will be ruined, and the fuses in the house will be blown out; it is advisable for this reason to test the condenser for short-circuit, with a battery, before applying the capacity test.

A somewhat similar method of testing capacities, which is more accurate and is applicable to a wider range of capacities, has been described in the *"Aerovox Research Worker"* of February 25, 1929. It is in part as follows:

The capacities of the average condenser of from .01- to 10 or more mf. can be measure very easily if the ordinary 110-volt A.C.

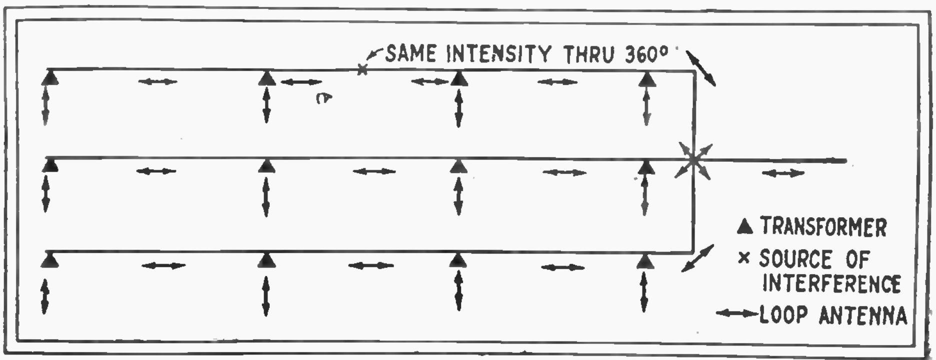


Fig. 6
Following interference along wire lines with a loop is not always successful; *see page 1144.*

current, a high-resistance A.C. voltmeter and an A.C. milliammeter are available. The circuit used to make the measurements is shown; this consists of an A.C. milliammeter A connected in series with the condenser C whose capacity is to be measured, and provides for an A.C. voltmeter V to read the voltage applied to the terminals of the condenser.

The circuit can be connected to the terminals of a standard plug which will serve as a convenient connection to the 110-volt A.C. outlet. The first step in making the test is to be sure that the condenser is not short-circuited, by connecting it into a test circuit, consisting of a battery and voltmeter connected across a battery. If the voltmeter registers, the condenser is short-circuited, and no further time should be spent with it.

After the soundness of the condenser has been assured, it can be connected into the test circuit. The milliammeter reading is then noted and the switch for the voltmeter is closed so that the voltage across the condenser can be read. It will be noticed that, when the voltmeter is connected, a higher deflection is obtained on the milliammeter. This is due to the additional current drawn by the voltmeter and it will be seen that it is important to obtain a reading on the milliammeter before the other meter is connected.

If the voltmeter is connected across the condenser when the milliammeter reading is taken, the results will be erroneous because of the additional current drawn by the voltmeter over that drawn by the condenser. It might also be mentioned that the voltage reading should be taken immediately after the current reading, to avoid any possibility of error because of a possible fluctuation in the line-voltage after the current reading has been taken. It is advisable to take several current and voltage readings and take the average of them all.

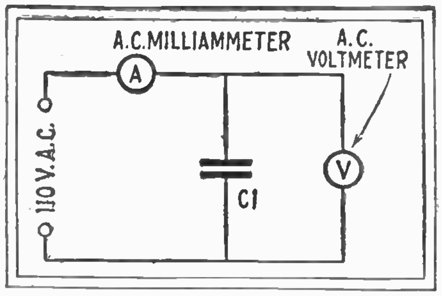


Fig. 5
The circuit above shown requires two meters, but gives more accurate results.

The capacity of the condenser is then determined by using a simple formula and substituting the readings taken on the two meters in it. The actual formula used when I is the reading on the milliammeter, f the frequency of the supplied current and E the reading on the voltmeter, is

$$C = \frac{1000 \times I}{6.28 \times f \times E}$$

It requires only a knowledge of arithmetic to find the capacity of a condenser from this simple equation. For example, suppose the current reading is 20, the voltage 110 and the frequency of the current 60. Then, multiplying 20 by 1000, and 6.28 by 60 and the result by 110, it is merely necessary to divide one into the other according to the equation, and the result is 0.48 (microfarad).

It must be remembered that both the methods described here for obtaining the capacities of condensers are approximate and neither is absolutely accurate. However, with filter condensers, the exact capacity is not very important. The second method is more accurate than the first and with careful handling the error should not be more than 5%, which is very small when the condenser is a large one. For instance, suppose we have a condenser with a known capacity of 1 mf. and the measured capacity is 1.05 mf., this difference would indicate 5% error.

Editor, Radio News:

On page 933 of the April issue of Radio News I note a method of locating sources of radio interference, referred to as "triangulation," using the directional properties of a loop antenna to secure compass bearings. This idea is practical and considerable accuracy results when applied to compass bearings from ship to shore, but it is unreliable on land, and absolutely worthless in a city; due to the following fundamental difficulties.

(Continued on page 91)

Radio Regulations Drafted for Air Service

THAT the field of opportunity for the aircraft radio operator and service man will speedily be widened is evident from the proposed regulations which the Airways Division of the Department of Commerce has proposed to the air transport companies. While these may undergo changes in detail before their adoption, they indicate the general principles which will undoubtedly be followed out in the official rules finally adopted—a matter of months only.

Airplanes will thus be protected during flight by the hourly weather report broadcast by airway radio stations and will be in constant communication with these; so that orders to pilots for the protection of planes and passengers may be transmitted while the planes are in flight.

The proposed regulations also call for a radio officer among the complement of the large transport planes and require a constant watch to be maintained while in flight. Aircraft radio operators would be required to have a total of not less than twenty hours of flying and to demonstrate their ability to stand a radio watch on aircraft.

INTERNATIONAL SERVICE

For planes in international service, air transport operators will be required to comply with the international radio convention's regulations. These operators would also be required to comply with all other provisions relative to radio in aircraft in agreements with foreign countries relative to aircraft stations and aeronautical stations engaged in international service.

Air transport operators engaged in national service and in flights not passing beyond the three-mile limit would be required to equip planes carrying not more than six passengers for hire in interstate commerce over civil airways with radio-telephone receivers in order to take advantage of weather information and orders to pilots.

OPERATOR'S CERTIFICATE

The radio operator would be required to possess a radio-telephone operator's certificate or one of a higher grade, and maintain his watch throughout the flight. Large planes carrying more than six passengers in national service would be required to carry a radio-telephone receiver and either a radio-telegraph or a telephone transmitter powerful enough to communicate at any time during flight or forced landing by voice or telegraph with the nearest aeronautical radio station.

If radio telephone is used, the operator would be required to possess a second-class radio-telegrapher's certificate or one of higher grade.

In accordance with international practice the radio service on a plane in transit would be under the supreme authority of the pilot in charge of the plane, whose position corresponds to a ship captain's.

INCREASING AIR FACILITIES

The new air mail schedules, which went into effect May 1, provide double daily service over the transcontinental system between New York and San Francisco and over four connecting routes. The latter are operated between Salt Lake and Los Angeles, Salt Lake and Pocatello, Idaho, on the Salt Lake-Great Falls route, and between Cleveland and Pittsburgh and Cleveland and Buffalo on the Cleveland-Albany route.

The new route runs from St. Louis to Omaha by way of Kansas City, a distance of 403 miles. The schedule for this route, on a single daily basis, synchronizes with that of the night transcontinental, placing St. Louis within twenty-four hours of San Francisco and Los Angeles.

The night transcontinental air mail leaves New York at 8 P. M. and Hadley Field at 9:35 P. M., arriving in San Francisco at 4:30 o'clock the second morning. Eastbound air mail leaves San Francisco at 8 P. M. and arrives in New York at 6.43 A. M. the second morning. Mail leaving Los Angeles makes connections at Salt Lake City with the eastbound mail; while mail from the East arrives at Los Angeles at 4:15 A. M. the second morning out of New York.

The existing schedule on the Albany-Cleveland route has been changed so that westbound planes, instead of leaving Albany at 10 A. M., hop off at 3:45 P. M. with a much larger accumulation of the day's business mail and in time to connect at Cleveland with the westbound night transcontinental. Eastbound planes pick up mail from the West over the night transcontinental and arrive in Albany at 8:10 A. M., serving Buffalo, Rochester, Syracuse, Rome, Utica and Schenectady en route. The additional service between Cleveland and Buffalo provides planes to leave Buffalo westbound at 10:30 A. M., and Cleveland eastbound at 12:20 P. M.

An additional service provides planes which leave Cleveland at 12:15 A. M., and arrive at Pittsburgh at 1:45 A. M., and in the other direction leave Pittsburgh at midnight and arrive in Cleveland at 1:30 A. M.

"DX" and the "Band-Isolator" Receiver

With an Introductory Survey of Broadcast Conditions

By S. Gordon Taylor

Mr. Taylor with the receiver whose performance and circuit are described below.

IS good long-distance ("DX") reception possible during the early evening hours? Or has the large number of broadcast stations now on the air made anything but local reception out of the question, unless one is willing to wait until midnight or after, or unless one has a particularly favorable location?

This is a question that has been the subject of much discussion, particularly since the wavelength reallocation which took place November 11 last. It is probably fair to say, the majority of urban fans believe that reception from distant stations is well nigh impossible before midnight. This is particularly true of fans located in the more populous metropolitan centers, where local broadcast stations are numerous and the interference correspondingly great.

Any discussion of this question must necessarily be limited to conditions obtaining in one particular locality. Reception conditions, particularly from the standpoint of local interference, vary so greatly that a general discussion is out of the question. The fan who lives in an outlying section, with the nearest broadcast station perhaps fifty or a hundred miles away, requires only a sensitive receiver to bring in any number of stations throughout the country. For him, good distant reception is always possible.

But, to the fan who lives in the center of a nest of broadcasters (as in New York City or Chicago) conditions are entirely different. Here, with a large number of high-power local stations in simultaneous operation throughout the evening, distant reception becomes a real problem, requiring a receiver with both sensitivity and selectivity of a high order.

Conditions in New York City are probably as bad as (if not worse than) can be found anywhere else in the country. Such being the case, this offers a good location for discussion; if distant reception is possible here it is certainly possible anywhere.

Any discussion, to be worth while, must be based on actual measured performance, not on hearsay or random observations. The facts brought out in this article were obtained through a series of tests conducted for the special purpose of determining the exact degree of distant reception possible in this location. To show the impartial naure of the tests, a brief description of the layout will be of interest.

CONDITIONS ENCOUNTERED

The receiving station was in an apartment in New York City and in a location entirely surrounded by other apartment houses. The aerial employed was seventy-five feet in length, including the lead-in, and was one of forty on the one roof. Some of the other thirty-nine approached within five feet of the test aerial; so it is obvious that the location and the antenna installation were anything but ideal. However, they are typical of the conditions under which most fans labor, if their receivers are located in the city.

All tests were made *between the hours of 7:30 P. M. and 11:30 P. M.;* thus limiting them to the hours when the evening locals were going strong and, incidentally, the most popular hours for reception. From the foregoing, it is evident that all conditions were as truly representative of average New York City reception conditions as could be arranged.

The receiver employed was the only exceptional thing about the tests. It will be described in detail later on in this article, and in the article to follow. Suffice it to say here that it is a receiver designed by the author for use in his home, and incorporates the features most desirable in a good home receiver. But, in addition, it is a receiver which combines extreme sensitivity with an unusual degree of selectivity, as will be shown by the results of the reception tests, as given below.

Two sets of tests were made. The first, just prior to November 11, were to obtain a true picture of conditions existing under the old wavelength assignments and to provide a basis for comparison in determining the effect of the reallocation. The second set of tests was made about a month later; this lapse of time being allowed to permit the stations to get settled down in their new channels. All conditions were identical during the tests, except that the atmospheric conditions improved somewhat as autumn ended and winter approached.

The composite "log" given herewith shows the reception conditions that were found on the ninety channels used by broadcast stations in the United States; both before and after the wavelength changes. During the first tests the local noise level ("man-made static") was very high on the higher-frequency (shorter-wave) channels, which accounts largely for the fewer stations logged on these channels at that time.

BETTER SIGNALS EVERYWHERE

There are several outstanding points disclosed by the figures given here. First is that, during the first tests, signals were heard on 80 of the 90 channels then in use by U. S. broadcasters and, during the second tests, this record was improved by ***stations being heard on 85 of the 88 channels then in actual use.*** Two channels were not in use during these tests, pending reconstruction of the stations to which they were exclusively assigned. This does not mean that good, clear reception was obtained on 85 channels. In many cases long-distance reception which would have been amply loud for good loud-speaker reception was so garbled by heterodynes that nothing was clearly distinguishable except a conglomeration of distorted noises and whistles.

The second noteworthy point is found in the fact that only seven of the channels occupied by out-of-town stations suffered interference from local stations operating on adjacent channels. This means that, in spite of the proximity and high power of several local stations, ten-kilocycle selectivity was obtained in most cases; and even the highest-powered locals did not cause interference beyond the adjacent channel on either side of its own.

The third point is in the amount of havoc wrought by the one thing with which receiver design cannot cope—heterodynes. Before November 11 heterodynes completely wrecked programs on 9 channels and heterodyne whistles were heard through the reception on 27 other channels. Thus a total of 36 channels carried heterodynes, or 40% of all channels in use. After November 11 conditions were little improved in this respect for, although heterodynes were heard on a total of only 32 channels, they succeeded in completely ruining reception on 18 of these channels. This increase in the number of channels on which reception was completely garbled by the heterodynes was probably partly due to better reception conditions which permitted distant heterodyning stations to come in with greater intensity; thus causing a stronger heterodyning effect.

The analysis given herewith provides a bird's-eye picture of conditions as they were found to exist. It provides indisputable evidence that the labors of the Radio Commission were not in vain, so far as the new assignments of wavelengths were concerned, in their effect on reception in New York City. Before November 11, out-of-town stations could be brought in entirely free from heterodynes and interference on only 17 channels. After November 11, good, clear distant signals were found on 35 channels. After making due allowance for the local electrical interference that killed reception on a few of the high-frequency channels during the first tests, the improvement in distant reception runs around 75% or higher.

Considering the obstacles to be surmounted, it is rather surprising that this much improvement was brought about by the commission in Washington. With the high number of stations that must be accommodated on the air, it is utterly impossible to eliminate heterodynes. But by limiting some stations to daytime transmission, in other cases requiring a more extensive time-splitting, and by the assignment of exclusive channels, the situation has been cleared up to such an extent that reception conditions, at least in New York City, are better now than they have been in several years.

BETTER RECEIVERS REQUIRED

The objection may be made that the results indicated by the foregoing analysis cannot be obtained with the average commercial or home-built receiver. This is quite true, but after all, the whole burden of improving reception cannot be placed on the broadcast stations or on the Radio Commission. The point is, that these two elements have brought about a condition where reception free from station interference is obtainable on exactly half the number of channels employed by stations of the U. S. *if a sufficiently good receiver is used.* If a fan employs a receiver which is so lacking in sensitivity and selectivity that he is able to bring stations in on only a part of these channels, he is scarcely justified in placing all of the blame on the broadcast stations.

At the present time it is hard to imagine any further improvement that can be brought about by governmental regulation. It therefore appears that improvement must come in the receiving equipment. This brings us to the discussion of the receiver problem.

It is an unfortunate fact that the average commercial receiver is designed primarily for local reception and incorporates neither adequate sensitivity nor sufficient selectivity to meet present-day requirements for distant reception particularly in urban locations. Out in the country, where there are few, if any, local stations to cause interference, and where the freedom from surrounding obstructions results in fine reception conditions, the average receiver will usually give a fair account of itself; because under such conditions a receiver can function with no handicaps whatever. But even here a superior receiver will provide correspondingly better results.

This lack in commercial receivers is not the fault of the engineers who design them. It is due partly to production problems and limitations and partly to the public's demand for low prices and small physical dimensions. It has been said that radio manufacturers are individually so obsessed with the idea of becoming the Henry Fords of radio that there is none left to produce the Lincolns and the Cadillacs of the ether. Perhaps there is something in this; but, to an observer who has studied the field, it would seem that more time and thought is being put into cabinets and appearance than into the technical superiority of the manufacturer's product. Thus high prices do not by any means indicate superior sensitivity, selectivity and tone quality.

A SET FOR DISTANCE

In presenting a description of the "Band-Isolator" receiver for those who are interested in constructing, or in having constructed for them, a receiver which will enable them to duplicate the reception shown in the tests just described, the claim is not made that this is the only receiver that will achieve such noteworthy results. But it is an important fact that this receiver was designed to incorporate *all* of the qualities so necessary to the complete satisfaction of the real radio enthusiast. This means not only unusual sensitivity and selectivity, but also simplicity of operation and the complete elimination of instability or any other factors which might adversely affect tone quality. This last is a most important consideration because, no matter how good the audio amplifier may be, tone quality may be completely ruined as a result of an improperly-designed radio-frequency amplifier.

This receiver does not incorporate any fundamentally new ideas. Rather it is made up of known and tried principles, combined in such a way as to maintain the better qualities of the systems employed and eliminate the objectionable features. Perhaps the best way to explain the circuit and the reasons underlying its superior qualities is to describe the line of reasoning followed in planning the design.

It was realized that, in order to obtain the desired degree of selectivity and sensitivity with any system of tuned radio-frequency amplification it would be necessary to employ three, or more likely four stages; and incur all the accompanying grief of instability, the difficulty in balancing the stages, etc. The only alternative seems to be to employ a superheterodyne circuit, but past experience indicated that good selectivity would be difficult to obtain when using a fair size outdoor aerial, and there would be the other evils of the average super to content with—harmonics, "repeat" points, ragged tuning and instability. Evidently, therefore, the ordinary

Analysis of Composite Log of the "Band-Isolator"

	After Nov. 11, 1928	*Before* Nov. 11, 1928
Total channels in use (U. S.)	*88 Channels	90 Channels
Stations heard on	85 "	80 "
Nothing heard on	3 "	10 "
Stations heard on	85 Channels	80 Channels
Calls obscured by heterodynes	18 "	9 "
Calls obscured by fading or noise	2 "	5 "
Station calls logged on	65 "	66 "
Station calls logged on	65 Channels	66 Channels
Accompanied by heterodynes on	14 "	27 "
Interfered with by locals	7 "	8 "
Good reception without interference or heterodynes on	44 "	31 "
LOCAL RECEPTION		
Total channels in local use (evening hours)	10 Channels	19 Channels
Stations received without interference on	10 "	19 "
Reception accompanied by heterodynes on	1 "	5 "
Total channels of pure reception	9 "	14 "
DISTANT ("DX") RECEPTION		
Total DX channels (total less locals)	78 Channels	71 Channels
Nothing heard on	3 "	10 "
Call letters obscured by heterodynes, fading, etc.	20 "	14 "
Calls logged, but accompanied by heterodynes, on	13 "	22 "
Interfered with by locals on	7 "	8 "
Free of interference or heterodynes on	35 "	17 "

* Two channels temporarily out of use at time of tests.

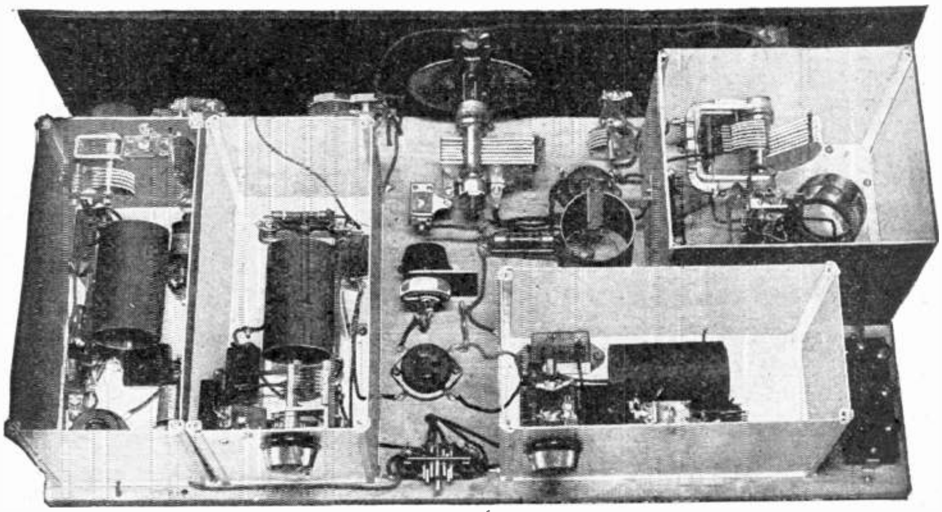
Geographical Distribution of Stations Logged

Location	*No. of Stations*	*Location*	*No. of Stations*
California	1	Minnesota	2
Colorado	1	Missouri	1
Connecticut	2	New Jersey	3
Florida	1	New York	15
Georgia	1	North Carolina	1
Illinois	8	Ohio	2
Indiana	2	Pennsylvania	4
Iowa	3	Tennessee	3
Kentucky	1	Texas	2
Louisiana	1	Utah	1
Maine	1	Virginia	2
Maryland	1	Wisconsin	1
Massachusetts	1		
Michigan	4	Total channels in 25 states	65

superheterodyne and tuned radio-frequency were both somewhat out of question.

Experiments made some time before had brought the conviction that most of the difficulties encountered with superheterodynes (such for instance as the fact that most of them are erratic and that two built from identical parts are likely to give widely varying results) were the result of using a very low intermediate frequency and fixed-tune intermediate transformers. The low intermediate frequency necessarily resulted in the presence of repeat points on the oscillator dial for the same station, and of harmonics which are made known by the presence of "birdie" whistles all over the dials. The fixed-tune transformers make their contribution in the form of broad tuning and, frequently, a lack of sensitivity as the result of poor matching.

The use of a low intermediate frequency practically requires the use of fixed-tune transformers; because the large inductances and capacities required in tuned circuits to operate at these frequencies (in the neighborhood of 50 or 100 kilocycles) would be prohibitive in size and cost. Furthermore, with tubes of the 301A type, it was necessary to employ a low intermediate frequency if adequate amplification were to be obtained, together with at least a fair degree of stability.



The "Band-Isolator" is shown above with its shield-tops lifted; it will be observed that ample room is given to every coil and condenser. This is a necessity where it is desired to have circuits tuned to cover exactly the full sidebands of each broadcast channel—and no more!

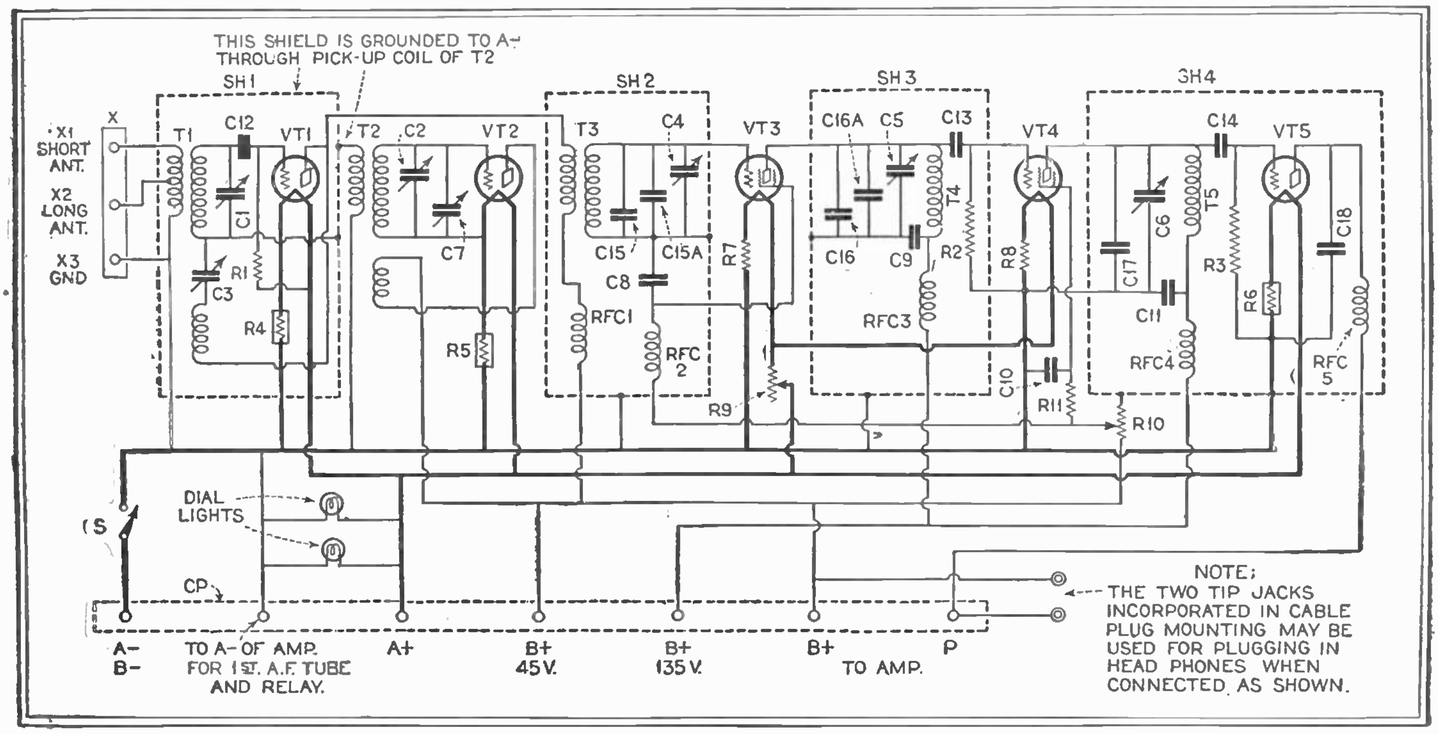
Other experiments had proved that a properly designed detector-oscillator circuit will provide in itself a very fair degree of selectivity, and, when used in conjunction with even a moderately selective intermediate amplifier, an unusually high degree of over-all selectivity is obtainable.

HIGH INTERMEDIATE FREQUENCY

The logical conclusion, based upon these observations, was that the proposed ideal receiver should employ; first, a superheterodyne circuit because of the greater stability thus obtainable; secondly, a high intermediate frequency to get away from repeat points and harmonics, and to eliminate the necessity for fixed-tune transformers; thirdly tuned coupling circuits in the intermediate amplifier to permit tuning the intermediate circuits to exact resonance with one another; and finally, screen-grid tubes in the intermediate amplifier, so that high amplification could still be obtained in spite of the use of a comparatively high intermediate frequency.

The first problem was to determine the best intermediate frequency to employ. A little slide-rule manipulation showed that, if an intermediate amplifier is tuned to any frequency above 475 kilocycles, there can be no repeat points and no trouble from harmonics. But, on the other hand, the amplifier must operate anywhere in the broadcast band because of the probability of conflict between the intermediate frequency and the carriers of broadcast stations operating on approximately the same frequency as the intermediate amplifier.

With these general considerations out of the way, the next consideration was that of the details of the circuit parts, particularly the coupling coils and the tuning condensers to be employed with them. Although the intermediate stages are to be tuned, there appeared to be no necessity for using regular variable condensers for this purpose; because only a very limited frequency-variation range was required. Such being the case, it was decided to employ a fixed condenser, shunted by a small variable instrument for tuning each stage. Solenoid coils were then made up, having considerably more inductance than the ordinary tuned R.F. transformer. The oscillator coil had to be of special design, because of the high intermediate frequency employed and the correspondingly higher frequency range required in the oscillator. Other circuit considerations involved the necessity for a pick-up coil of rather un-



In the "Band-Isolator" circuit, it will be seen, a large number of condensers are used; these, however, are in parallel, to facilitate exact adjustment of the stages. The feature of the intermdiate amplifier is that its tuning is adjustable, to avoid possible station interference.

MR. TAYLOR, known to many of the readers of RADIO NEWS *for his contributions to technical literature (including the "Pre-Selector," which appeared in the November, 1928, issue of this magazine), will give constructional details of the "Band-Isolator" in* RADIO NEWS *for July.*

It is designed for the fan who wants distant reception, and also volume and quality. While stations must do their part to maintain frequencies, the set owner can no longer expect to single one out of the many outside his own locality unless he constructs a receiver which will tune to a single carrier and be deaf to whisperings and whistlings outside it. The "Band-Isolator" does this; while its delicately adjusted filter passes the full range of audio frequencies from the selected station.

usual dimensions to be incorporated in the oscillator coil unit. Finally, special coils were made up for the antenna circuit and for the input circuit to the first intermediate stage.

DEVELOPMENT OF THE DESIGN

At this point the first experimental model of the receiver was assembled, with results that were fully up to expectations and rather astonishing. Although the intermediate-amplifier stages were individually shielded for the sake of stability, it had not been considered necessary to shield the first detector or oscillator. It was found, however, that the sensitivity of the model was so great that, *with no aerial connected,* it was possible to bring in stations 400 and 500 miles away, through the direct pick-up of the unshielded antenna coil. This circuit was therefore shielded and direct pick-up thus effectively eliminated.

From this point on numerous experiments were carried on to determine the best values for the coils, capacities and coupling; and the final model was then built up. At about this time a number of fans who had heard the receiver in operation expressed a desire to build duplicates for their own use but found the necessity for constructing their own coils more or less of a stumbling block, particularly as the coil constants are rather critical. This trouble was eliminated by submitting the coil specifications to the Hammarlund Company, who made up several sets for this purpose. Further demand has resulted in this company's manufacturing these coils on a larger scale, with the result that they are now available from a number of jobbers and dealers. € Inasmuch as all of the other parts are standard, anyone interested in constructing the receiver will have no difficulty in obtaining all of the parts.

The completed receiver consists of first and second detectors, oscillator, and two intermediate-frequency amplifier stages. Five tubes are required in all. It operates either from batteries or from "A" and "B" power units and employs the usual outdoor aerial and ground. An audio amplifier was not included in the receiver, because it was planned to use an external two-stage push-pull amplifier. By thus excluding the audio end, it was made possible to keep the size of the receiver down to the standard 7 x 24 inch panel size.

The article to follow will describe the "Band-Isolator" receiver in complete detail; so that readers who are interested in duplicating the results shown in the log given here will have all necessary constructional data to build up duplicates of the model receiver.

A. T. R. F. Transformer

(*Continued from page* 40)

L_1 is small. From equation (6) we note that L_2 should be made as large as possible consistent with tuning to the highest frequency desired; also, for a given plate resistance Rp, μ should be as large as possible. That is, choose an amplifier tube that has the largest amplification constant per unit plate resistance.

The foregoing equations have given us the complete design data for maximum amplification in a tuned-radio-frequency amplifier, but have left us with one option in equation (7); *i.e.*,
in regard to whether we shall make the coefficient of coupling large and the primary inductance small, or vice versa.

Let us now consider the question of *selectivity* of the transformer; for then the above question will be answered.

The selectivity of a tuned circuit depends upon its resistance. Thus, were the primary not present, the value of R2 would determine how sharp the secondary would tune. However, instead of R2, let us consider the more accurate selectivity factor η_2. It may be shown that, because of the effect of the primary, the effective resistance in the secondary circuit is increased. Call the effective resistance in the secondary circuit due to its resistance plus the effective of the primary R½ and let

This is now the selectivity factor of the system, and should be as small as possible.

$$⑧\quad \eta_{\frac{1}{2}} = \eta_2 + \frac{\iota\eta_1}{\eta_1^2+1}$$

Maximum amplification — see equation (5)—has given a certain relation between ι, η_1, η_2 which must be satisfied. Placing this in equation (8) we obtain

$$⑨\quad \eta_{\frac{1}{2}} = \eta_2 + \frac{\eta_2}{\iota}$$

This gives a measure of the selectivity of the circuit when the radio-frequency transformer is designed for maximum amplification. For maximum selectivity, $\eta_{1/2}$ must be as small as possible. Now we have already, by using a condenser and coil whose losses are low, reduced η_2 as much as possible and fixed its value. However,

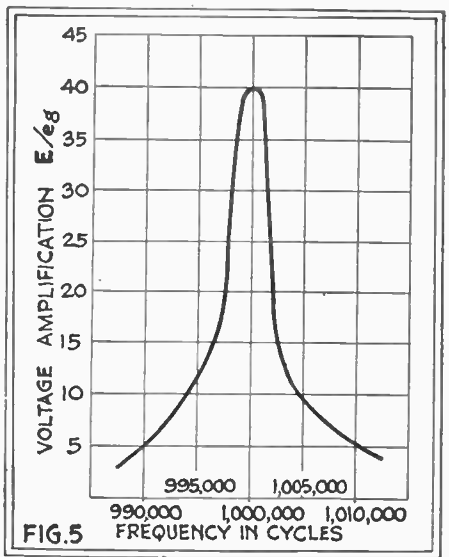


FIG. 5

Above the curve of a transformer designed as described here. In the complete tuner, for of these are used, their peaks staggered to give a band-pass effect.

if we make ι large, $\eta_{1/2}$ will be smaller (ι has a maximum value of 1.0.). Thus, if $\iota = 1.0$, $\eta_{1/2} = 2\,\eta_2$.

If ι were only 0.5 (about the usual value in a radio-frequency transformer), the selectivity is 50% poorer.

Therefore, from the standpoint of selectivity, ι should be large.

Thus the option left us in equation 7 before mentioned has now been answered when the problem of selectivity is considered. The above equations give rise to the following statement:

In a tuned-radio-frequency transformer with a fixed secondary winding, working in conjunction with a given amplifier tube, the selectivity for a given voltage amplification depends upon the coefficient of coupling.

It is now necessary to examine the characteristics of the A. C. screen-grid tube in order to determine the values of plate resistance and amplification factor. Fig. 3 gives these quantities.

It will be noted that the plate resistance, instead of being about 10,000 ohms (which is the case in the 01A-and 27-type tubes) is about 500,000. This means that the primary inductance of the radio-frequency transformer must be increased accordingly. Unfortunately, there is a very definite limit to the amount of inductance that may be used for the primary; for, if too many turns are used the primary will be tuned to some definite point in the broadcast range by the distributed capacity of the winding and the capacity in the screen-grid tube which is directly across the primary. Therefore, it is necessary to increase the coefficient of coupling as much as possible.

The writer worked some time on this problem and was able by careful design to obtain values of coupling up to 90 per cent. With this high coupling factor, and as many turns on the primary as possible consistent with keeping the tuning of the primary below 200 meters, a transformer was designed that performed unusually well, from the standpoints of both amplification and selectivity. This may be observed by an examination of Fig. 4, where the voltage amplification of the A. C. screen-grid used with the transformer described is plotted against wavelength. An average amplification of about 32 is obtained, as compared to an amplification of about 15; the latter is all that can be obtained when the 01A tube is used with a well-designed radio-frequency transformer. Thus we have secured twice as much gain with the A. C. screengrid tube as it was possible to get before its introduction and, if the circuits are properly shielded, no neutralization problem confronts us.

How to Build the Taylor Band Isolator

By GORDON TAYLOR

For those of our readers who desire to build an up-to-the-minute super-heterodyne, Mr. Taylor's receiver will make an especial appeal.

Only parts of highest grade have been employed in its construction, and if the builder desires to obtain reception similar to that outlined by Mr. Taylor, it is recommended that he adhere strictly to the use of those parts listed.

IN LAST month's article a general description of the theory of the Band Isolator receiver was given, together with the records of tests made to determine the ability of this receiver to step out and pull in far distant stations right through the early evening hours with local New York stations going full blast. During these tests reception was obtained on all but three of the channels then in use, which means that, starting at the lower end of the dials and tuning on up throughout the entire broadcast band, stations were heard at 10 kilocycle intervals, except at the channels occupied by the three stations that could not be brought in, and on two channels on which stations were not operating. All of this was accomplished from a typical New York City location and before 11:30 P. M. Twenty-five states were represented in the resulting log, including such far distant states as California, Colorado, Florida, Texas and Utah.

This record speaks volumes for both the sensitivity and the selectivity of the Band Isolator receiver All but the most powerful local stations were readily cut out to bring in DX stations in adjacent channels and even the most powerful local did not interfere beyond one channel either side of its own frequency.

All of this is accomplished with but five tubes (excluding the audio end, which is not included in the receiver proper). No r.f. amplification is used ahead of the first detector and only two intermediate frequency stages are used. The extreme amplification obtained is the result, first, of using screen-grid tubes in a circuit that takes the fullest advantage of their tremendous amplifying powers. Secondly, the intermediate amplifier stages are individually tuned with midget condensers to permit bringing them to exact resonance with one another and in this way eliminating the broad tuning and comparatively poor amplification obtained with some super-heterodyne receivers.

In addition to the selectivity and sensitivity (which were more fully explained in last month's article) is the fact that this receiver is unlike other super-heterodynes in operation. It tunes like any tuned r.f. receiver, rather than a super-heterodyne. The tuning is sharp, but stations always come in at the same dial settings, without whistles or squeals, and without repeat points on the oscillator dial.

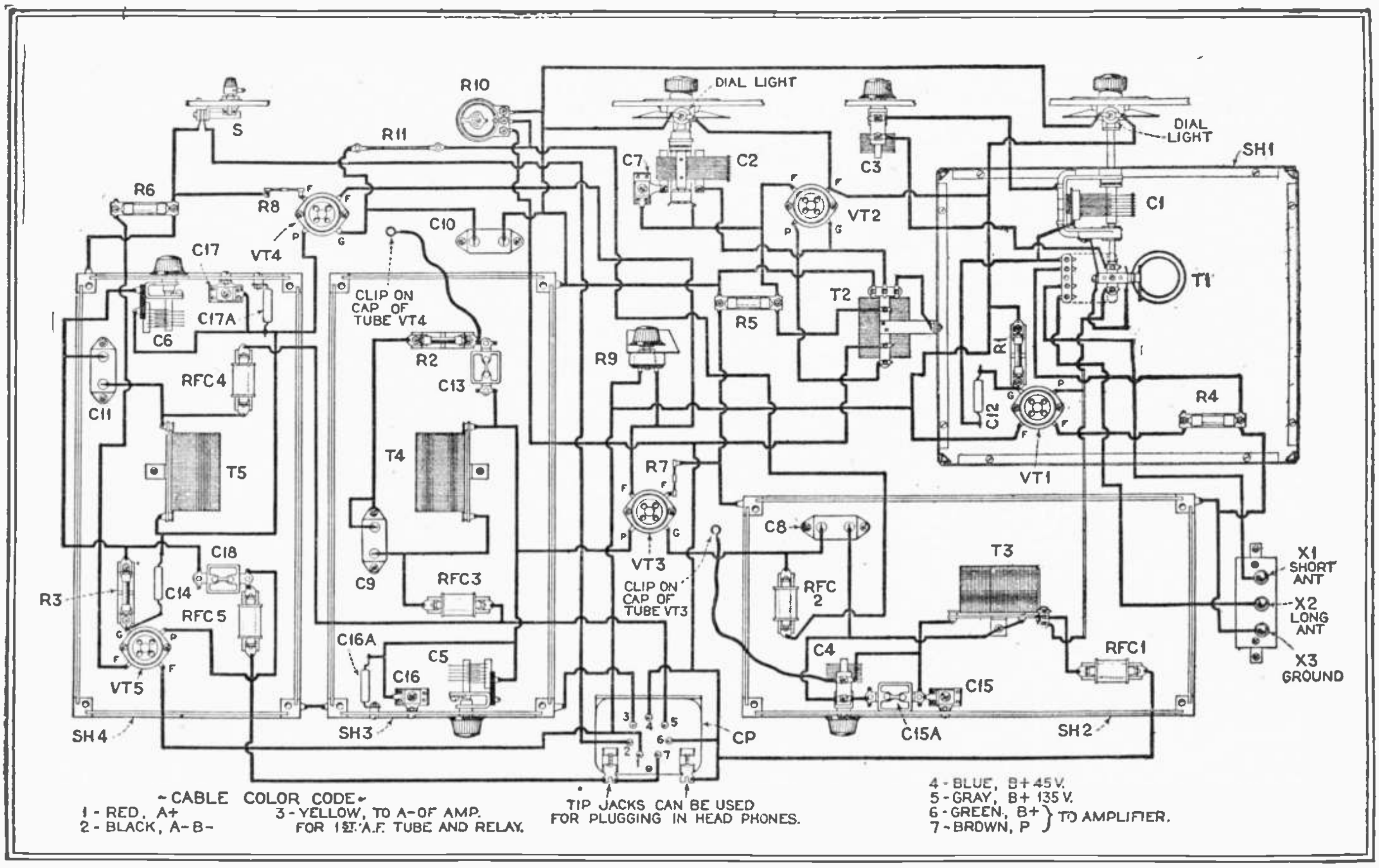
A detailed description of the various features of the receiver is best given by following through the schematic diagram of the circuit. The input, or first detector circuit, consists of a specially designed three-circuit auto-coupling transformer with center-tapped primary, secondary and feed-back coils. A standard variable condenser is employed for tuning the secondary and a midget condenser to control feed-back where it may be required in the reception of very distant or weak stations. The auto-couple principle is obtained by mounting the transformer directly on the rear of the tuning condenser so that its primary is moved in and out of the secondary by means of a cam arrangement as the condenser plates are meshed and unmeshed. Thus the coupling is loose for low-wave stations and close for the high-wave stations.

The oscillator pick-up coil, which is part of the oscillator transformer, T2, is connected in series with detector grid return, at the filament end. It is not desirable to have the pick-up coil included directly in the tuned circuit of the detector, so the tuning condenser is shunted across only the secondary coil of T1. This means that the rotor plates of the tuning condenser are not at ground potential, being separated from ground (A—) by the oscillator pick-up coil. Inasmuch as this condenser is mounted directly on the front the shield, SH1, this shield cannot be at ground potential either, otherwise the pick-up coil would be short-circuited and no signals would be heard. It may seem a little unusual to shield a circuit without directly grounding the shield but it has absolutely no harmful effects in this case.

The oscillator circuit is not shielded because experiment showed that nothing was to be gained by shielding here. The transformer, T2, like all of the other transformers used in this receiver, was especially designed. Inasmuch as an unusually high intermediate frequency is employed in the Band Isolator intermediate amplifier, the oscillator must necessarily have a correspondingly high-frequency range; which in turn involves the use of fewer turns than on the ordinary oscillator coil. Moreover, a pick-up coil of unusual design is included in this transformer, with the result that adjustment of the oscillator tuning condenser has absolutely no effect on the tuning of the first detector circuit and the two tuning controls are therefore entirely independent of one another. The extra variable condenser indicated at C7 is a balancing or equalizing condenser employed to bring the oscillator tuning dial settings into track with those of the other tuning control. It need be adjusted only once and then left in that position.

In the input circuit of the first intermediate stage is a tuned transformer consisting of primary and secondary. The tapped primary is, of course, connected in the plate circuit of the first detector, with the choke coil, RFC1, between it and the "B" supply. No by-pass condenser is used here. If it were, no regeneration would be obtained in the first detector circuit, even with the plates of the midget condenser, C3, entirely meshed. Omission of the choke has the same result.

The secondary of the input transformer is tuned by means of three condensers, each of which serves a definite purpose. First there is a fixed condenser which provides the main tuning capacity. Unfortunately, even the best fixed condensers of a given capacity rating are not exactly alike in capacity. They are manufactured with a tolerance of 10% plus or minus, which is quite close enough for the purposes for which fixed condensers are ordinarily used. But for their use in this circuit, where they are employed for tuning purposes, greater accuracy of capacity is required. Moreover, it is desirable to have room for a small frequency variation in the tuning of the intermediate circuits, to permit obtaining exact resonance. Third, the preferred frequency



In this parts-layout diagram of the band isolator receiver, note that the individual parts are not drawn to scale. Each of the parts, however, is centered exactly in its proper relative position. In this way, it is possible to show all the wiring, without the confusion that would result from picturing all the component parts full scale size

at which to operate this intermediate amplifier requires the use of approximately 200 micro-microfarads capacity. The nearest standard fixed condenser to this is rated at 100 mmfd.

To meet all these conditions, the fixed condenser is shunted by an equalizer condenser and a midget variable condenser. The equalizing condenser is adjusted so that, with the rotor plates of the midget condenser all out, the circuit is brought to resonance with the other two circuits. Thus the tuning characteristics of the three tuned circuits are equalized and each has the 50 mmfd. variable capacity of the midget condensers to provide room for variation of the intermediate frequency if desired.

Another purpose served by the midget condensers, which are mounted with their knobs on the outsides of the three shields, is to permit variation of the circuit capacity to make up for slight changes which take place when the shield covers are put in place. If these midgets were not used the circuits would have to be adjusted to resonance with the shield covers off; only to be thrown out again when the covers were put in place.

The second tuned intermediate circuit, which is located inside shield SH3, is tuned in the same way as the input circuit, although in this case the tuned coil is in the plate circuit of VT3 instead of in the grid circuit. This means that this coil is at plate potential. To permit mounting the three tuning condensers on the shield walls the fixed block condenser, C9, is included in the circuit so as to isolate one side of each tuning condenser from the high voltage supply. This blocking condenser serves at the same time as a by-pass condenser across the 135-volt plate supply.

The second detector circuit is similar to that of the second intermediate stage, except that its output is carried directly to the cable plug through the choke, RFC5, after by-passing through C18. The second detector stage, like the two preceding stages, is inclosed with its own shield. The three shields, SH2, SH3, and SH4, are all grounded to A—.

In addition to employing chokes in the two detector plate leads, chokes are also included in the plate supply leads of the two screen-grid tubes, as well as in the screen-grid lead of VT3. In the case of VT4, a resistor is used in the screen-grid lead. A choke might have been used instead of this resistor but seemed to have no advantage, so the resistor was employed because of its smaller size.

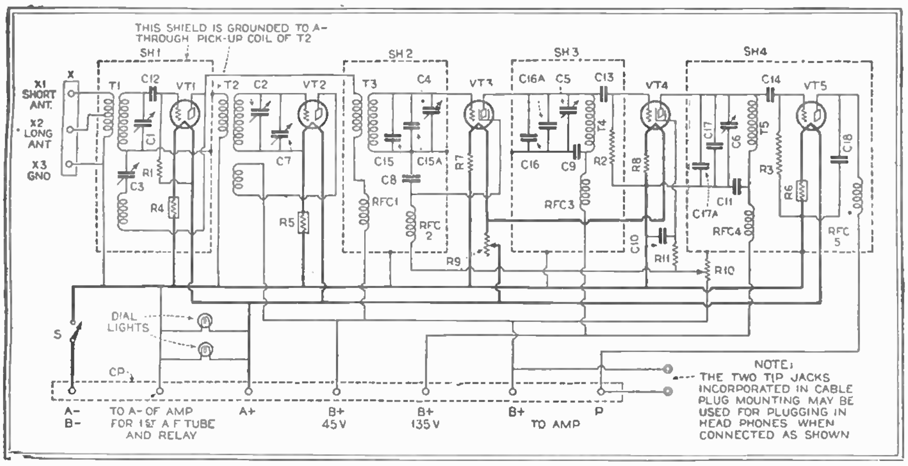
There will probably be some surprise when it is stated that this receiver was designed to use CX-299 tubes for first detector and oscillator. The reason for this is that these small tubes are just as good as larger tubes in these positions and have the advantages of smoother control of regeneration, in the case of the first detector, and lower filament current consumption. 301A tubes may be employed in these two positions if desired, but results will be somewhat more satisfactory with the small tubes.

The filament current for VT1, VT2 and VT5 is controlled through the the use of individual amperites. In the case of the screen-grid tubes a fixed resistor is inserted in the negative side of each filament circuit to provide the required "C" bias voltage. In the positive side of the circuit a rheostat is incorparted to permit exact adjustment of the filament voltage.

A somewhat unusual feature is found in the connections of the filament switch, S. This switch not only controls the filaments of the five tubes and the two dial lights in the receiver, but may also be made to control the filaments of an external audio amplifier by connecting the A— terminal of the latter to the lead provided in the cable plug of the receiver, instead of to the "A" battery direct. If a relay is used to provide automatic control of a trickle charger and the power pack, it also may be operated from this same switch by this means.

The volume control employed, R10, is a 500,000-ohm potentiometer. This is connected directly across the 45-volt supply but its resistance is so high that the current drain is only a fraction of one milliampere. Moreover, the circuit is broken when the receiver is turned off so in cases where batteries are used for the "B" supply there need be no worry about this drain.

There are just two more points for consideration before starting the construction. For the second detector a 300A tube is recommended for maximum sensitivity. Second, the cable plug



This circuit diagram of the band isolator receiver embodies a correction which should be noted. The original diagram on page 61 failed to include condenser C17A, *in shield can* SH4

specified contains two phone tip jacks. When wired as shown in the diagram, headphones may be plugged in. This is a convenience to DX fans who prefer headphones when "fishing" for DX.

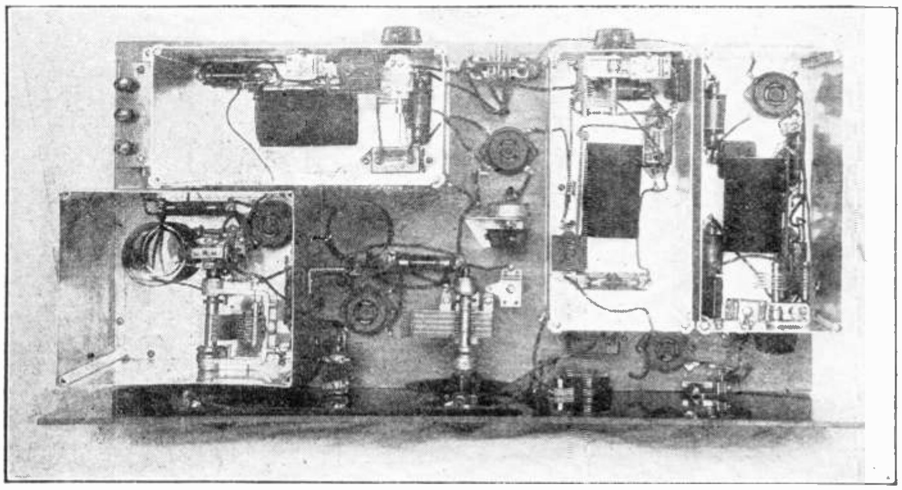
Most of the details of the assembly of the Band Isolator Receiver are made clear by the accompanying illustrations. However, there are some points which require explanation, and there are some suggestions which are in order.

All of the instruments which are to be mounted on the baseboard should be laid out in place, including the shield bottoms and the instruments that are to be mounted thereon. Then, with a pencil or scriber, the locations of all mounting holes should be marked on the base and shield bottoms. During the assembly the shield bottoms will be attached to the baseboard only by the screws used in mounting the instruments; to pass which, holes should be drilled through the aluminum bottoms. Directly under the corner holes of the bottoms of shields SH2, SH3 and SH4 half-inch holes should be drilled through the baseboard so that after the receiver is completed it will always be possible to tighten up the corner screws from underneath. Also, these half-inch cutaways permit the insertion of soldering lugs under the heads of these screws without raising the shield bottoms off the baseboard. A 3/8-inch hole should be drilled through the bottom of SH1 and baseboard, directly under the hole in square bar at bottom of primary coil carriage. This will permit special coupling adjustment, as described later.

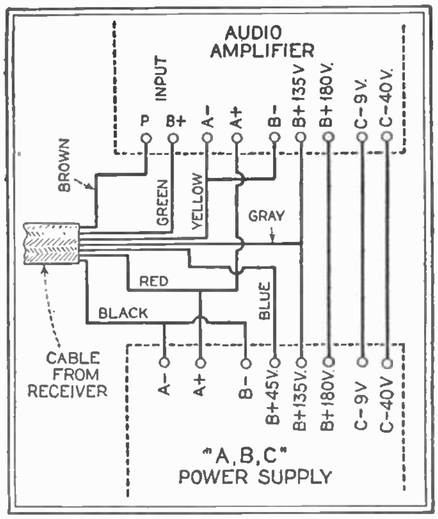
All of the holes required in the shield bottoms to permit the passage of the mounting screws of the various instruments should be drilled, and any burrs which result should be filed off before attacking to baseboard. Otherwise, burrs between shield bottoms and baseboard will cause the shields to buckle.

All of the wires which are brought in or out of the shields SH2, SH3 and SH4 are provided for by filing three-cornered slots in the bottom edge of the sides or ends instead of drilling holes for their passage. This simplifies the wiring, because there is no necessity for threading the leads through holes, but more important, the shield sides and ends need not be placed in position until the wiring has been completed.

This cannot be done so readily in the



Looking down on the completed band isolator receiver, with shield removed to show the various parts



Connections for the cable from the tuning unit to audio amplifier and power unit

case of SH1, so there the usual practice of drilling holes to accommodate the leads is followed. The other exception is in the case of the leads going to the top terminals of the screen-grid tubes. They are provided for by filing slots in the top edges of the end plates of the corresponding shields.

The instruments to be mounted on the shield bottoms are as follows:

SH1—BT1, R1, R4.
SH2—RFC1, RFC2, T3 and C8.
SH3—RFC3, C9, T4 and R2.
SH4—RFC5, VT5, RFC4, C11, R3 and T5.

After "spotting" and drilling the mounting holes for these, the assembly may proceed. First attach the four corner posts to each of the bottoms of shields SH2, SH3 and SH4, placing a soldering lug under the head of each screw used for this purpose. Then place these aluminum plates in position on the baseboard and mount the instruments listed above, using wood screws for this purpose. The bottom of SH1 may also be put in position and in instruments mounted in position. In this case no corner posts are used.

The three tuning condensers in SH2, SH3 and SH4 are mounted on the side or ends of the shields, as close to the top edges as possible but leaving ample clearance for the shield covers. Inasmuch as one side of each of the condensers in these shields is at ground potential, it is convenient to mount them solidly on the shield walls in this manner, except for the fixed condenser in SH2, which is supported between the terminals of the other two condensers. The balance of the assembly work is sufficiently clear so that no further explanation is required. It may be worth while to note that if a suitable mounting bracket for the rheostat, R9, is not available, one of the metal templates which accompanies the Hammarlund tuning condensers may be bent to serve admirably.

The method of wiring does not require explanation. It is suggested, however, that long leads carrying the "A" and "B" currents be run underneath the baseboard for the sake of appearance.

After the wiring has been completed the usual tests should be made to make sure that no connections have been omitted or incorrectly made. If everything checks up satisfactorily, the "A" and "B" supplies, amplifier, antenna and ground should be connected up. The shield covers may be left off for the time being. Now adjust the three midget condensers to a half-way position and turn the screws of the equalizers C15 and C16 all the way in, but the screw of C17 only half-way in. Then, with the volume control turned three-quarters up (clockwise) and with the plates of the midget condenser C3 unmeshed, tune in a station with the two main tuning dials. It must be remembered that at this point these two dials may or may not run alike, because the balancing condenser, C7, has not yet been adjusted. Nor is the signal tuned in likely to be loud, because the intermediate stages are thus far only tuned roughly to resonance.

If nothing is heard, turn the volume control up a little more and again tune through the entire scale slowly, being especially careful with the right-hand dial because of its extreme sharpness of tuning. It is safe to assume that a station will be heard this time. When it is, adjust the two tuning dials exactly. Then, leaving these two dials alone, adjust the three midget condensers, C4, C5 and C6, individually to exact resonance. Should it be found that one of the intermediate circuits cannot be brought into resonance due to lack of capacity, or too much capacity, in the midget condenser the circuit capacity can be increased or decreased by readjusting the corresponding equalizer condenser. It may be found that even with the midget and equalizer condensers in one of the circuits set for their maximum capacity that circuit can still not be brought to resonance with the others. In that case, turn the oscillator dial back one-half degree. This will raise the heterodyne frequency and thus raise the intermediate frequency. A resetting of the tuning condensers of the intermediate stages will then be necessary and it will probably be found that the three circuits can now be brought to resonance. If not, repeat this procedure.

Having reached this point, the adjustment should be carried a little further so that resonance is obtained with the three midget tuning condensers meshed to the same degree. This is accomplished by readjusting the equalizer condensers to add or subtract capacity, at the same time keeping the circuit in resonance by readjusting the corresponding midget condensers. This is suggested because then the intermediate amplifier has a small tuning range which permits the selection of a frequency within this range which provides the best results. Finally, tune in a weak distant station and again test the intermediate tuned circuits for resonance, because it is sometimes difficult to bring these circuits to exact resonance when using signals from a local station, because of the great volume.

Now the shield covers may be fastened in place. This may alter the circuit capacity slightly, necessitating a final readjustment of the midget condensers. With this job finished the equalizer condenser, C7, is adjusted. For this purpose tune in a station at about 40 on the antenna dial. If the oscillator dial reads higher than the antenna dial, turn the screw of the equalizer in a little and then readjust the oscillator dial. Continue this balancing act until the two main dials read alike. They will then read alike for most other stations, with some variation on very low or very high wave stations.

In locations where extreme selectivity is required there are three adjustments provided in the Band Isolator receiver to permit obtaining the required degree. First, the long and short antenna terminals permit the use of either half or all of the primary of the antenna coil. For normal conditions, and with any but a very small antenna, only half of the primary should be used because the use of the entire primary provides abnormally tight coupling.

The second method of increasing selectivity is by adjusting the screw on the under side of the coil carriage (for which provision was made by drilling a hole through the bottom of shield SH1 and the baseboard). With this screw taken out entirely, thus permitting the primary to slide away inside of the secondary when tuned to high wavelength stations, it is probable that the coupling will be satisfactory for the medium and low-wave stations. In other words, this automatic coupling variation arrangement does not vary the coupling in direct proportion to the wavelength. By turning this adjustment screw to the right the degree of coupling at the maximum position becomes less but remains the same as before the medium and low-wave stations. The best position for this screw is usually that where it holds the primary (at a dial setting of 100) only half-way inside of the secondary.

The third selectivity-increasing adjustment is made by connecting only part of the primary of the first intermediate transformer, T3, into the detector plate circuit. To use this whole primary the detector plate is connected to the lower terminal of the end terminal strip of this coil and the choke, RFC1, to the top terminal. To employ only half of the primary the choke should be connected to the middle terminal instead of the top.

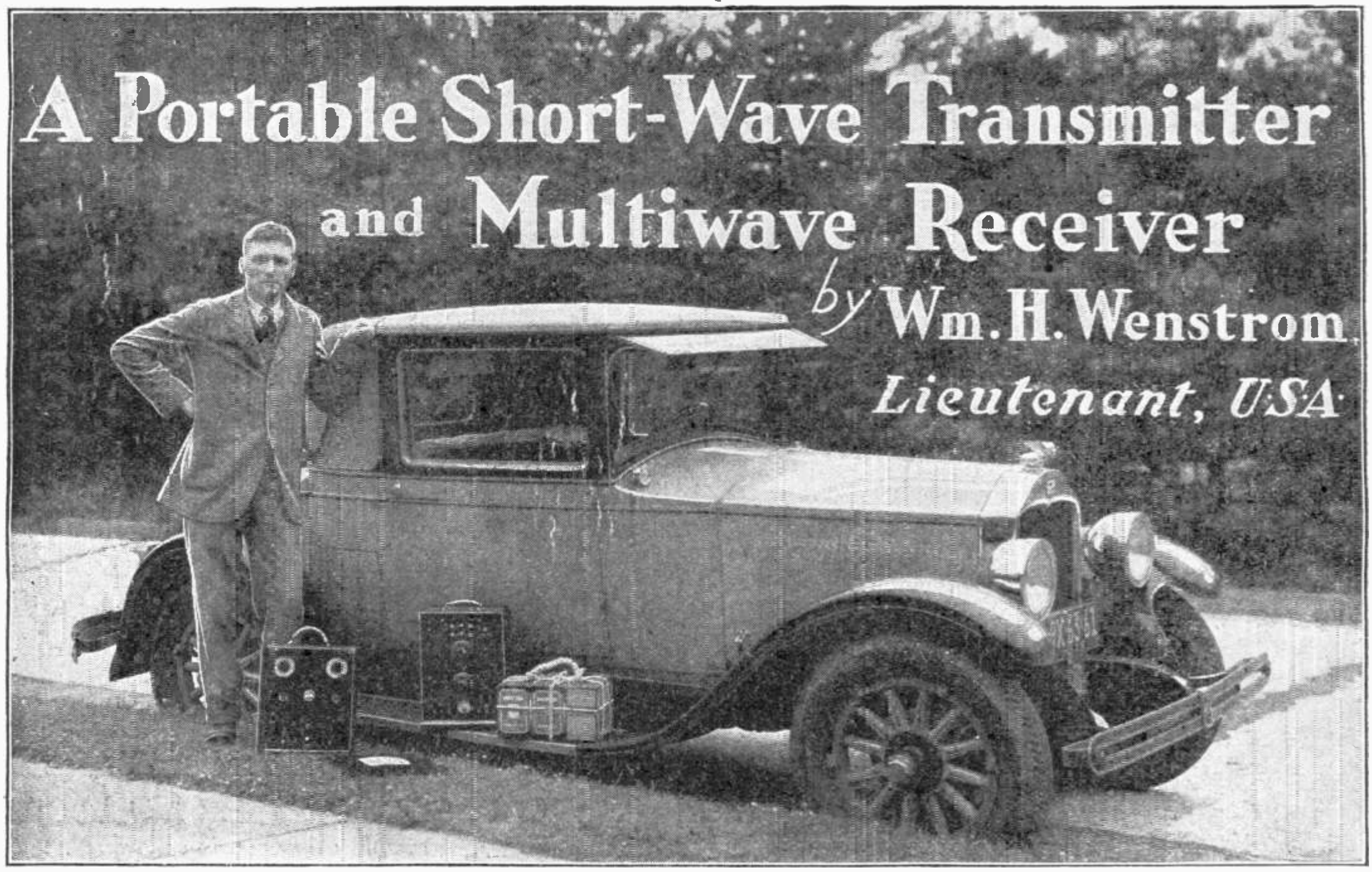
The foregoing features for increasing selectivity have been included and described so that any one building this receiver can obtain adequate selectivity, regardless of how bad local interference problems may be. For normal conditions of interference these special adjustments need not all be made, of course.

LIST OF PARTS USED

C1, C2—Hammarlund ML-17, .00035 mfd. Midline variable condensers.
C3, C4, C5, C6—Hammarlund MC-11, 50 mmfd. midget condensers.
C15, C16, C17, C7—Hammarlund type EC, equalizer condensers.
C8, C9, C10, C11—Aerovox No. 250, .5 mfd. bakelite by-pass condensers.
C12, C13, C14—Aerovox No. 1450, .00025 mfd. moulded mica condensers.
C15a, C16a, C17a—Aerovox No. 1450, .0001 mfd. moulded mica condensers.
C18—Aerovox No. 1450, .001 mfd. moulded mica condensers.
CP—Yaxley No. 669, cable connector plug and mounting with two terminal jacks.
R1—Lynch metallized grid leak, 3 megohms, with mounting.
R2, R3—Lynch metallized grid leaks, 1½ megohms, with mountings.
R4, R5—Amperites No. 1A or No. 6V-199, depending on tubes used.
R6—Amperite No. 1A.
R7, R8—Aerovox No. 985, 10 ohm wire wound resistors.
R9—Yaxley No. 510, Junior filament, rheostat, 10 ohms.
R11—Electrad 5,000 ohm Truvolt wire wound grid resistor.
R10—Electrad 500,000 ohm Type E, Royalty potentiometer.
RFC1, RFC2, RFC3, RFC4, RFC5—National Type 90, radio-frequency chokes.
SH1—Hammarlund Type AS-1 aluminum stage shield.
SH2, SH3, SH4—Hammarlund Type HOS-1, aluminum stage shields.
S—Yaxley No. 10, midget battery switch.
T1, T2, T3, T4, T5—Hammarlund No. VI-5, special Band Isolator coil set, consisting of five coil units, complete with mountings.
VT1, VT2, VT3, VT4, VT5—Eby tube sockets.
X1, X2, X3—Eby binding posts, engraved, Short Ant., Long Ant., Gnd.
X—Bakelite binding post strip, 1½" x 3½" x 3/16".
5 Lynch bakelite mountings for the five chokes, RFC1 to RFC5.
2 Hammarlund spring clips for top terminals of screen-grid tubes.
2 National Type VED dials equipped with No. 28 illuminators.
1 Courtland Panel Engraving Co.'s drilled and engraved Band Isolator panel, 7" x 24".
Tubes—2 Cunningham C-299 (or CX-301A) for sockets VT1 and VT2. 2 Cunningham CX-322 screen-grid for sockets VT3, VT4. 1 Cunningham CX-301A for socket VT5.
Screws, wire, solder, soldering lugs, and two 1" x ¼" tubular brass collars for mounting binding post strip, X.

A Portable Short-Wave Transmitter and Multiwave Receiver

by Wm. H. Wenstrom, Lieutenant, U.S.A.



THERE are finite limits to all terrestrial DX. The antipodes are only twelve thousand miles away; in time London palls and even Australia goes stale. Our morale may rise on hearing the signals of a transatlantic airplane, but it really takes a jump when we hear our friend say from the far shore of a mile-wide lake: "We reached the cove before the storm hit—everybody safe."

For such occasions, and for more prosaic work as well, this low-power portable transmitter is designed. Its reliable daylight range is two miles with phone and twenty miles with code.

Of course, "communication" is a dual affair and depends as much on the receiver as on the transmitter. The description of a suitable receiver follows this article. The transmitter's dimensions are slightly different from those of the receiver, but in general it is designed as a companion unit.

As in the receiver, one-fourth inch bakelite serves as the panel and also as the framework of the set. Though this construction is not the most compact, it has advantages. It is very easy to assemble, strong and rigid, and accessible—when the panel is tipped forward all parts are instantly exposed to view.

Circuit Details

The transmitter circuit is a series-fed Colpitts, often called the Hoffman split Colpitts. It is shown in Fig 1. All standard oscillator circuits are much alike in efficiency, despite the arguments of their advocates; but the Colpitts has two advantages which make it ideal for portable use: first, one variable condenser absolutely controls the oscillator frequency over a wide range (see calibration curve, Fig. 6) with no guess work inductance clips, no flopping out of oscillation, no plate current acrobatics; second, two large condensers directly across the tube elements keep the emitted wave exceptionally steady—practically as steady as that of an oscillator-amplifier circuit. In addition, the series feed brings the plate supply and grid bias leads into the radio frequency circuit at points of low potential. A minor disadvantage of this circuit—no control of grid feedback, as evidenced by heavy plate currents—is nullified by using a high value of grid leak (around 10,000 ohms).

The Power Supply

After the circuit itself, the matter of power supply demands consideration. An "A" battery of dry cells may be essential when the outfit is packed on horses or mules, but for most uses a small storage battery, which will deliver a more constant voltage, is preferable. The plate battery, however is a different matter. Dry "B" batteries are bulky enough; wet ones are out of the question. No dynamotor is made small enough for a set like this. The only trouble with the dry "B" battery is its bulk and weight; in other ways it is ideal. For any sort of economy we must use heavy-duty units, of which two or three, even though equipped with a handle, are not too easy to carry. The plate battery, then, is limited to either 90 or 135 volts—preferably 135.

We now have to find a tube that will produce some semblance of antenna amperes on the meager plate voltage of 135. It is a good deal like asking a confirmed drunkard to get hilarious at a prohibition picnic. Several UX-201As in parallel would take up too much space, but it fortunately happens that the UX-171 is

OSCILLATOR OUTPUT AND COMPARATIVE EFFICIENCY

On 85 meters, antenna and counterpoise terminals shorted through r. f. ammeter

	Ep	Ip	EIp	R.F.	Efficiency Index*
UX-171A	96	21	2.19	.75	34
	142	40	5.68	1.30	.23
UX-112A	96	16	1.53	.60	.39
	142	28	3.98	1.00	.25
UX-201A	96	11	1.06	.45	.42
	142	16	2.37	.60	.26
WE-216A	96	12	1.15	.50	.44
	240	42	10.01	1.40	.14

*The Efficiency Index Is of Very Doubtful Value, as It Is Entirley Comparative, and Probably Inaccurate

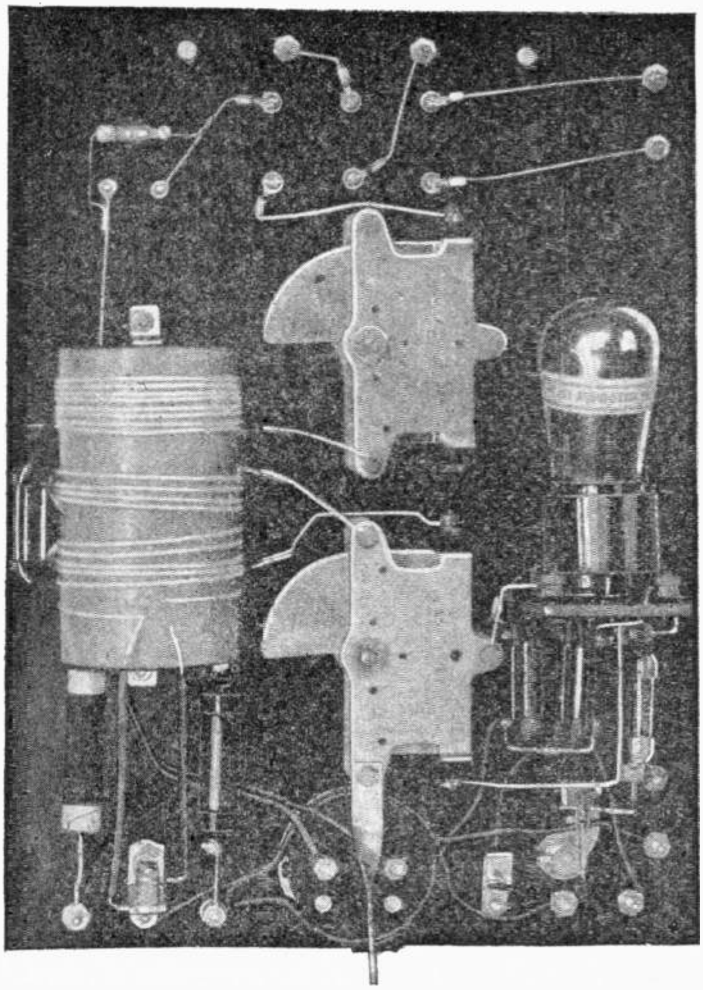
The Purpose of This Test Was to Get an Idea of the Performance of Various Tubes in the Portable Transmitter. The UX-171A, or 171, Was Chosen Because of Its High R.F. Output with a Low Voltage Plate Battery.

SHORT-WAVE transmitter designs are legion, and so are multi-wave receivers; but, to provide portability in both instances, is distinctly a horse of another color. And this is exactly what Lieutenant Wenstrom has done in the case of the transmitter and receiver described here.

With a conservatively rated, dependable daylight range of two miles for telephone, and twenty miles for code transmissions, the short-wave transmitter is adaptable to a wide variety of uses—some of which are suggested in the accompanying illustrations. And it is worth emphasizing, that the word "portable," in this case, is decidedly not a mere figure of speech.

The companion receiver—equally literally portable—covers a range of both short and broadcast channels and is so designed as to accommodate any type of "B" supply available. It also provides for phonograph pick-up, voice amplifier adaptation, and for the use of power audio output where (in fixed locations) the latter is at hand.

The author's particular fetish, in designing these portables, has been accessibility; a feature especially desirable in equipment which is to be used under camping or traveling conditions.



A REAR VIEW OF THE TRANSMITTER SHOWING PLACEMENT OF PARTS

ideal. Its superiority is shown in the oscillator output table. The figures were secured with a 171A, but apply also to the 171, which is more rugged and generally satisfactory. (See page 33)

Sometimes there arises the question of code versus phone. In reality there is no such question, for a phone experimenter must, under the law, be a code man as well. This is not at all unreasonable, for really good phone work demands a higher degree of technical skill than does code. Code usually has a range ten times as great as equi-powered phone, but phone is very handy when there is a great deal to say.

In choosing the operating band for this transmitter, we must hark back to its primary purpose, which is to cover dependably the distance of an ordinary camping trip or pleasure drive. The twenty-meter and forty-meter bands are unsuitable because of their pronounced skip-distance and because they are not open to phone. Though phone is permitted in the 160-meter band, this band would require too large an antenna. Thus by elimination do we arrive at the best—the 80-meter band. Coil specifications and arrangements are shown in Fig. 5.

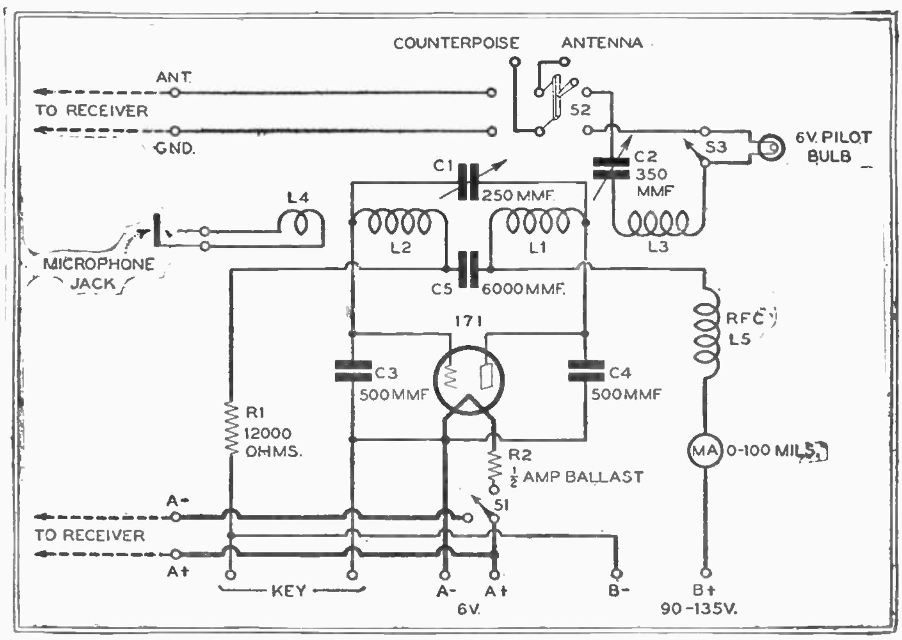
Suitable Antennas

The antennas used with this set are described in some detail in the receiver article. Their exact dimensions appear in the diagram (Fig. 2), and the photographs show their construction. The special insulators, cut from 3/8" hard rubber rod, are worth noting.

Constructional Details

The construction of a portable, being more exacting than that of a fixed set, should be unhurried. It might be well to start construction and preliminary tests several months in advance of actual portable use. This is particularly true of this set, as there is no danger of its going suddenly out of date. There are very few parts, and the photographs show clearly how they are assembled and wired. Some experimenters may wish to vary the arrangement. Down the center line and at noted distances from the panel top are: the change over switch, S2, which is removed from its base and mounted directly on the panel (2 in.); the antenna condenser, C2 (5 in.); the oscillator tuning condenser, C1 (9½ in.); and the milliameter (1⅜ in. from bottom). The coils of No. 16 D.C.C. wire (except modulating loop of No. 20) are wound on a fiber form 2½ in. by 4½ in. The coils are held rigidly in place by a "dope" of

FIG. 1—THE CIRCUIT DIAGRAM OF THE TRANSMITTER



celluloid dissolved in acetone. Of course any "dope" on short-wave transmitter coils is pure heresy, but in this case the most important thing is that they stay in place. The coil form is fastened to the panel by angles on the right (from panel front) of the condensers. The condenser C5 is fastened directly to the center coil ends. Above the coil, to the right of the changeover switch, is the socket for the antenna resonance bulb, mounted directly in the panel; and the shorting switch S3, also mounted in the panel. Below the coil, and held by bus bars, are the grid leak R1 and the radio frequency choke, L5. The latter is about one hundred turns of No. 30 wire on a half-inch wooden cylinder. Below these parts is the microphone jack.

On the left of the condensers is the tube socket, far enough down to have its base even with the oscillator condenser. There is plenty of room above it for a UX-210 tube when the set is used at a fixed location. Directly below the socket and held by bus bar are the "Colpitts" condensers, C3 and C4, and to the left of them is the filament ballast, R2. The filament changeover switch, S1, projects through the lower left part of the panel, balancing the microphone jack on the right.

The carrying case is made of ½ inch white pine, nailed together with heavy brads and provided with a suitcase handle. The lumber cutting dimensions follow:

- 1 piece 11⅛" x 15⅛" (back)
- 2 pieces 4½" x 11⅛" (top and bottom)
- 2 pieces 4½" x 14⅛" (sides)

Though the portable receiver had a front cover this set has none, because its many binding posts do not allow one. For use in an auto, or in any place where it has a tendency to tip over, the box should be screwed to a 1 inch base of convenient size.

The key, and a small knife switch to close the key circuit for phone, are mounted on a separate board ¼" x 5" x 10". This board is provided with a twisted pair lead long enough so that the key may be used on any convenient rest, such as the operator's knee. The microphone, which may well be salvaged from an ordinary telephone, is provided with a twisted pair lead ending in a plug. To reach the microphone terminals, rather inconspicuous screws on the inner frame, the outer case must be taken apart. The A battery lead is another twisted pair, with battery clips at the far end; or the far end may terminate in a plug which fits a jack on the car dashboard. The B batteries are tied tightly with heavy clothesline into a bundle as compact as possible, and like the other units connect to the set through a twisted pair lead. There follows a list of the parts used in this set, though any parts which are mechanically and electrically similar may be used:

TRANSMITTER PARTS LIST

C1—Cardwell .00025 mfd. variable condenser;
C2—Cardwell .00035 mfd. variable condenser;
C3, C4—2 Sangamo .0005 mfd. fixed condensers;

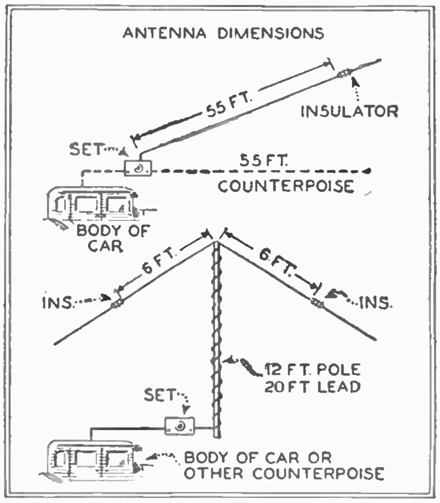
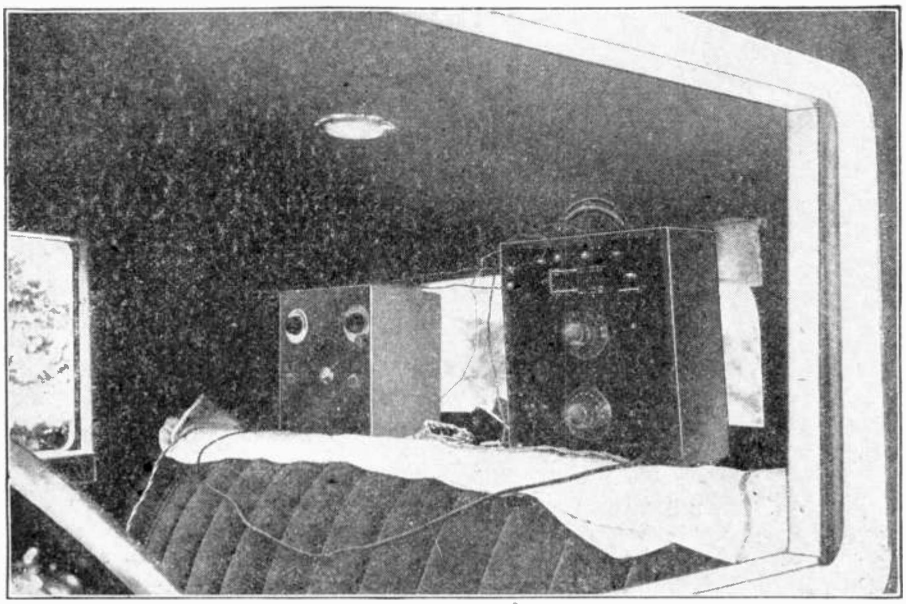


FIG. 2—SOME SUGGESTED ANTENNA SYSTEMS (ABOVE)

BELOW: THE PORTABLE RECEIVER AND TRANSMITTER READY FOR USE IN A COUPE



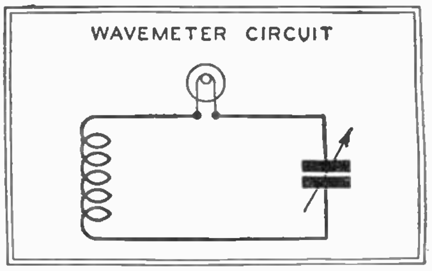


FIG. 3—A WAVEMETER, WHOSE CIRCUIT IS SHOWN ABOVE, IS HELPFUL IN CALIBRATING THE TRANSMITTER

C5—Sangamo .006 mfd. fixed condenser;
L1, L2, L3, L4—4 Home made coils (see coil diagram and text);
L5—Radio frequency choke (see text);
R1—Western Electric resistance, type 38-B (see text);
R2—Daven ½ amp. ballast, with mounting;
S1—Yaxley junior jack switch, SPDT;
S2—Trumbull knife switch, DPDT (see text);
S3—Midget knife switch, SPST (see text);
1—Benjamin spring socket, type 9040;
1—Weston milliameter, type 506, 0-100 mils;
2—Dials, 3 inch bakelite;
1—Lamp socket, miniature (see text);
1—Bulb, 6 v. pilot;
12—Eby binding posts, large size;
1—Bakelite panel, ¼" x 10⅛" x 14⅛";
1—Carrying box, complete.

OPTIONAL HEISING MODULATOR PARTS

T1—Thordarson small type 2:1 audio transformer;
R3—R.C.A. rheostat, type PR-535, 0-1.5—6 ohm;
R4—Tobe grid leak, .5 meg.;
L6—Primary of R.C.A. filament transformer, type UP-1656;
2—Sockets, Fahnestock clips, baseboard, etc.;
1—Two stage speech amplifier;
1—Cone speaker.

Before any operation is attempted, a wavemeter should be procured. It is simple enough to make. As shown in the diagram, Fig. 3, its parts are three: a coil, a condenser and a flashlight bulb. The bulb should be of the 1.25 volt variety, as higher voltage bulbs give too broad a reading. Once made, the wavemeter must be calibrated through the receiver from a standard one. Its use is the simplest of all: With the transmitter in operation, place the wavemeter coil near the oscillator and turn the wavemeter dial until the bulb lights brightest. Of course, one must use caution—or a plentiful supply of bulbs.

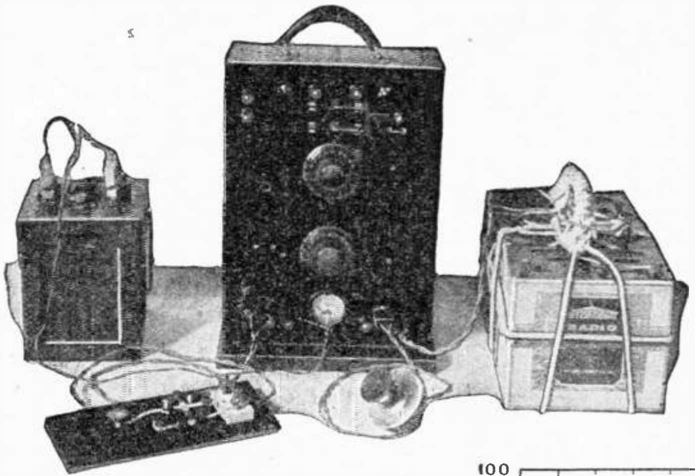
Operation

First of all connect the "A" battery, see that the tube lights, and check the voltage across its terminals. Then connect a 45 volt "B" battery to the set, leaving the antenna and counterpoise off and setting the oscillator condenser at about 50. When the key is closed the milliameter should read about 5 mils. Next connect a short length of wire directly between the antenna and counterpoise binding posts. Tuning the antenna condenser should change the milliameter reading—at one point should almost double it. This test indicates that the tube oscillates normally; but to make sure of it place the receiver across the room from the transmitter, with no antenna or ground on either. The receiver easily picks up the loud cw whistle of the transmitter. Then plug the microphone into its jack, and get someone to talk into it. The telephone signals should be clearly audible in the receiver headphones. It will be noticed at this point that plugging in the microphone lowers the wavelength about a quarter of a meter.

The set is now completely tested and ready for full-powered operation. Actual communication tests should be made from a fixed location before trying portable work. Connect the antenna and counterpoise or ground, and also the 90-135 volt B battery. With the 90 volt battery, the plate current will run somewhat as follows: Antenna detuned, 12 mils; antenna tuned to maximum, 50 mils; normal operation, 25 mils. With the 135 volt B battery; Antenna detuned, 18 mils; maximum, 80 mils (will soon ruin tube); normal operation, 40 mils. As the pilot light reaches normal brilliance at about .1 ampere, one can guess at the antenna current. With the antenna condenser tuned somewhat below the maximum for normal operation, the antenna current runs about .08 ampere for 90 volts and .12 ampere for 135 volts.

Before any real operation, the transmitter must be carefully calibrated—an easy proceeding with the flexible Colpitts circuit. Each new set should be calibrated individually, and a chart like the one in the diagram should be made up. Both the transmitter and the wavemeter may be checked against the receiver on such known wavelengths as 62 meters (KDKA) and 74.7 meters (NAA).

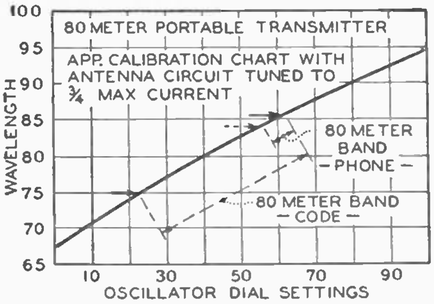
It is worth noting that a Federal license is required for transmission, and that an amateur must stay strictly within the prescribed bands. The 80 meter band extends from 75 to 85.7 meters (4,000—3,500 kc.) for code, and from 84.5—85.7 meters (3,550—3,500 kc.) for phone. While a few careless or deliberate amateurs operate off wave, just as a few drivers labor under the delusion that they own the highways; if every amateur followed suit the whole fraternity would soon be wiped out by government action.



THE 80 METER TRANSMITTER WITH COMPLETE ACCESSORIES. ITS SIMPLICITY AND COMPACTNESS ARE APPARENT

When the transmitter is used for portable work with the Portable Multiwave Receiver, the binding posts on the left side of the panel are used. The A battery posts are connected by twisted pair to the external battery plug of the receiver, and jumpers run from the upper left binding posts on the transmitter to the antenna and ground posts on the receiver. When using the single wire antenna, a .00025 mfd. condenser is wired in the antenna jumper to change the antenna fundamental so that the 80 meter receiver coil will oscillate normally. To transmit, throw S1 and S2 to the right, lighting the transmitter filament and connecting antenna and counterpoise to the transmitter. To receive, throw both switches to the left, lighting the receiver filaments and connecting antenna and counterpoise to the receiver.

FIG. 6—BELOW, AN APPROXIMATE CALIBRATION CHART OF THE 80 METER TRANSMITTER



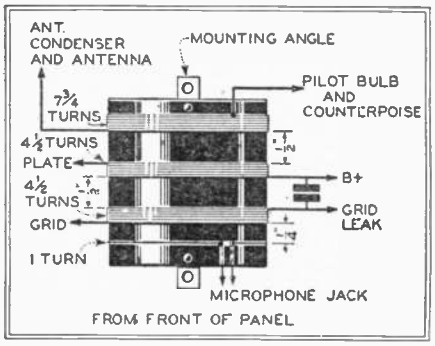


FIG. 5—DETAILS OF THE COIL CONSTRUCTION

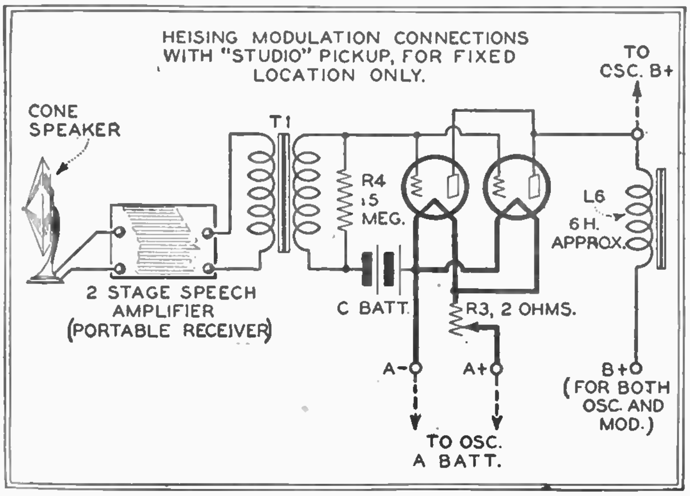


FIG. 4—IN A PERMANENT LOCATION PHONE TRANSMISSION CAN BE IMPROVED BY THE USE OF A VOICE MODULATION SYSTEM WHOSE CIRCUIT IS SHOWN AT THE LEFT

It is best to arrange the first tests with some amateur friend not over 20 miles away. When outsiders are worked later, the operator either tunes in a station calling CQ and calls him when he signs off, or himself calls CQ and searches for an answer in the form of his own call sent by some other station.

The choice of good location will greatly facilitate portable work. Hollows below the general land level and heavily wooded spots are unfavorable to transmission. Electrical conductors, good or bad, absorb radio frequency energy. This absorption is not very important in reception, but the waves should at least be given a fair start from the transmitter. Of course, nothing absolutely stops transmission — submarines transmit under water—but poor locations do cut down the range, and open spaces on water or fairly high ground are best.

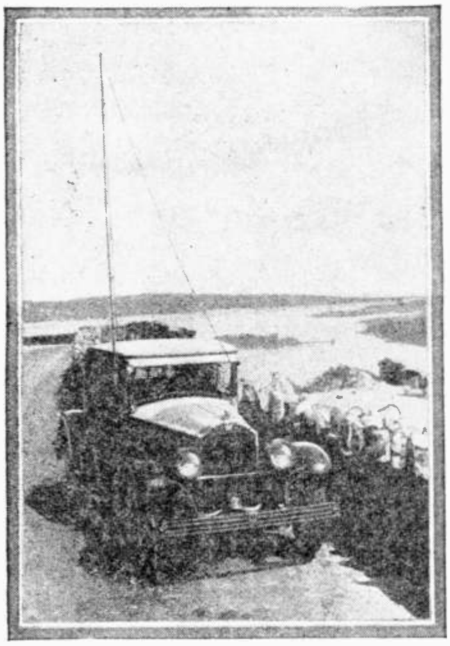
When the set is used for some time in a fixed location, more complicated arrangements may be found worth while. For this work a fixed receiver, such as the National Thrill Box or Pilot Super-Wasp, may be used. The transmitter is preferably placed up out of the way in another room and operated by remote control. Since more power is available, a UX-210 can be substituted for the UX-171, and storage battery, generator d.c. or rectified, filtered a.c. may be used on the plate. The plate current runs 45 to 60 mils at plate voltages around 300 or 350. Up to 500 volts may be used if the current is kept down by detuning the antenna.

With increased power, loop modulation becomes unsuitable, and is replaced by Heising modulation. For telephone work the transmitter becomes, in effect, a miniature broadcasting plant. This sounds complicated but, as a matter of fact, the arrangements are quite simple.

In a permanent location it is inconvenient to talk into a hand microphone. A "studio" pickup which will transmit sounds that originate anywhere in the room is already in the possession of most experimenters. It is nothing more or less than a cone speaker, and its terminals are connected to the input of the speech amplifier. This arrangement makes the loudspeaker work backwards, or convert sound energy into electrical energy.

The speech amplifier is merely a two stage audio amplifier using fairly good transformers and almost any sort of tubes. It may be the audio part of the Portable Multiwave Receiver. As shown in the diagram, Fig. 4, the speech amplifier output goes through an ordinary transformer to the grids of the modulator tubes.

The modulator tubes are preferably the same type as the oscillator. One modulator tube works quite well. Two in

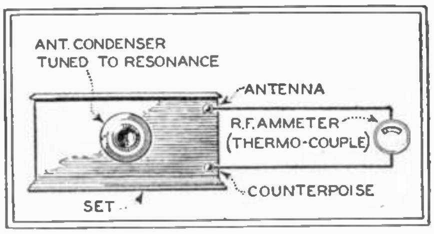


The antenna erected and ready for use.

parallel work very well indeed. Four would be still better, but a rather unnecessary and expensive refinement. The reason for more than one modulator tube is apparent when we recall how Heising modulation works. As far as audio frequency is concerned, the total current supplied to both oscillator and modulator is held quite constant by the choke, L6. The modulator, in accordance with the audio frequency voltages impressed on its grid, draws more or less current—acts as a variable resistance across the oscillator plate-filament. For complete modulation this variable resistance should equal the fixed resistance of the oscillator plate-filament. At normal grid bias, four modulator tubes in parallel draw about the same plate current as one oscillator.

RESULTS

While this transmitter is conservatively rated at two and twenty miles with a 171 and five and fifty miles with a UX-210, much greater distances are often covered.



Circuit used in obtaining the oscilator output table shown at the beginning of this article.

When the outfit was first set up at West Point, fifty miles north of New York City, a 210 was used with a 300 volt storage battery for plate supply. The location—in mountainous country—was none too good, and the late spring weather was thoroughly bad. In addition, the set was a rugged portable rather than a low-loss wonder resting mainly on air. In spite of these things we worked stations in Brooklyn, N. Y. (50 miles); Oneta, N. Y. (120 miles); Pottstown, Pa. (120 miles); Auburn, N. Y. (200 miles); and Greenburg, Pa. (300 miles). Heising phone was audible at a couple of hundred miles, but no verbatim phone reception was logged beyond Newburgh, ten miles away.

Then a 171 replaced the 210 for a few days' test, and the plate voltage was cut down to 100. The input was 2.7 watts, and the estimated output 1 watt. With this rather Lilliputian power we worked Newburgh easily enough; Riverside, N. J. (120 miles); Watertown, Mass. (175 miles); and actually disturbed the daylight ether at Lima, Ohio, 500 miles out—not bad for the 80 meter band. The 1 watt phone was heard weakly a hundred miles distant, but was not checked word for word beyond a receiver in Highland Falls, two miles away. In order to see how far the phone comedy would go, we put a UX-201A in the socket and cut the B battery to 40 volts. Highland Falls still got most of our conversation.

Its laboratory tests finished, the portable was at last ready for field and highway, lake and river. It was installed on the package rest behind the seat of a coupe, and fed by the car battery and a 90 volt B battery. We then drove to an open place in the hills three-quarters of a mile from the receiving operator, and put up the umbrella antenna. Every word went through without difficulty, even when we started the car and drove slowly along the road.

The next test was on the Hudson River. The transmitter, an A battery, a 90 volt B battery and the umbrella antenna were crowded into a small rowboat. On most seagoing craft the radio installations are inadequate, but this one may be truly said to have been overruled. Our phone signals were continuously understandable at West Point up to two miles, when both the strength and good nature of the rowers gave out. At the same time, Newburgh, at eight miles, copied our code and heard the phone.

As a final test of portability, the set (provided this time with a 135 volt B battery) was placed in the car along with the receiver and driven seventy odd miles to Garden City. We expected on arrival to find all the nuts loose and half the tubes broken, but no such thing happened; both the transmitter and the receiver worked perfectly at the end of the trip. We did some satisfactory two-way code and phone work up to two miles with 2GY, Radio Broadcast's station, and with 2VM at Mitchel Field. Then we drove south to Long Beach, and set up close by the restless Atlantic. At about ten miles we worked perfect communication for an hour with 2GY, using code at first and then, to our surprise, phone.

So much for the story of the 80 meter portable transmitter—a long story, perhaps, but not without a certain amount of meat. The set will not raise Australia in the small hours, nor will it pump every last microwatt of energy into the antenna. But after banging around in a boat or car it will do its modest two and twenty without complaining. And that, after all, is what a portable is for.

Push-Pull 245 Amplifier

(*Continued from page* 48)

minals on the terminal board and the "B+Det" post also located here. Plate voltages to other tubes which might be in the tuner are supplied from the other terminals provided. The 2.5-volt A.C. heater line in the tuner should be examined and, if the mid-points of any of the center-tapped resistors connected across it have been by any chance connected to anything but "B—," they should be disconnected, so that there cannot be any short circuits.

In the center are the circuit connections required when the detector tube of the tuner unit obtains its plate-voltage supply from an external battery source. Note that this makes unnecessary any connection between the input terminals and the terminals supplying plate voltage from the combination unit.

At the right is the connection of a phonograph pick-up to the audio channel of the combined unit. If, previous to the connection of the pick-up, a tuner unit has been connected to the voltage-supply terminals of the power supply, then connection of the pick-up circuit to ground is automatically obtained. If a tuner has not been used or connected, then one of the input terminals, as shown, must be grounded and connected to the "B—" terminal, to avoid the production of hum and high-pitched whistles.

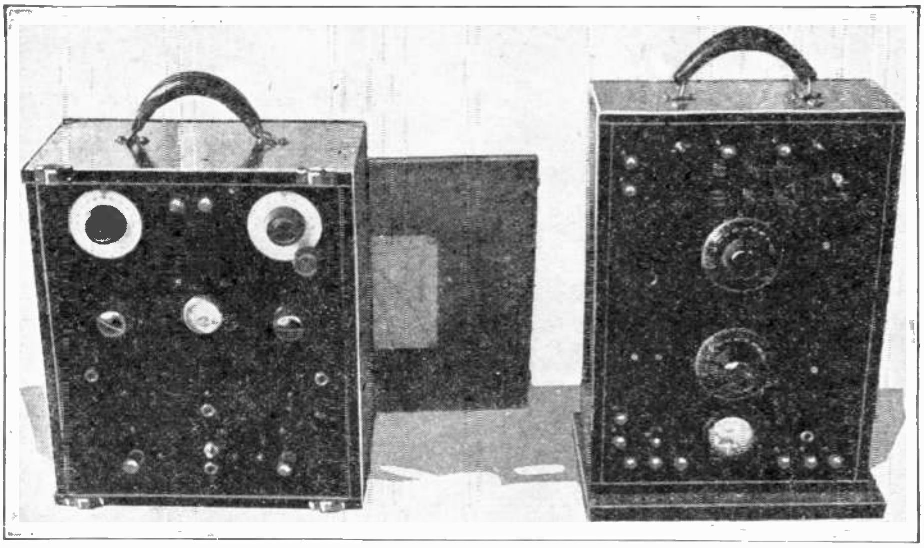
When connections have been completed, and the tubes have had sufficient time to reach their normal operating temperature, the "B" voltage levers should be adjusted, so that the tuner is operating at best efficiency. It will generally be found desirable to separate the amplifier and tuner at least two feet. Sometimes improvement in operation results also from changing the angle between the positions of the amplifier and tuner. Because of the incorporation in it of the Mershon condenser, the amplifier should always be operated right-side up.

OTHER APPARATUS

The illustrations accompanying the article show other amplifiers. Fig. C is a commercial 245-type combination power amplifier-power supply unit, put out by Ferranti, Inc.

(*Continued on page* 91)

THE PORTABLE MULTIWAVE RECEIVER, DESCRIBED BELOW



THE TRANSMITTER, DESCRIBED IN THE PRECEDING PAGES

Wenstrom's Multiwave Receiver

A Companion Unit to the Portable Transmitter

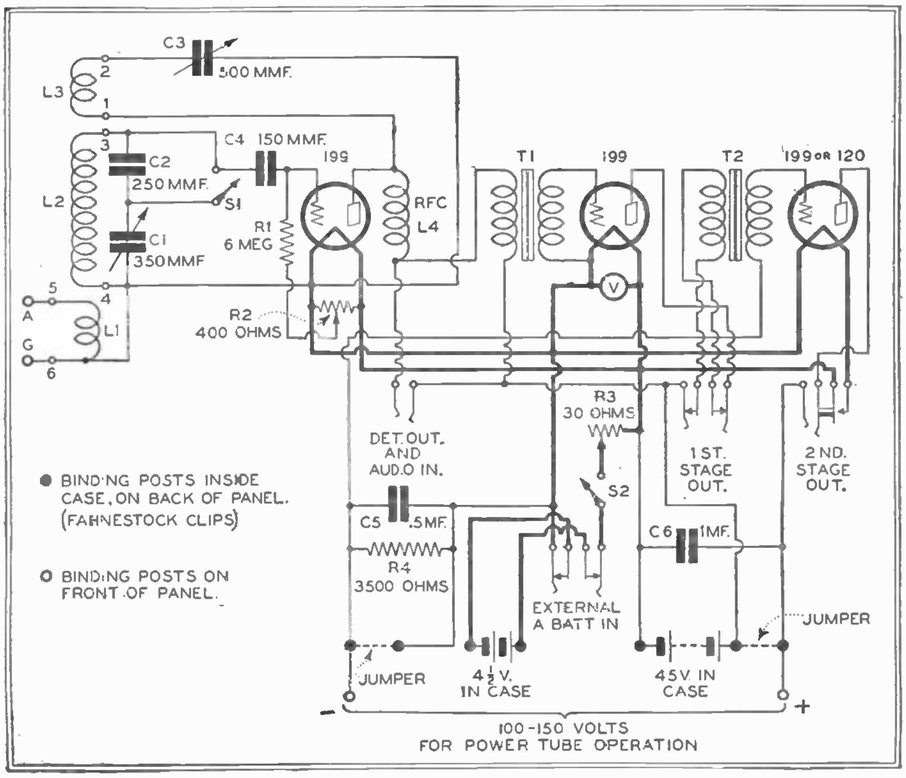
PORTABLE receivers maintain a refreshing variety unknown to the more staid and domestic sets of the home. We find puzzling extremes—portables that monopolize a large truck, and portables assembled in a nutshell. The search for compactness can easily be carried to ridiculous extremes; for a thumbnail portable, requiring phones and batteries much larger than itself, gains very little in overall convenience. For real portability, batteries should be included in the set, and the assembly should be of a size and weight easily carried in one hand. These requirements bring us logically to about half-suitcase dimensions; and indicate a carrying box built to fit the set rather than a set crammed into the odd corners of some ready-made container. The design and construction of a portable, needless to say, is more difficult than that of a fixed set.

The circuit used in this receiver and shown in Fig. 1 is easily recognized as a slight modification of the standard regenerative circuit. It covers a wide range of wavelengths. The regenerative detector with one or two stages of audio is practically standard where maximum performance and dependability are desired from minimum apparatus. While the circuit is not as sensitive as some multitube arrangements, it is more reliable and generally satisfactory.

Antenna Design

As the set is ill adapted to loop reception, some form of antenna circuit must be used for everything except local work. Portable antennas are as varied as the sets themselves, but a fairly constant rule is that the smaller and more convenient an antenna, the less signal it picks up. For use with this set three forms have been developed which do quite well for their size. The first is a single wire about 50 feet long, attached at its free end through an insulator to thirty feet of light clothesline which can be made fast to the highest support that happens to be available. For easy coiling the wire should be stranded, flexible and insulated, like lamp cord; and the insulator should be made from 3/8 inch hard rubber rod, as the standard types are too large. This antenna is probably the best of all, but in some locations, such as a moving car or a small boat it is not so suitable. For this work we use something reminiscent of the wave coil investigated some years ago by General Squier. Thirty or forty feet of bell wire is wound spirally on a solid bamboo fishing pole eight or ten feet long, the turns falling about one or two inches apart. The top end of the wire is fastened to the top end of the pole, which of course is vertically upright in use, and the bottom end of the wire is connected to the antenna terminal on the set. The third design, a modified umbrella antenna, is also built on a bamboo pole about twelve feet long; but the bell wire lead is not over twenty feet long with turns widely spaced, and two flexible wires each about six feet long are sol-

FIG. 1. CIRCUIT DIAGRAM OF THE MULTIWAVE RECEIVER; A SLIGHT MODIFICATION OF THE STANDARD REGENERATIVE CIRCUIT

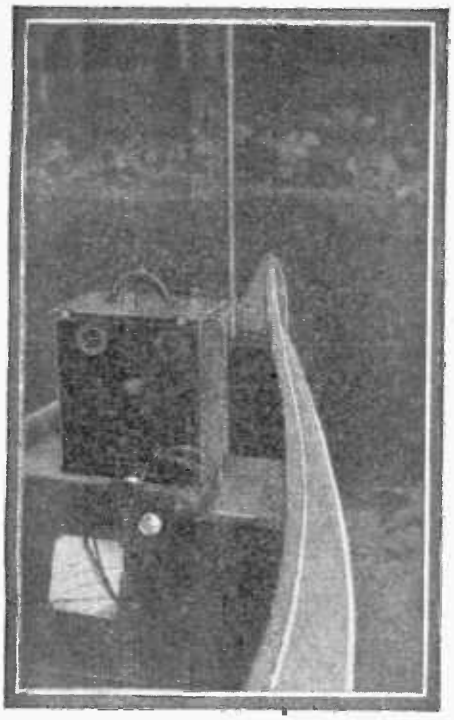


COIL TABLE

Band	*Coil Range*	*Type*	*Pri. turns*	*Grid turns*	*Tickler*
40*	23—45 m.	S-M No. 111-C, altered	2	5	20
80*	45—92 m.†	S-M No. 111-B, altered	3	13	35
Broadcast	200—550 m.	S-M No. 111-A		Unaltered	
Marine	600—1400 m.	S-M No. 111-D, optional		Unaltered	

* The first two coils are altered from Silver-Marshall standard. On primaries and grid coils turns are taken off; on ticklers turns are added; no change in wire size.

† The 80 meter coil goes up to about 135 meters with switch S1 closed.



The receiver, as set up in a canoe.

dered to the bell wire at the pole top, and held out from the pole at convenient angles by insulators and guy cords at their lower ends.

Unless a good conductive ground exists, such as a water pipe or a metal fence, a counterpoise, or insulated wire laid under the antenna, is desirable. The frame of an auto makes a good counterpoise, as does any large metallic object insulated from the ground. Various makeshift grounds, such as a metal plate or wire in a lake or stream, or a nail driven into a live tree, have possibilities.

RECEIVER RESULTS

The parts are mounted in a rather unique way—a way that bears some resemblance to the deck construction of a broadcast transmitter. A one-fourth-inch bakelite panel serves not only as the panel but also as the whole frame of the set. Everything except the batteries is mounted directly upon it with no other support. Perhaps each radio designer may be permitted one fetish that he expounds above all others—the writer's happens to be accessibility, and it was developed fixing military sets that had to work but wouldn't. The all-panel mounting is ideally accessible, as well as strong and rigid, for when the panel is slid out of the box and laid face down, all the parts are spread out as on a breadboard.

Tubes of the 199 type are chosen for their small size and battery economy. The rather small gain of these tubes makes two stages of audio desirable even for headphone work. UX-199s might be used with separate sockets; but as a 3 gang shock absorber socket is made for UV-199s these were decided on. The gang socket is more compact, stronger, and easier to mount. As one sometimes wishes to use a loudspeaker on a strong signal and the 199 is entirely inadequate as an output tube, the set is designed so that a 120 tube may be used in the last stage. The Sonatron V-120 fits the gang socket; the UX-120 requires an adapter. The grid bias of this tube is secured from a resistance in the set, and requires no separate C battery.

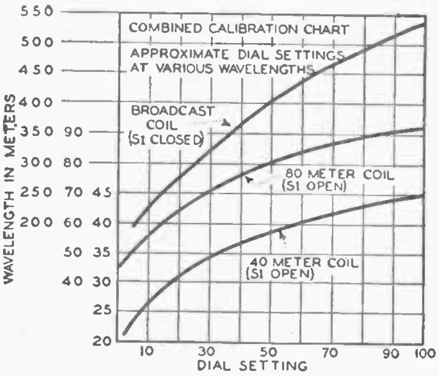
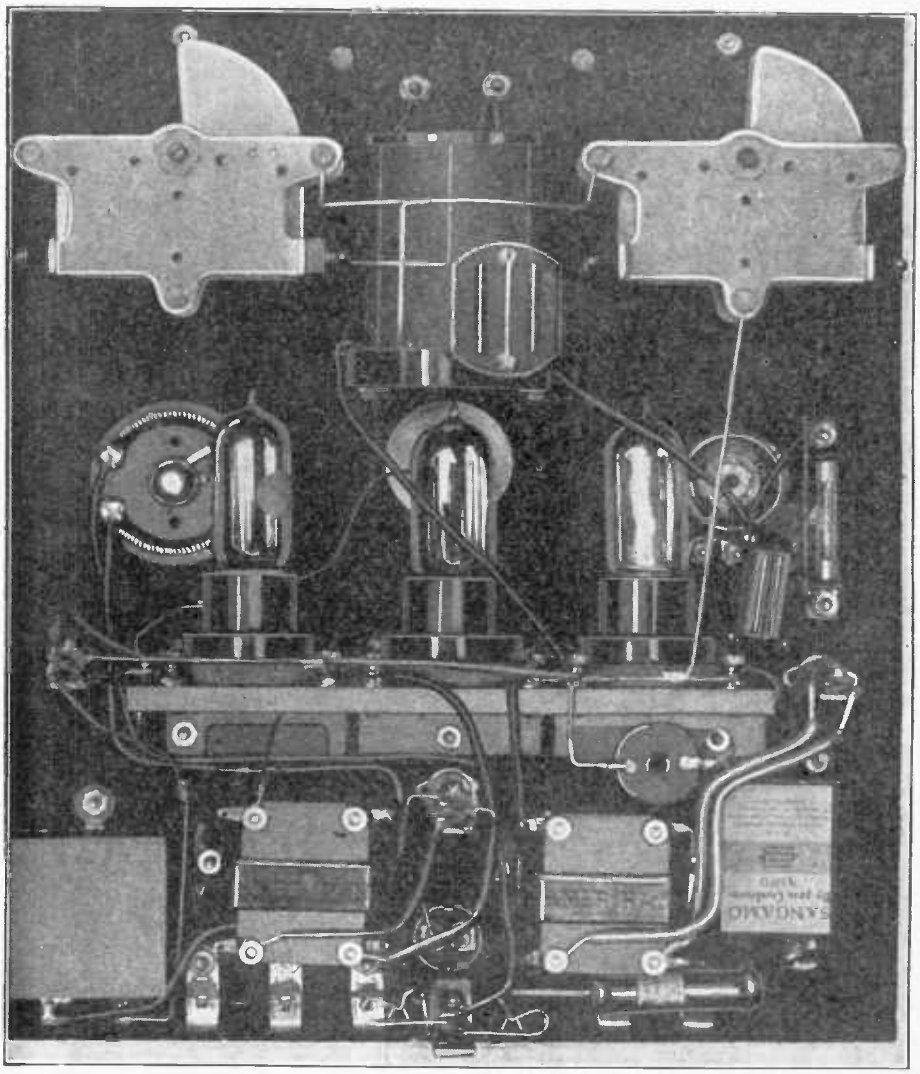


FIG. 2. *A calibration chart of the plug-in coils.*

Most portables cover only the broadcast band, but this one has a much greater range of usefulness due to its Silver-Marshall plug—in coils. As the broadcast band is considered most important, the circuit constants are arranged to cover it completely with one coil. There is also much of interest between 25 and 100 meters, including the 40 meter and 80 meter amateur bands, so that this range is covered with two coils. An optional coil, chiefly of interest to yachtsmen, covers the ship and radio compass waves. These coils are fully described in the calibration chart, Fig. 2, and in the coil table. Note that the amateur bands are placed well up in the short wave coil ranges, on the flat part of the curve.



A quarter-inch bakelite panel serves not only as the front panel, but as the support for all parts.

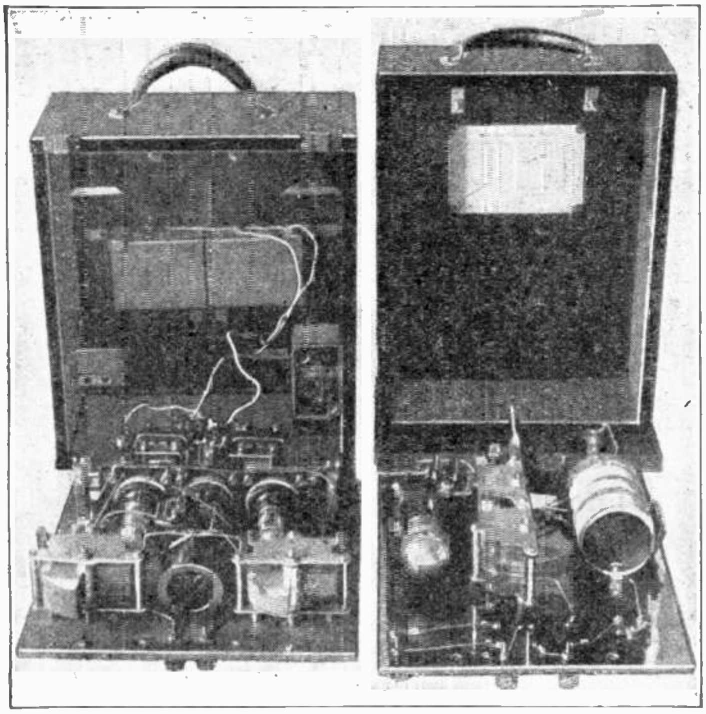
The .00035 mfd. condenser used for tuning through the broadcast band would of course be too large for the short wave coils. We resort to an unusually compact way of getting a smaller tuning condenser for the short waves. A fixed condenser equipped with a shorting switch is wired in series with the variable one. With the switch closed the tuning capacity goes up to .00035 mfd.; with it open the limit is about .000145 mfd. A potentiometer controls the grid bias of the detector and regulates its selectivity and sensitivity. It is usually negative for code reception and positive for phone.

The filament voltage is controlled by a high resistance rheostat and a midget voltmeter. This system permits the use of any A battery, dry cell or storage, and insures correct operation of the delicate 199 tubes. So that different batteries will not affect the amplifier grid biases, the rheostat is wired in the A+ lead.

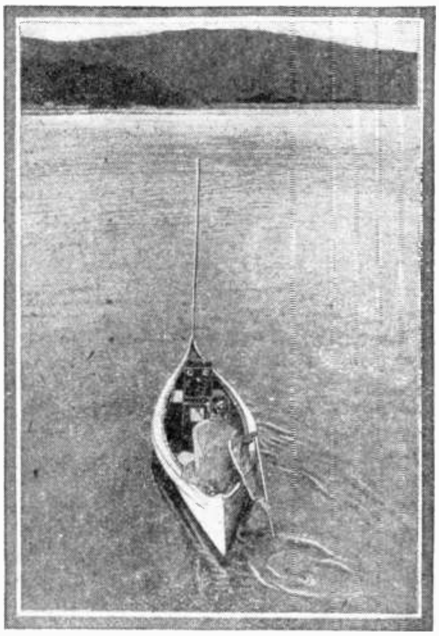
Though the jack system seems quite complicated, it is decidedly useful. The first jack is across the primary of the first transformer, and serves for testing the detector output, as well as to introduce an audio input with the detector tube removed. This last connection is handy when an electric phonograph pick-up is used, or when the set acts as a speech amplifier. The first-stage output goes to a conventional two-circuit jack. The output jack of the second stage is a filament lighting one, so that the last tube is lit only when in use.

The battery system also seems quite weird at first, but it was planned from much portable experience. The internal A battery consists of two 4½ volt C batteries wired in parallel, the leads from which go to the inside contacts of a double-circuit jack. When an external A battery is plugged into this jack, the internal one is automatically cut out. This external A battery may be three dry cells in series, or a 4 or 6 volt storage battery. If the set is to be used much in a car, the metal dashboard can be drilled for an ordinary open circuit jack. The back of the dash near the hole is scraped clean, grounding the sleeve contact, and a wire is run from the tip contact to the ammeter. This jack makes a convenient outlet from the car battery to a radio set or an emergency light.

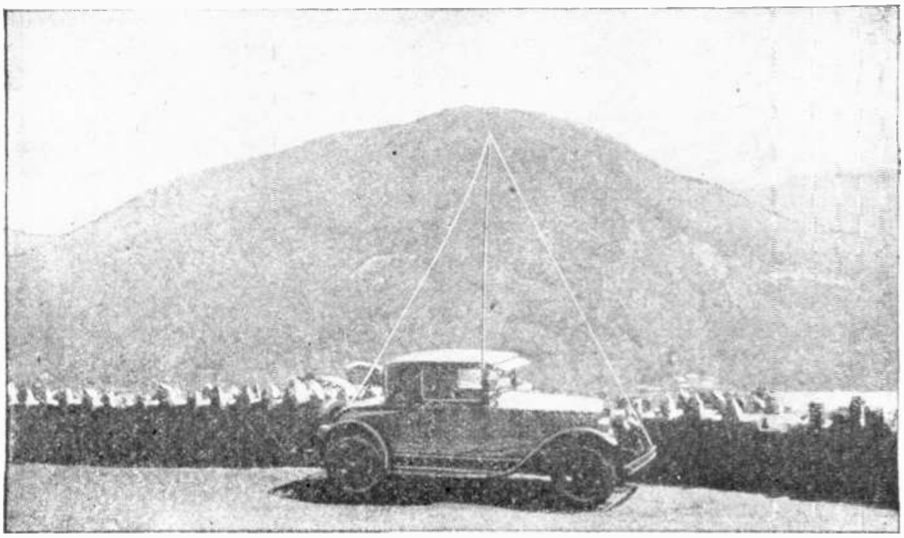
NOTE, AT THE RIGHT, THE COMPACT INTERNAL ARRANGEMENT OF PARTS, OF BOTH RECEIVER AND TRANSMITTER



BELOW—ALL LOCAL NEW YORK STATIONS WERE EASY TO GET, ON THE HUDSON, AT WEST POINT; WGY AND WICP ALSO CAME THROUGH WELL



BELOW—READY FOR REAL WORK, IN THE OPEN COUNTRY



The internal 45 volt B battery, applied to all tubes alike, consists of two 22½ volt units of the very smallest size (2" x 2½" x 3½"). When a power tube is used in the last stage two jumpers, or short pieces of connecting wire, are removed. This removes the internal B battery from the last tube, and permits to function the resistance which, at the rated current, applies the correct C bias to the power tube grid. The B-C battery for the power tube is then connected to external binding posts. Due to the automatic grid bias, this B-C source can be practically anything between 90 and 150 volts—from batteries or eliminator.

Constructional Details

The arrangement of parts is clearly shown in the photographs. Permissible variations will doubtless occur to the experimenter. The front panel is of bakelite, and measures 11 by 13 inches. Its ¼ inch thickness insures the strength necessary to support all the heavier parts, which are bolted directly to it with machine screws. A few lighter parts are held by bus bar, which is used in some places to strengthen construction. Other connections are made with small, rubber-covered wire. After the panel has been drilled, the mounting of parts can proceed by three distinct sections.

The top section includes the tuning and regeneration condensers, placed close to the outside edges of the panel to leave plenty of room between them for the plug-in coil. The condenser centers are two inches below the panel top. The coil socket is held horizontally by brackets midway between the condensers and 4⅜" below the panel top. Some bus bar is used to steady the coil socket, and the series fixed condenser is held by bus bar just behind it. The shorting switch S, of the midget knife type, is screwed directly into this condenser. At the top center of the panel are the antenna and ground binding posts. The dials are mounted on the front of the panel, and the right one, controlling the tuning condenser, is a vernier.

In the center section and 8½ inches below the panel top is mounted the gang socket. Few if any radio stores carry it in stock. It is the "Frost No. 616 3-gang shock absorber socket for UV-199 tubes," and can be obtained from Herbert H. Frost, Inc., Elkhart, Indiana. In the middle of the center section is the voltmeter, to the right is the rheostat, and to the left the potentiometer. The grid leak is behind the extreme left of the panel, and the grid condenser is held by bus bar just above the tube socket. The radio frequency choke is held by bus bar just under the socket. The three phone jacks are placed one at each end of the gang socket and one just under its center.

The two audio transformers occupy most of the bottom section. Old style Amertrans were chosen for their high gain, small size and light weight and also because they happen to be on hand. Others of good make may naturally be substituted. Between the transformers is the filament switch; and below it is the external A battery jack, to which fahnestock clips for the internal A battery are soldered. All the other internal binding posts (fahnestock clips) are bolted to the bottom edge of he panel, and the two outside ones are also external posts. Behind the panel outside the transformers are the plate and grid by-pass condensers for the power tube, and its grid biasing resistance is held by bus bar below the left transformer. All wiring should be done in definite steps: first the filament circuits, then the various grid and plate circuits in order.

The carrying box is built of ½ inch white pine, nailed together with brads, reinforced with brass corners, and fitted with a suitcase handle. The lumber is cut as follows: 1 piece 12" x 14" (back), 2 pieces 6" x 13" (sides), 2 pieces 6½" x 12" (top and bottom), one piece 12" x 13" (front). The front is fastened to the rest of the box by snap catches, and when in place completely covers the panel. The back of the panel is held 1⅜" behind the inside of the front cover by two thin wooden at the bottom, and at the top by wing nuts on two bolts set in iron angles. The two B batteries are at the back bottom corners of the box, and the two A batteries are against the center of the back. All batteries are held in place by brass angles. Two plug-in coils are clipped into the back top corners. The entire carrying box is finished with walnut varnish stain. The phones could be crammed between the panel and the front cover, but few users will care to give them or the panel this sort of punishment.

OPERATION

When the set is completed, it should be thoroughly tested in the workshop before any outside work is attempted. The operation and calibration of this receiver is practically the same as that of any standard regenerative circuit. First of all, connect the internal A battery for a test of the filament circuit and controls. Then connect the internal B battery and test each coil for even oscillation throughout its range. At this stage a few signals should be heard on the 40 meter coil without antenna or ground. Next plug in the external A battery and again test the filament controls. Finally, with antenna and ground connected test each coil for actual reception and calibrate it.

To test the power tube connections remove the two jumpers, change the 199 in the last socket to a 120, and plug a small cone speaker into the last jack. Then connect the external B-C battery and tune in a strong signal, which should be reproduced with good quality at comfortable room volume. When any trouble develops the jack system comes in handy, for one can immediately localize the fault in detector, first stage or second stage circuits. There follows a complete list of parts used in the set. Other parts, electrically and mechanically similar, may be used, but their dimensions should be carefully checked against the available space.

LIST OF PARTS

C1—Cardwell old type 350 mmfd. variable condenser;
C2—Sangamo 250 mmfd. fixed condenser;
C3—Cardwell old type 500 mmfd. variable condenser;
C4—Sangamo 150 mmfd. fixed condenser;
C5—Sangamo .5 mfd. by-pass condenser;
C6—Sangamo 1 mfd. by-pass condenser;
L1, L2 and L3—See coil table;
L4—Silver-Marshall r.f. choke, type 275;
R1—Tobe tipon grid leak, 6 meg. (label removed);
R2—Carter midget potentiometer, 400 ohm;
R3—DeJur rheostat, 30 ohm;
R4—Ward Leonard vitrohm resistance, small size, 3,500 ohm;
1—Frost 3 gang socket (see text);
1—Silver-Marshall coil socket, type 515;
1—Hoyt midget voltmeter, type 541, 0-4 volts;
1—General Radio dial, type 302, 2¾" vernier;
1—General Radio dial, type 310, 2¾" plain;
2—American transformers, type AF-6, 5-1;
1—Jack, open circuit;
2—Jack, double circuit;
1—Jack, filament lighting;
1—Filament switch, small push type;
4—Eby binding posts, large;
7—Fahnestock clips;
1—Grid leak mounting;
1—Bakelite panel, ¼" x 11" x 13" (see text);
1—Carrying box, complete with batteries (see text).

PORTABLE RESULTS

Recently some rather interesting tests were made with this receiver near West Point, 50 miles north of New York City. They extended over two or three evenings. There was no attempt to drag in extreme distance or to invoke the powers of the listener's imagination; we wanted simply to find out what the set would do under average conditions. As some signals had been heard accidentally in the laboratory while testing the set without antenna or ground, on the first test the two inch coil in the set was the only pickup. The set was placed on the high concrete wall of an athletic stadium up in the hills. On the broadcast coil, WEAF was tuned in intelligibly by zero beat. With the 80 meter coil in place KDKA came in quite distinctly on 62 meters, and amateur code came through from Connecticut and Pennsylvania. Then the 40 meter coil was plugged in, and brought in amateur code from New Jersey, Pennsylvania, New Hampshire, Virginia, North Carolina, Ohio and Indiana.

The set was next driven in a car to a location close to the first one, beside a reservoir in the hills. The car was the counterpoise, and the single wire antenna was strung out on a slight upward incline to a nearby wall. On the broadcast coil WEAF, WJZ and WOR of the New York area, as well as WGY of Schenectady and WOKO of Beacon, came through with faint loudspeaker volume. KDKA of Pittsburgh, WGP of Hartford, WCAM of Camden and WCAP of Asbury Park were also heard, along with WNYC, WMCA, WGBS, WPCH and WABC of the New York area. On the 80 meter coil KDKA was up to fair loudspeaker volume; code amateur signals came in from Massachusetts, Delaware, Pennsylvania, Michigan, and Prince Edward Island, Canada; amateur phones in Pennsylvania and Long Island were clearly understood. The 40 meter coil was somewhat of a surprise. Amateur code signals came in from all over the United States; from Quebec, Ontario and British Columbia; from Mexico and Germany; and from Cameroons and Liberia in Africa and a Portuguese ship. But this is not spectacular when we remember the carrying power of short waves, and particularly the carrying power of code.

The next test was made with the wave coil antenna to see what could be done with the car in motion. Of course there was some ignition noise, but on the broadcast coil it was not loud enough to obscure speech. On the 80 meter coil it was worse, so that only loud signals came through; and on the 40 meter coil it was very hard to hear anything but ignition noise. On the broadcast coil we tuned in WGL, a thousand watt station 50 miles away. Then the car was started, and at 20 miles per hour WGL still came through with a clearly understood weather report. After a few minutes of this, the local weather turned to distinctly overcast in the form of a tree limb which knocked the antenna off the car, but we put it back on and continued the test long enough to show that there is nothing difficult about broadcast reception in a moving car. Some interesting shadow effects can be visualized by noting the signal changes in hilly country.

The final test was made in a rowboat on the Hudson for a half hour in the late afternoon. The umbrella antenna was used, along with a small copper plate in the water for ground. WEAF, which in this vicinity might be called "Old Faith-

(*Continued on page* 89)

Automatic Tuning Adjustment

ONE of the undesirable peculiarities of the regenerative receiver is the resetting of the tuning condenser made necessary by each adjustment of the regeneration condenser—which accounts for the constant "juggling" necessary when tuning a regenerative receiver. A suggested method of overcoming this condition as shown in Fig. 1.

It is nothing more than a semi-circular piece of bus-bar wire, curved directly over the position occupied by the rotor plates when they are unmeshed, or turned quite out of the stator section of the tuning condenser. Ordinarily it is found necessary in tuning, while reducing the capacity of the regeneration condenser, to increase the capacity of the grid tuning condenser in order to follow the station. This wire, together with the action of the rotor, eliminates this; it serves as one plate of a condenser which automatically increases in capacity as the regeneration condenser decreases in capacity, thereby keeping the wavelength constant.

The exact location, position and size of this wire must be found by experiment. If good results are not obtained, by reason of insufficient capacity of the wire, a piece of sheet brass can be tried; cutting its width down by experiment until the proper results are obtained. Obviously, the "wrinkle" outlined above can be employed only with condensers using semi-circular rotor plates.—*Contributed by Martin Mytas.*

Bearings for a Tickler Shaft

IN constructing tuning coils with rotor coils, such as three circuit couplers with variable ticklers, trouble is often encountered in making suitable bearings for the rotor coils. A very simple and neat method is to use the rotor plates of an old variable condenser, cut down as shown in Fig. 2.

When used on a fiber, hard-rubber or bakelite tube, the plate should be cut as shown at "A." Two machine-screws are passed through the holes in the coil form and bushing, and secured in place. A ¼-inch shaft passed through the rotor coil and bearings, with suitable washers to keep it centered properly, will provide an excellent means of adjustment.

If a cardboard tube is used for the secondary, or stationary coil, the plate of the condenser may be cut with sharp ends (as at B), which are then pushed through the wall of the tube and bent over. This will provide a solid support without the necessity of drilling the bushing or tube.

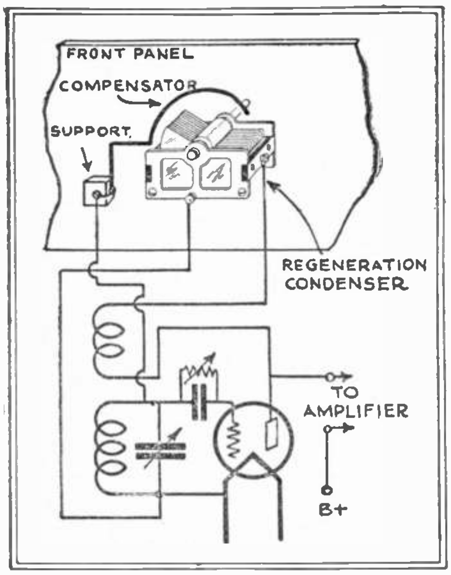


Fig. 1
The ingenious device indicated increases the capacity of the tuning condenser slightly as that of the regeneration condenser is reduced.

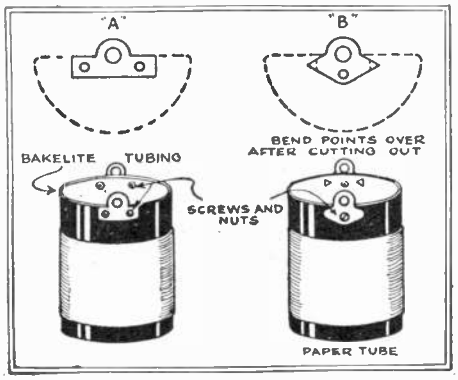


Fig. 2
The discarded rotor plates of an old variable condenser can be converted into mounting for the shafts of several rotary tickler coils.

A single screw placed through the bushing will strengthen it if any strain is placed on the latter.

The washers which were used between the plates in the condenser will serve to center the rotor coil and, in some cases, the shaft also may be utilized for the coil. In most condensers the plates are made of thin sheet aluminum or brass and a pair of tin shears or heavy scissors will cut it with little trouble.—*Contributed by D. S. Jenkins.*

Mounting Tubeless Coils

CONSTRUCTORS of receivers, either for the broadcast range or the various short-wave bands, will appreciate this simple suggestion for mounting coils. Self-supporting inductors are a great nuisance unless they can be mounted correctly and the distance between the various windings kept constant. A suggested method is shown in Fig. 3.

In making these coils, first procure a fibre or hard-rubber rod about ½-inch in diameter and about five inches long. Then, with a hack-saw blade, cut a slit lengthwise through the rod far enough down to hold all the coils of the coupler. Finally, drill a hole at the top of the rod, above the coils, and insert a machine-screw, to hold the coils firmly.

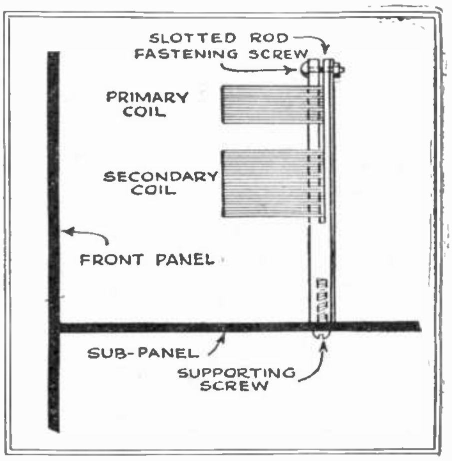


Fig. 3
A small piece of insulation is quickly made into a low-loss, rigid support for coils.

The rod holding the coils may be mounted in any way satisfactory to the constructor. Perhaps the simplest way is to drill a hole in the end of the rod, lengthwise, and tap the hole for either a 6-32 or 8-32 screw.

When a variable tickler (or other coil) is desired, it may be mounted directly on the panel of the set, with a suitable bushing, and the secondary and primary coils on one of the split-rods, as shown. The correct relation between the coils in a coupler can be obtained by making the slit longer than

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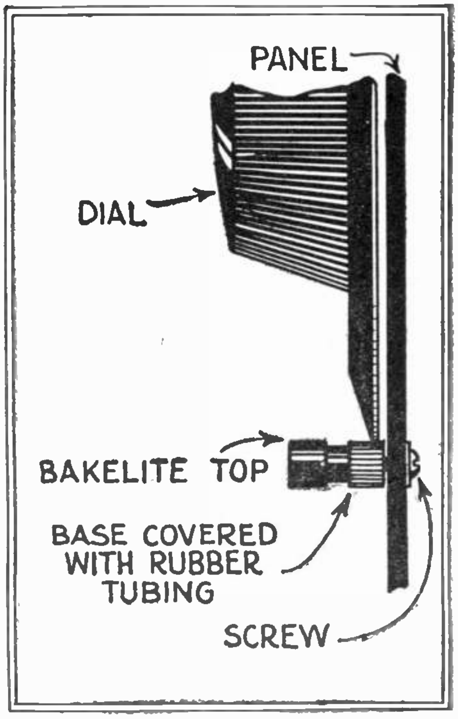


Fig. 4
A vernier adjustment for an old-style plain dial may be improvised from a binding post and a short length of rubber tubing, as shown.

A Tube and Set Tester for a Lean Purse

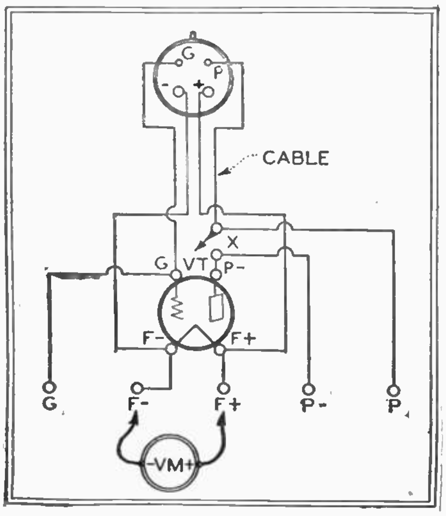
A Practical, Home-Made Device that Does Away with "Hit-or-Miss" Methods

By M. K. Barber

BEING an experimenter and set builder in a small way, and having long felt in need of a good tube tester and set analyzer, but not having the necessary seventy-five or eighty-odd dollars with which to purchase a real good one; and, being too fussy to be satisfied with a low-priced one equipped with a couple of cheap meters and having limited adaptability, I decided to get the old brain and pencil working to devise a tester which would approximate the adaptability of one of the real good ones at the cost of one not so good. I also wished to have all the test connections aboveboard, where I could see what I was doing—rather than "throw switch A to the right and switch B to the left" just because the directions said to do so; and thus add somewhat to my knowledge of radio testing.

The following paragraphs and the accompanying diagrams describe a general-purpose tube and set tester which may be assembled by anyone at a cost of approximately fifteen dollars, and which will enable the set-owner quickly to locate any trouble his radio set may develop. In addition, it will keep him advised of the condition of his tubes and batteries or eliminator voltages, and so he may anticipate and correct the cause of about ninety-five per cent of all set failures.

FIG. 1.—THE SCHEMATIC CIRCUIT OF THE TUBE AND SET TESTER



THERE are a number of excellent set testers on the market. But the service man or experimenter whose work of this nature is only occasional, hardly feels justified in investing a large sum in testing equipment.

Here is an answer to that very problem: a practical device that is not only easy to construct, but well within the means of the leanest purse.

Any radio receiver and its accessories may be tested, with the aid of only three simple pieces of equipment. These are: a voltmeter, a milliammeter, and a single, high-resistance phone receiver. If the resistance of the voltmeter is known, and is of a suitable value, it may be used either as a voltmeter or as a milliammeter, and its range in either capacity may be extended to cover all normal requirements, by means of a variable resistance which will handle about five watts for a few seconds at a time.

You say, "I have an old phone receiver and a rheostat in my junk box. I will get a voltmeter and so be equipped to do all my own testing." Suppose you lift the cover of your radio set and look at the works. In the majority of sets, this is what you will see: from five to seven tubes with their bases set flush on a metal subpanel; two or three variable condensers; the upper edge of a rheostat; a box with a covered cable extending down under the base; and a metal case or two containing audio transformers or what-not. No wires or terminals are visible.

Now, where are you going to connect your voltmeter or phone receiver to make your first test? You lift out one of the tubes and it occurs to you that if you could clip the voltmeter across the socket terminals you could test the various circuits connecting to that socket. So you could, but to make the test complete you must also keep the tube in that socket and have the set turned "on." The main purpose of any tube and set tester is to enable you to do this.

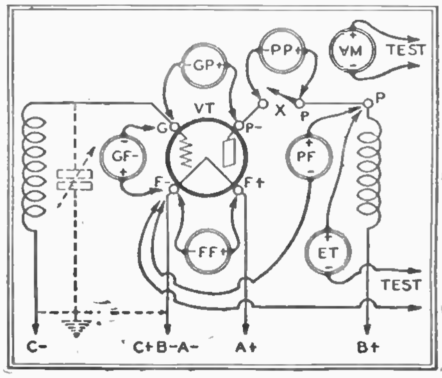
Look at Figs. 1 and 9. At the top is a tube-base plug to be inserted in a tube socket of the set. It is connected by a cable to the tube test socket (VT) mounted on the tester panel. Five pin-tip jacks are connected to VT. The tube we removed from the set is inserted into VT. Our voltmeter is equipped with a pair of short, flexible leads having a pin-tip on each. Switch X connects the plate prong of AD either directly to the plate of VT, or opens this lead for connecting a milliammeter in series with the plate.

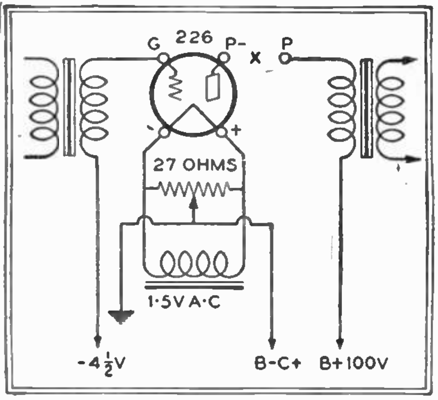
Now look at Fig. 2. This shows an amplifier stage in the receiver. The "doughnuts," except P—, indicate the four terminals of the tube socket in the set. They also, including P—, indicate the five pin-tip jacks on the tester, to which the socket terminals are connected through the four-wire cable and its plug, AD. The circles marked GF, FF, etc., indicate the various voltmeter connections which are made by plugging the voltmeter test cords into the pin-jacks. VT indicates the tube plugged into the test socket. The tests obtained by the various voltmeter connections shown are as follows:

FF tests continuity of filament circuit and voltage drop across filament. If it is desired to read the full "A" battery voltage, minus the small drop in the filament leads and rheostat, simply withdraw the tube from VT. A separate a.c. voltmeter, of the tube-base plug-in variety, is provided for testing the filament circuits of a.c. sets.

GF— tests continuity of grid circuit in amplifier stages biased with a "C" battery. This also shows the negative voltage applied to the grid, and, if the volt-

FIG. 2.—THE VARIOUS TESTS ON THIS AMPLIFIER STAGE ARE EXPLAINED IN DETAIL IN THE TEXT ON THIS PAGE





FIGS. 3 AND 4, ABOVE AND AT THE RIGHT, SHOW THE CONNECTIONS TO THE TEST SET WHEN TESTING, RESPECTIVELY, A D.C. AND AN A.C. AMPLIFIER STAGE

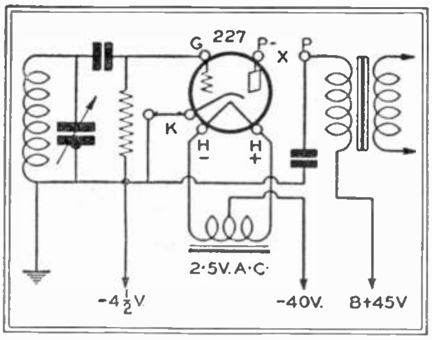
age of the "C" battery is known, the voltage drop across the transformer secondary. GF+ makes use of the "A" battery for grid continuity tests in those stages having no "C" battery bias.

GP tests the continuity of any grid circuit except those detector and R.F. amplifier stages, in some sets, which have a condenser in the grid lead and a grid leak shunting the tube input terminals. In such a circuit the voltmeter will show a small deflection due to current flowing through the grid leak, but to test the continuity of the transformer secondary it is necessary to short out the grid condenser with a test cord and clips. In a detector circuit where the grid leak shunts the grid condenser, any deflection of the voltmeter indicates the continuity of the grid circuit.

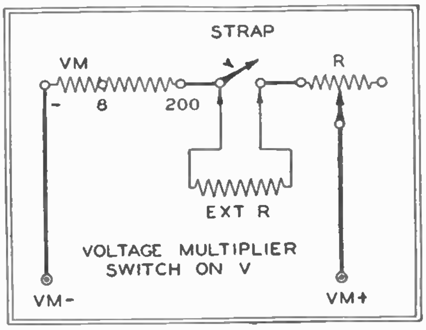
PF tests continuity of the plate circuit and voltage applied to the plate. If the full voltage of the plate battery has been determined, the difference between the two readings is the voltage drop through the plate coil, or plate resistance, or both, as the case may be. PF— includes the "A" battery voltage where A plus and B minus are common.

PP tests the plate current when switch X is opened. Plug AD into an amplifier stage having the correct "A," "B" and "C" voltages for the type of tube under test and compare the voltmeter deflection obtained with a similar reading taken with a tube which is known to be good. Directions for reading the plate current directly in milliamperes are given in a following paragraph. Remember that any change in the filament rheostat, grid bias, or plate voltage while making plate current comparison tests will cancel the readings previously taken.

ET is for external testing. This connection places the voltmeter and "B" voltage from the set in series with a pair of test cords for the purpose of testing circuits or apparatus separate from the source of the testing voltage. Know your circuits well before prodding around inside of the same set in which you have the test plug.



VM is simply the voltmeter with a pair of long test leads and it is safe to use this test even though the plug AD is in one of the set's tube sockets. The leads should be insulated to within one-eighth inch of the points, to avoid danger of a short circuit. All continuity and voltage drop tests are conveniently made by connecting VM negative to B negative and using the VM positive lead for probing each circuit from B plus up to its ending at a tube terminal. It is assumed that the set has been removed from its cabinet and turned up on a work table for this kind of testing.

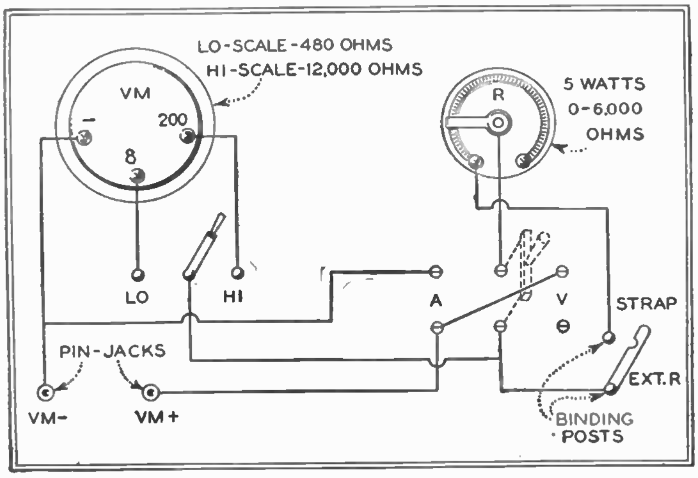


Figs. 3 and 4 show the connections to the test set when AD is plugged into an amplifier stage of an a.c. set, and into a UY socket through a UX-UY adapter. In the latter case, a UY-UX adapter is inserted into VT and the cathode connection between the set socket and the adapter socket is completed with a flexible test cord having a clip connector on each end. This cathode connection may be omitted, for most of the tests, by connecting K to one of the heater terminals, H, on the UY-UX adapter.

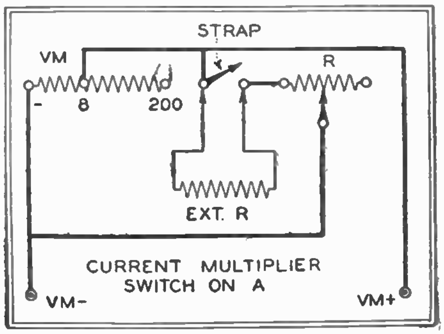
Figs. 5, 6 and 7 show the connections of the rheostat (R), series-parallel switch (AV), voltmeter (VM) and voltmeter switch (LO-HI), also voltmeter pin-jacks, and binding posts for cutting extra resistance in series with R. Figs. 6 and 7 are schematic diagrams showing the connection made when the switch AV is operated towards either V or A.

VM is a double range, 0-8-200 volts d.c. instrument having a resistance of 60 ohms per volt on either scale; *i.e.*, 480 and 12,000 ohms for the 0-8 and 0-200 scales respectively. By Ohm's law, 16.666 milliamperes will cause a full scale deflection on either scale. Of course, 25 times the voltage of the 10 scale, or 200 volts, must be applied across the HI scale terminals to cause the same current to flow that 8 volts applied to the LO scale will cause to flow. It is better to use the LO scale, with a suitable value of shunt resistance, for all plate current measurements, where the current to be measured is larger than 16 milliamperes, because the reading thus obtained will more nearly approximate the current reading obtained by the use of a standard milliammeter. This is because the lower resistance in the plate circuit will allow a larger current to flow. 16.666 milliamperes divides itself into 2.083 milliamperes per each one-volt division on the LO scale. This may conveniently be called two milliamperes per volt, or one milliampere per each one-half volt division, and amounts to a direct reading, 0-16 ma. scale, for all practical test purposes. A milliammeter of this range will handle the plate current of any tube up to a UX-171 in size, where not more than 135 volts are used on the plate of the 171 and with a grid bias of 27 volts negative. For larger plate currents to be measured, a shunt resistance is necessary.

The resistance R is a wire-wound potentiometer of 0 to 6,000 ohms range and five watts capacity, with reverse rheostat



FIGS. 5, 6 AND 7, SHOWING CONNECTIONS FOR THE RHEOSTAT, SERIES-PARALLEL SWITCH; ALSO VOLTMETER PIN-JACKS AND BINDING POSTS FOR CUTTING IN EXTRA RESISTANCE



connection for direct resistance calibration on a two-inch clockwise dial. Though a 0 to 500-ohm rheostat would provide sufficient resistance for all current multiplier values to the LO scale, and the two binding posts provided allow the connection of a higher resistance in series with R for voltage multipliers to the HI scale, the resistance described above is of greater utility. R must be completely short circuited when rotated to the zero resistance position of the dial. The extra rheostat carried for the voltage multiplier resistance may be one of the carbon compression type with a range of from about 200 ohms to 30 megohms, though 24,000 ohms will triple the range of VM and is the most that will be needed. To the writer's knowledge there is no variable resistance on the market which has the necessary range (0 to 24,000 ohms), the required current handling capacity, and that is also small enough to be mounted, in place of the one first described above, in the small space available on the tester panel. Such a high resistance in one unit would be most difficult to adjust on the lower values required as a current multiplier to the LO scale.

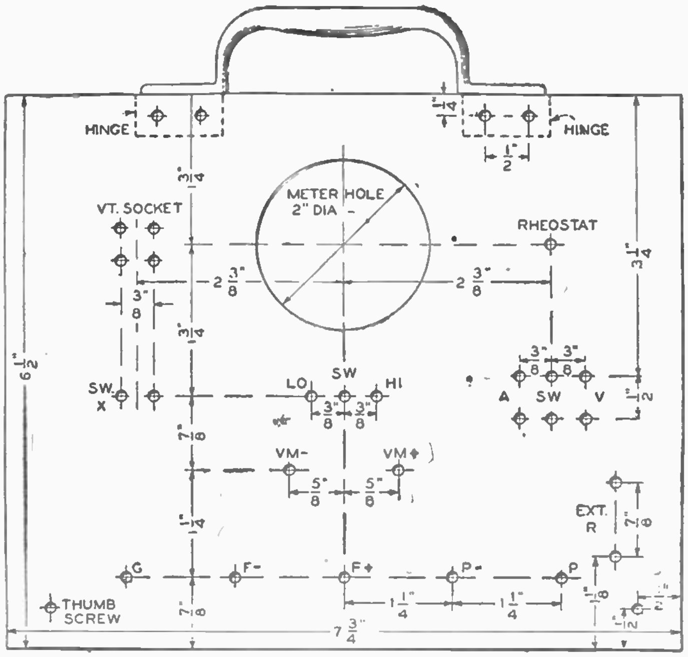


Fig. 8.—The panel layout

Adjusting R to the value required for use either as a voltage or current amplifier to VM is a very simple operation. For example, if a range of between 200 and 400 volts is required, connect VM to as high a voltage as can be obtained, up to 200 volts, and count the unit divisions of the scale from zero to the point of needle deflection. A voltage multiplier constant of two is desired.

Cut in enough resistance to bring the needle back to one-half of its former deflection and the range has been doubled. The method of increasing the milliampere range is similar, except that the switch AV is operated to the A position after the first reading is taken, for the resistance adjustment.

Figs. 8, 9 and 10 show the complete wiring diagram, the panel layout, and the dimensions of the box used by the writer. The box used once housed a Radiola III, and the five-wire battery cable from the same set (unused wire cut off) is used for the adapter cord. The adapter plug (AD) was improvised from a CX-199 tube base and a section from the handle of an old electric soldering iron. A piece of broomstick with a hole drilled lengthwise for the cord will do as well. The socket adapters, except the UV99-UX, are improvised from Pilot sockets and old tube bases.

It is only necessary to drill a No. 6 hole through the bottom of the tube base, ream out the eyelet which holds the Pilot subpanel socket together, solder pieces of tinned hookup wire to the socket terminals, push the wires through the proper prongs of the tube base, and bolt the whole assembly together with one 6/32 machine screw. Trim off the ends of the wires which protrude from the tube base prongs and solder them to the prongs. Even the tiny UV-199 tube base is quickly and easily converted into a UX-UV199 adapter in this manner.

The panel is hinged to the back edge of the box and held closed by two thumb-screws (improvised from old style brass binding-post screws, nuts and split-washers) in the front corners. The size of the panel and box, which can be home-made, may be any size desired by the constructor, but the size described here permits the carrying of all necessary accessories, including a few tools such as pliers, screwdrivers, wrenches, files, etc., a small flashlight, a telephone receiver with cord and plug, and the adapter cord and plug AD, within the box and with a minimum of waste space.

A metal handle is bolted to the back, and four rubber-headed nails on the bottom corners prevent the marring of any polished surface upon which the tester may be set. When in use, the adapter cord protrudes through a notch cut in the side edge of the box, near the socket (VT) to which three of its wires are terminated; the fourth or plate lead terminating on one side of the switch (X), which is near to VT.

(Continued on page 92)

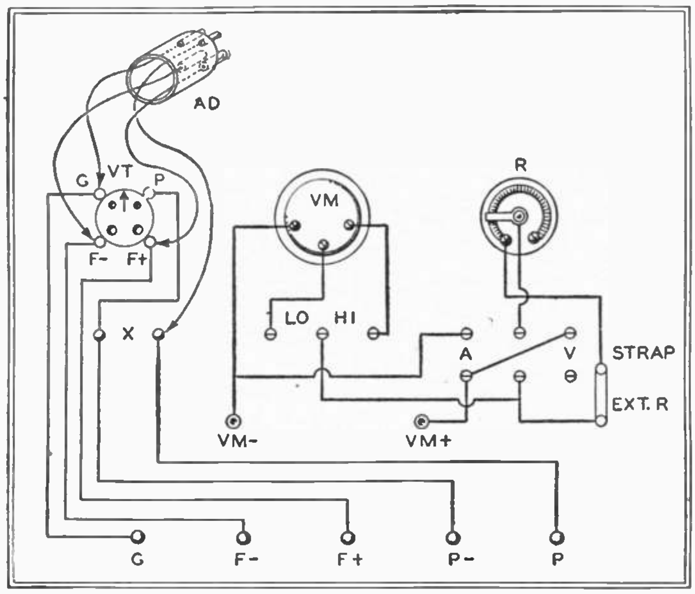


Fig. 9
At the left is the picture diagram of the parts and wiring of the test set

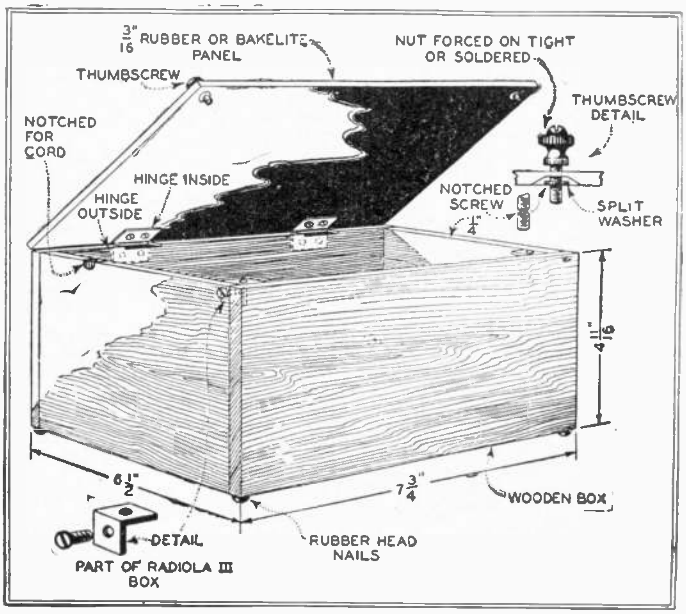
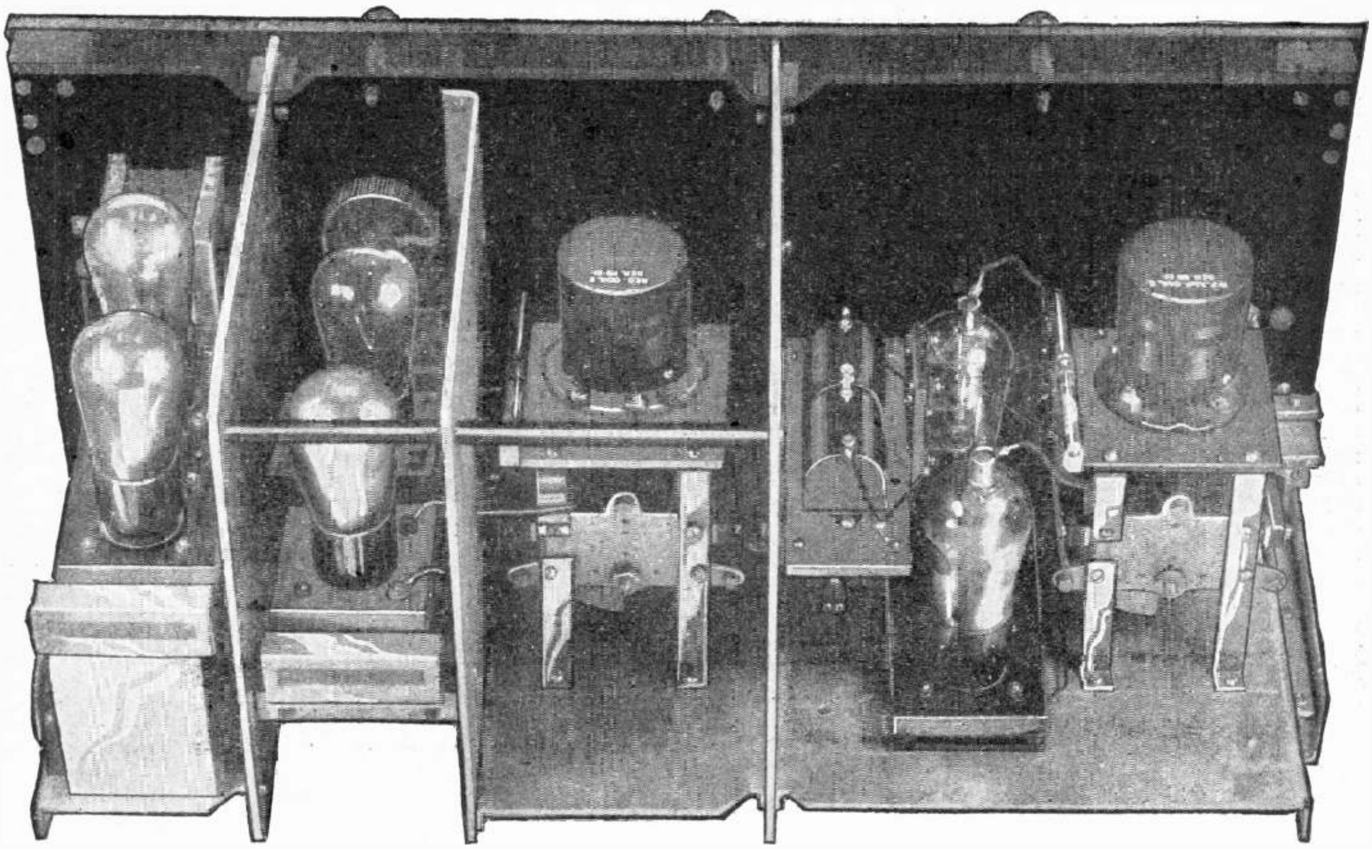


Fig. 10
Dimensions and details of the carrying case used by the author are shown at the right



A rear view of the assembled receiver used in Mr. Marshall's tests

Some Experiments on Ultra-High Frequencies

By THOMAS A. MARSHALL

BACK in 1925, when 12 meters or thereabouts was considered the shortest wavelength on which transmission of signals could be obtained, a radio theory was advanced, perhaps as a relief to those who had ambitions to talk to Mars and other heavenly bodies, that since the waves shorter than 12 meters could not possibly be used successfully over the earth, they could be used for interplanetary communications. This supposition was offered as it appeared that these short waves would be capable of piercing our atmosphere as well as that of other planets. It was also believed that the course of the interplanetary wave on leaving the earth would be strongly influenced by the electrons coming from the sun and would be diverted directly toward the sun, where it would reach an electron density of more than 100,000 per cubic centimeter, which would cause total reflection. The wave might then be reflected toward Mars or other planets. Many prominent scientists, however, did not agree with this theory, and believed that satisfactory transmission could be obtained on these ultra-short wavelengths. They said "Time will tell."

TO the many experimenters who have been delving into the mysteries and behavior of transmission and reception on the extremely short wavelengths Mr. Marshall's observations as outlined here will be of distinct interest.

Mr. Marshall, formerly connected with the U. S. Naval Research Laboratory at Bellevue, D. C., and recently with the U. S. Battle Fleet in southern waters has, over a period of nine months made the observations which form the basis for the article presented herewith. His work in this field has undoubtedly provided him with much authoritative information and we are pleased to present to our readers his theories, together with a description of the receiver he used in his work.

From personal observations, it appears that time *has* told. The writer has just completed a long series of observations concerning actual reception at fundamental and second harmonic frequencies of signals being transmitted by a host of stations now operating on short wavelengths, the results of which seem to indicate that it is entirely practicable to utilize the band of 13 to 7.5 meters for transmission purposes on our own planet. By the use of his own type of receiver, he has received excellent signals from Washington, D. C., on wavelengths as low as 7.5 meters, at a distance of 2,000 miles.

The dotted line in Fig. 1 shows the skip distance effect as expounded by Dr. Hulbert in one of his lectures. It would indicate that a wavelength of 15 meters jumps over the earth approximately 1,400 miles and that a 10-meter wave is totally reflected. The heavy line indicates the skip distance as observed by the writer, as compared with that obtained by Dr. Hulbert in his investigations along these lines.

The data for extending Dr. Hulbert's curve were obtained by observations made over a period of nine months. There appears to be no longer any doubt that there does exist another favorable series of wavelengths below 13 meters, suitable and adaptable for long-distance signalling. From 6,600 to 23,000 kilocycles, which is the present band in use, there is a band of 16,400 kilocycles. From observations made, it appears that this band may be increased from 23,000 kilocycles to 40,000 kilocycles, which is 17,000 kilocycles in width, thus doubling the width of the high-frequency band.

Since the absorption of extremely short wavelengths is negligible in the Kennelly-Heaviside layer, and the skip distance is long, as shown in Fig. 1, strong signals should be received from stations located at great distances. The line (A) in Fig. 2 shows the possible angle of radiation from a certain type of antenna adjusted to 25 meters. The primary skip distance depends entirely on the angle of radiation and the height of the Kennelly-Heaviside layer. It is possible, by employing plane antennæ and reflectors, to concentrate the antenna radiation at an angle most advantageous for reception at a given distance. For extreme distances, it would be possible to control the radiation angle to increase the skip distance, and thus increase the signal strength from three to four times at the receiving station. The line B shows how the radiation angle may be changed so as to reach point D on the earth. Note that the 40° angle would give strong signals at C and diminish in strength toward D. Radiation angle B would skip over position C and produce strong signals at position D.

The conventional type of receiving circuit as developed in the past has been incapable of giving high amplification in the short-wave bands, due to the relatively low input impedance of the circuit and to the low L/C ratio. The low impedance is due to the relatively high grid-to-filament capacity. This may be further explained as follows: this type of circuit, due to the high inter-electrode capacity, reduces the number of grid and plate turns of inductance for a given wavelength. The high inter-electrode capacity also limits the number of turns for feedback purposes, causing the circuit to be a poor oscillator.

The receiver circuit shown diagrammatically in Fig. 3 has many advantages over the single-circuit receiver in that it is especially suitable and adaptable for reception of wavelengths down as low as 3 meters. This type of receiver functions on push-pull principles in the radio-frequency stage and detector stage, making it possible to obtain very stable oscillations over the entire range. In fact, the receiver oscillates and performs as well at 5 meters as at 50 meters. In this circuit, the inter-electrode tube capacities are reduced: first, by use of the four-element tube which, in effect, tends to reduce the effective grid-to-plate capacity, which is effective on the input grid circuit; second, by using two split condensers having two halves which are in series across the inductance system; third, by connecting the two tubes so that each grid-to-filament capacity is across one of the series sections. Thus, the effective tube capacity upon the tuned circuit is halved, which in turn permits a higher L/C ratio for the short wavelengths and reduces the grid conductance, thereby increasing the amplification many fold. Due to the foregoing reasons, the circuit permits more turns of inductance for the plate and grid circuits at a given wavelength. The increased number of turns increases the input impedance, which increases the signal voltage, thus increasing the signal strength. Another feature in providing a greater number of turns in both grid and plate circuits is the increased feedback properties which are so desirable on short wavelengths in order to obtain stable oscillations.

Another commendable feature in the push-pull radio-frequency amplifier is the perfect neutralization of feedback conditions within the tubes. This is accomplished by connecting the tubes so as to balance each other, thus providing a perfect balance regardless of the wavelength. It is not possible to accomplish a perfect balance on all bands in a single-tube circuit. A slight feedback in a radio-frequency amplifier is desirable in order to overcome circuit resistance and increase selectivity. It will be noted that it is possible to accomplish this feature in the circuit as shown in Fig. 3. The radio-frequency stage should be balanced to a certain degree so as to reduce interaction with the detector circuit, which means no detuning effect taking place when the radio-frequency stage is tuned to resonance with the detector circuit.

The detector circuit also has another distinct advantage over the conventional single-tube circuit for voice reception, of about two to one, resulting from a change in plate current from two tubes instead of one, with a given impulse.

The push-pull circuit as shown in Fig. 3 has perfect electrical symmetry of the input circuit, which is so essential for loop reception. In a single-tube circuit, one side of the loop is connected to the grid while the other side is connected to the filament which is common to all the battery circuits, resulting in a very high

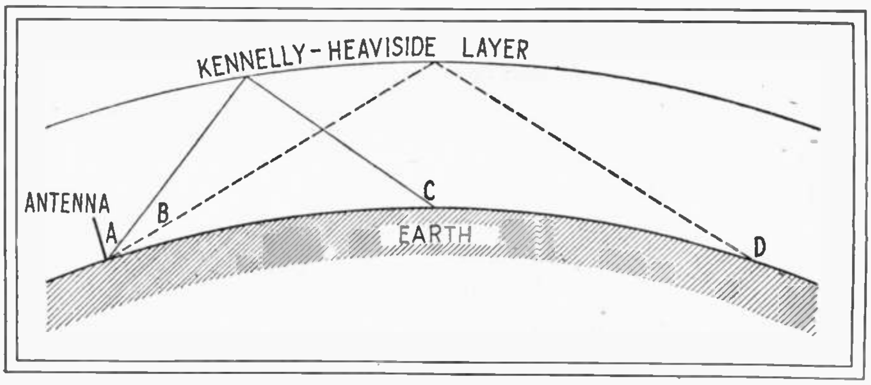


FIG. 2. ILLUSTRATING THE "SKIP-DISTANCE" EFFECT, AS EXPLAINED IN THE TEXT

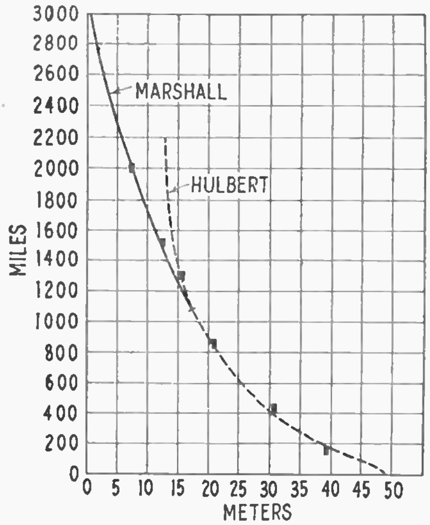
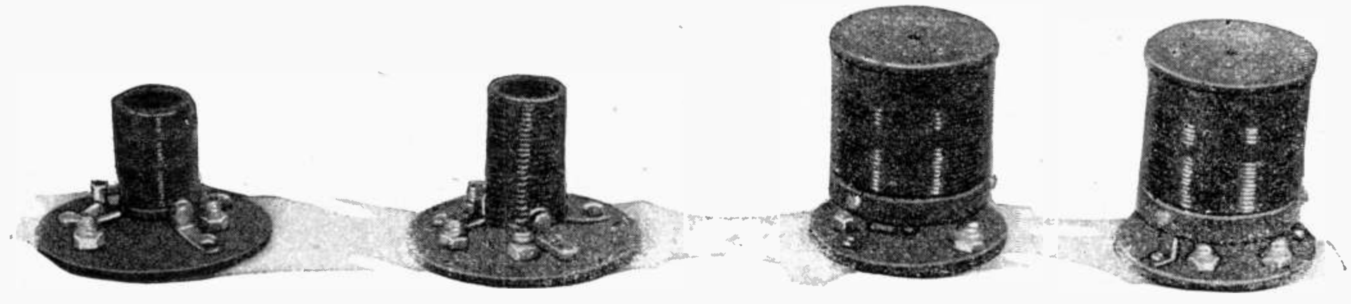
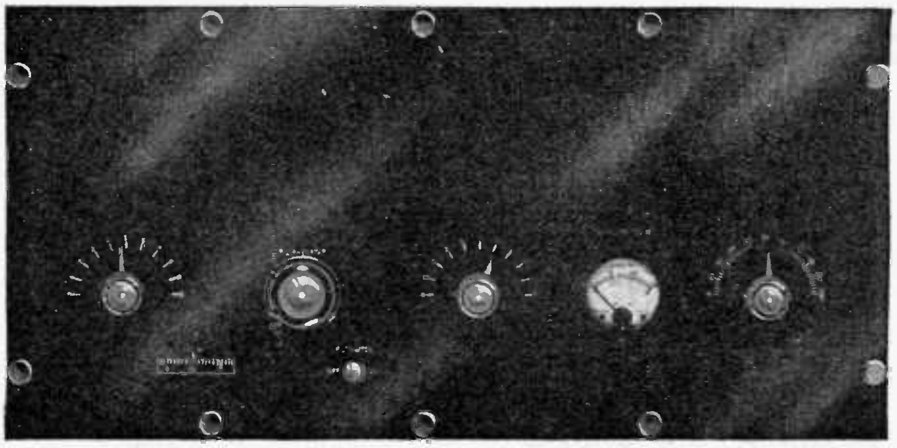


FIG. 1. A COMPARISON OF THE WAVE BANDS PREVIOUSLY ACCEPTED AS THE LOWEST PRACTICABLE FOR RADIO COMMUNICATION, WITH THOSE ON WHICH THESE EXPERIMENTS WERE CARRIED OUT

PLUG-IN COILS USED BY THE AUTHOR





A PANEL VIEW OF THE COMPLETED RECEIVER

ground capacity. This causes dissymmetry in the electrical properties of the loop system. The unbalanced condition of such a loop system brings about a certain degree of antenna effect, causing the zone of silence or minimum signal not to be present while rotating the loop. In order to minimize interference, it is essential that the loop have zero minimum signal.

Taking up in detail a description of the circuit shown schematically in Fig. 3, L and L1 are wound on a bakelite form and have fixed relationship to one another. C and C6 are Cardwell .00025 mfd. variable condensers having the stators split; which is accomplished by cutting the bus bar connections at the center. C1, C2, C7 and V3 are .0001 mfd. condensers.

C10 and C11 are plates ½ inch in diameter and are arranged so as to be variable in capacity. These condensers should be permanently secured between the tubes and have the top plates soldered to a brass screw which may be turned by using a wooden screwdriver while making final adjustments. C3 is a 1 mfd. condenser. R1 and R2 are 1 megohm grid leaks. R3 is a 190-ohm variable rheostat.

L2 and L3 are secured to the inside of the shield and are mounted horizontally about 3½ inches from coils L and L1. L4 is mounted vertically and directly underneath the junction of L2 and L3. C4 and C5 are 30 mmfds. each. L5 is the tickler coil and is coupled to L6. Both coils are wound on a bakelite form with fixed relationship to one another. L2, L3, L4 and L7 are Sampson 250 millihenry radio-frequency choke coils. R4 and R5 are ½ megohm grid leaks. R7 is a 400-ohm potentiometer. R6 is a 100,000-ohm variable resistor. C9 is a 2 mfd. condenser. A and A1 are 5:1 ratio audio transformers.

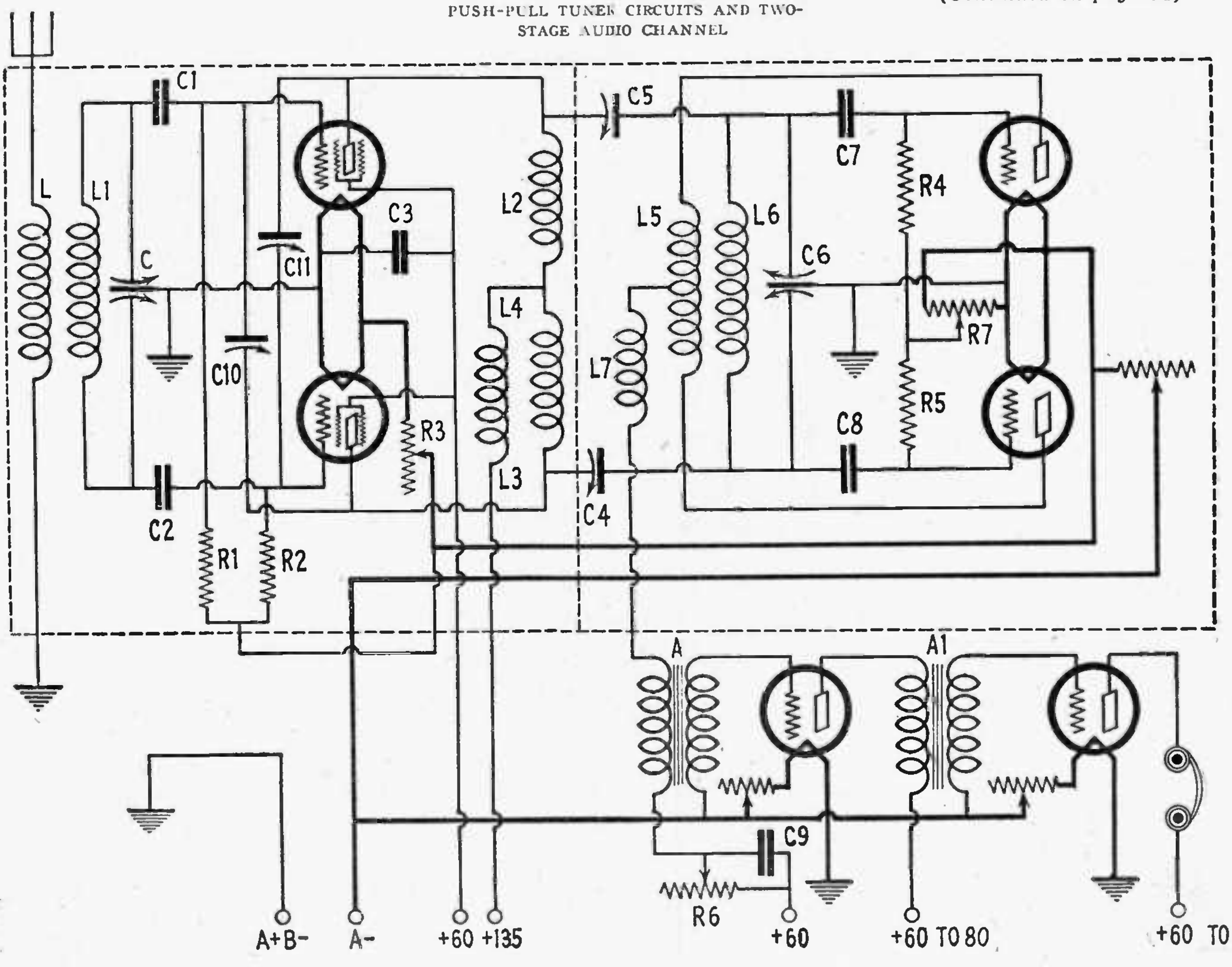
The shields are made of 3/16-inch aluminum in order to reduce microphonic noise. The tubes and coils should be arranged symmetrically as shown in the diagram. All battery leads should extend directly through the aluminum subpanel. The audio stages should be shielded from the other circuits, as shown.

After the circuit has been placed in commission, the radio frequency stage should be detuned and the detector stage set into oscillations by varying R6, which should be set at a point where the detector circuit is just barely oscillating. R7 should be adjusted until the detector will go in and out of oscillation without "hangover" effect. This will be observed by varying R6, which controls regeneration in the detector circuit. The radio-frequency stage should be brought near

(*Continued on page* 94)

FIG. 3

CIRCUIT DIAGRAM, SHOWING THE PUSH-PULL TUNER CIRCUITS AND TWO-STAGE AUDIO CHANNEL

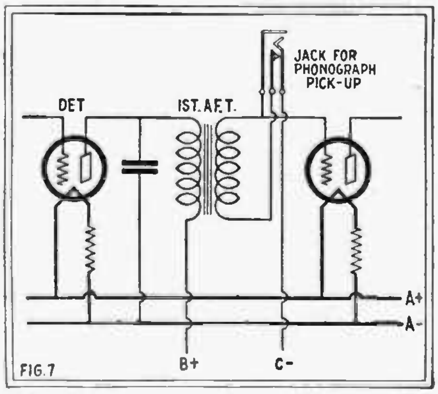


(*Continued from page 9*)

quite satisfactory in cases where the required volume is low or where a very powerful amplifier is employed. Either jacks or switches may be employed for changing from radio to phonograph, or an "adapter" supplied with a pick-up is plugged into the detector socket and connects the unit to the plate circuit of this tube; the connection thus made being equivalent; to that in Fig.6. In some cases, adapters are obtainable for both the four and five-prong sockets; so that the unit will be equally adaptable to battery sets and A.C. sets using the 227 type detector. The connections for power-operated sets are the same as for the ordinary battery sets using the common (201A-type) detector tube. The only change necessary is in the method shown at Fig. 5. In this case, the "C" battery is connected to the *cathode* terminal instead of to the filament wiring; this is done in order to keep the hum at a minimum.

In order to make operation of the phonograph entirely electric, and electric motor may be used in place of the usual spring mechanism. A number of constant-speed motors, some of which are equipped with turn tables, speed controls, etc., have appeared on the market; one of these motors is illustrated in this article. The motor is of the "induction" type and is equipped with a friction-type governor to keep the speed constant. The switch may be so arranged that the motor is automatically turned off when the record is finished, or that it will continue until it is turned off by hand.

For those who have neither a phonograph nor the inclination to purchase an electric motor and turntable, there is one very good way of making a cheap but good unit. The small portable phonographs which were made several years ago (and in fact are still being made) have a very satisfactory operating spring mechanism and, with an electric pick-up, one may be made into a high-quality phonograph. These portable phonographs will take full-size records. If desired, the mechanism may be removed from the case and mounted in another cabinet; in fact, this is a very good way of making a good combination phonograph-radio console. A switch placed on the panel of the radio connects the pick-up to the amplifier when desired.



This connection gives somewhat less volume than others, but is often satisfactory.

"HOME BROADCASTING"

While on the subject of uses for the audio amplifier of a radio set, it may be well to mention the pick-up devices now made for home "broadcasting." Such an outfit (one of which is pictured herewith) consists of a microphone, a long lead and an adapter to be plugged into the detector socket of the set. By connecting the microphone in this way, a great deal of amusement can be realized from "Broadcasting" programs and announcements at home. Such devices also have another use, besides experimental amusement; in cases where it is desired to make any public announcement and more volume is desired than the unaided voice can supply, the microphone with an audio amplifier and a speaker will serve the purpose.

MANUFACTURE OF RECORDS

The distortion in the old type of phonograph was not due entirely to the reproducer and horn used; the records themselves were made under conditions which cut off the low notes and distorted some of the higher ones. The apparatus for cutting the records consisted, fundamentally, of a large horn, a rotating ("screw-feed") mechanism and cylindrical record blanks of wax of the original type, mentioned before. The artist or artists (and there were often too many for the available space) were placed directly in front of, and very close to, the large horn. The wax record was then rotated and the needle, which was connected to a diaphragm at the small end of the horn, cut a wavy line in the wax. The wax master record was then used to make the great numbers of records which were sold.

The defects of the system were that the horn was incorrectly shaped, the diaphragm had resonant points, the artists were too closely crowded before the horn to play correctly, and the volume of the music was too weak to allo wthe diaphragm to be vibrated over a sufficiently wide range. The result was that the low notes were cut off because of the horn and the diaphragm, the higher notes were distorted because of the resonant frequencies of the apparatus, and the result was generally far from perfect.

RADIO METHODS ADOPTED

Even if an electric reproducer were used with these records, the sounds would not be natural and, for this reason, the method of making records was changed most radically some years ago. The modern phonograph studio resembles the radio broadcast studio very closely. Standard broadcast microphones are used, as many of them as necessary to give the best results. They are very carefully placed, and the sounds picked up are "mixed," or proportioned so that the instruments of even a large symphony orchestra are brought out properly. The musicians do not have to play softer, or shift around, in order to prevent some of the instruments from being drowned out. All this is regulated at the control board. The sounds are picked up through the "mikes" and the audio-frequency currents passed into power amplifiers. They are then converted into the required mechanical motion for cutting the records, by using light rays with a photoelectric cell and other suitable equipment. The advantage of this is apparent; the light rays have no "time-lag" or "inertia, and they carry all the impulses equally well, regardless of their speed or frequency. For this reason the low notes of a large orchestra or organ are heard with narmal volume, while the high notes are left natural. Special cutting machinery has been developed with practically no resonant points on the audible band and this takes care of another point at which distortion might be introduced.

The fan who wants the best quality should use the new records, and should be sure of getting that type when new records are purchased.

OTHER ELECTRICAL REPRODUCERS

Up to this point, the only unit which we have mentioned has been of the magnetic type. Besides this type, there are at least three others; the crystal, condenser, and carbon types; of these only the magnetic type is at present commercially important. One large corporation has experimented with a crystal pick-up, but this device is still in the experimental stage, and no information is available at this time as to the method of construction, or the quality obtained.

A pick-up of the condenser type was described in RADIO NEWS some time ago, but this unit is no longer on the market, notwithstanding its theoretical merits. A condenser reproducer has also been developed by one company which is interested in the use of the device for other purposes, but this unit is not a present available for public use. The condenser pick-up differs in operation from the magnetic type in the fact that it is connected to the *radio frequency* section of the set. A vibrating element is used as one side of a condenser and when it vibrates, the capacity changes. A small oscillator-tube circuit is employed and the variations in the capacity of the pick-up modulate the output of this oscillator. The resultant "signal" sent through the set is very similar to a broadcast signal picked up over the air. It is amplified and detected by the radio-frequency and detector tubes, and then amplified again by the audio amplifier. A description of the device and its operation will be found in the April, May, and June, 1927, issues of this magazine; but, as we have said, it is not being manufactured now.

Pick-ups of the carbon type have been known for a number of years, but only a few which will supply a high quality of reception have been developed. Such a pick-up depends for its operation on the changes of resistance in a mass of carbon granules when they are alternately compressed and released. This is the same principle as that used in the ordinary hand microphone or telephone transmitter (See RADIO NEWS for May, 1928, page 1206). When the needle vibrates, it compresses or releases the carbon grains in a small box attached to the unit. This type of pick-up is somewhat different from the magnetic type and is designed to operate a speaker without the use of an amplifier.

As explained above, however, the only type which is as yet of commercial importance is the magnetic, which is both cheap in production and good in quality. The difficulties of design are comparatively small and are easily overcome by the use of good material.

The Home Builder Seven

(*Continued from page* 15)

tain oscillation. A defective condenser at C5 will also prevent oscillation.

As the builder becomes acquainted with the operation of the receiver, excellent distant reception will be obtained. The DX possibilities of this receiver, as with any other sensitive set, will depend on the locality, the efficiency of the aerial and grounds, "atmospherics," and the ability of the operator.

BIASING A.C. TUBES

If the constructor wishes to build this set for A.C. operation, it is recommended that he use only tubes of the heated-cathode (227, A.C.-22, and similar) types except in the power stage. Here a 171A, or other power tube of any desired type, may be used with raw A.C. on the filament and the proper plate voltage, in the conventional way.

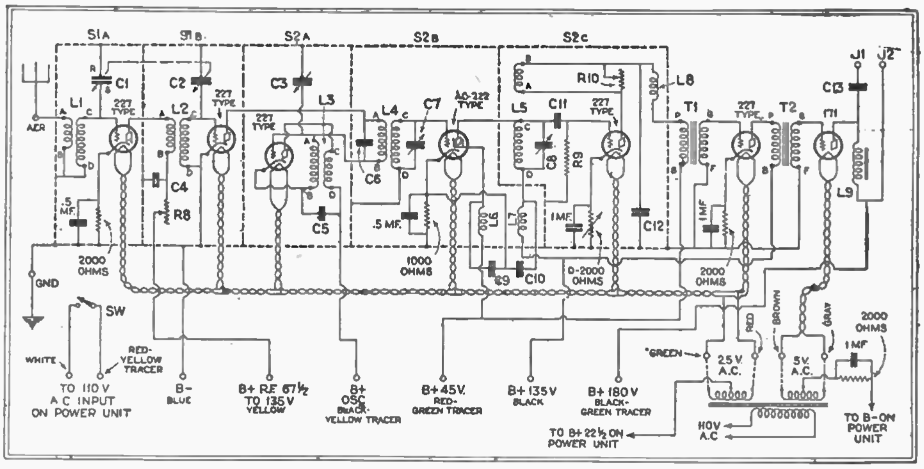


FIG. 1A

The "Home Builder's Seven," constructed to use A.C. tubes, follows the same layout as in the constructional drawings; the resistors and condensers shows replace thefilament ballasts.

If we compare the circuit for battery operation (Fig. 1) with that given here for A.C. tubes (Fig. 1A), it will be seen that the latter eliminates the amperites R1-R2-R3-R5-R6-R7 and the tapped resistor R4. All grid returns (including that of the detector) are made to ground and "B—" on the shielding, instead of to filament; and the cathodes of the tubes are maintained above ground potential by resistors, the voltage drop through which provides the necessary bias. This is the usual method employed in A.C. tube operation; the values of the necessary resistors may be calculated by dividing the bias (in *millivolts*) required for a given tube by its plate current (in milliamperes); for instance, if a tube requires a 6-volt bias, this is six thousand millivolts; the plate current of a 227-type tube is normally three milliamperes. Division of six thousand by three gives two thousand; and, accordingly, a 2,000-ohm resistor is what we need between cathode and ground to give a six-volt drop. Therefore, resistors of this value are required by the cathode returns of V1 and V6, in series with their ground leads. On the other hand, V2 and V3 do not require a grid bias; the former has no "B+" potential on its plate (because of the peculiarity of the Ultradyne modulation system) and the latter is an oscillator, and should a bias be put upon its grid, greater plate potential would be required to cause oscillations. The A.C. screen-grid tube V4 requires a "C" bias between 1 and 1.5 volts. With 45 volts on the screen-grid, and 135 on the plate, the normal plate current will be one and a half milliamperes, or .0015-ampere; and to give 1.5 volts "C" bias a resistance of 1,000 ohms will be required.

For the detector tube V5 it is recommended that the resistor be variable from 0 to 2,000 ohms; the proper resistance value is then conveniently found when the set is placed in operation. The value for the resistor in the cathode return of the power tube V7 should be 2,000 ohms, when 180 volts is used as the platesupply.

As the "C" biasing voltage is taken from the plate potential of the particular tube supplied, it follows that, to obtain the correct bias at the recommended "B" voltages, that the voltage output of the power unit must be increased at each "B+" tap by the amount of the "C" voltage. Thus, for the power tube, 40 volts plus 180 volts would require 220 volts at "B+180" for normal operation; as the cathode of the tube is 40 volts positive above ground potential.

BY-PASS CONDENSERS

To prevent the blocking of either the R.F., I.F., or the A.F. frequencies by the biasing resistors, the latter must be by-passed with suitable condensers; these, in the cathode circuits of the audio tubes, have a value of 1 mf. Where either I.F. or R.F. frequencies are by-passed, a 0.5-mf. condenser will be sufficient.

To prevent excess of hum, the proper value of "B+" potential should be applied to the center tap of the 2½-volt winding supplying the heaters of the 227-type tubes. Usually, this should be 45 volts.

For placing the A.C. set in operation, the same procedure is followed as with the battery-model receiver, as described above.

Volume-Control Methods

(*Continued from page* 17)

For this reason, series plate resistors are not advisable and resistors in the grid circuits (except in the first, when a resistor is used to couple the first audio-frequency tube to the aerial) are unsuitable. This leaves plate-control methods which do not affect the plate voltage, and the two aerial methods mentioned above.

Receivers using the filament-type tubes present a much more difficult problem. The balance in the filament and plate circuits must not be disturbed in any way. Any change in the plate voltage or the electrical balance in the filaments will cause a large increase in the hum and, when several stages of amplification are employed, this hum will become excessive.

There are four methods which are satisfactory; for small sets, or sets enclosed in shields, the two aerial-coupler methods are suitable. Of these, that shown as B (Fig. 4) is most satisfactory because of the greater amplification. The third, shown in Fig. 5 at B, employs a resistor which should be shunted across the secondary of the first tube, rather than in a subsequent stage. In the last method, shown in Fig. 3 at B and D, the resistor should have a value of about 10,000 ohms. If the first of these (3B) is used, the tuning condenser in the succeeding stage should be equipped with a midget condenser in order to keep the dial settings alike for each stage.

SCREEN-GRID SETS

Although screen-grid receivers might be classed under the general heading of battery sets, some special problems are encountered and, for this reason, it is advisable to treat these circuits separately. The extreme amplification gained in the radio-frequency amplifier, will prevent some of the above control systems from operating effectively; while the universal use of shielding in screen-grid amplifiers will allow the use of some systems which are not suitable for ordinary sets. Audio-frequency control methods are not advisable, because of the trouble with overloaded detectors. This is even more evident in screen-grid sets, because of the higher voltages supplied to the detector by the radio-frequency amplifier.

The series plate-resistor method described above is not practical for two reasons. In the first place, it is not advisable to change the plate potential and, in the second, the volume may not be reduced sufficiently, even when the "B" voltage is cut down. This is most evident in sets with more than one stage of screen-grid amplification, when the volume control is not in the last stage. The shunt-resistor system of Fig. 3B could be used, but 3D will be better in most cases. The control should be placed in the plate circuit of the last radio-frequency amplifier.

The two aerial control methods in Fig. 4 will be quite satisfactory, because screen-grid sets are almost always shielded carefully. The grid methods of Fig. 5 could be used, but are less desirable than the other two methods mentioned above.

RESISTANCE VALUES

The resistance values required for the different systems of volume control vary considerably and, for this reason, it may be of some assistance to give the (approximate) maximum values required for the different systems.

Fig.	*Arrangement*	*Resistor Value ohms*
3A	Series R.F. plate lead	200,000
3B	Across R.F. primary	10,000
3C and 3D	Potentiometer shunts primary	20,000
4A	Series aerial potentiometer	10,000
4B	Shunt aerial potentiometer	25,000
5A	Grid circuit potentiometer	500,000
5B	Grid-shunt resistor	500,000

Because of the difficulty in obtaining smooth and efficient volume control in sets using several stages of radio-frequency amplification, it has been suggested that several resistors be coupled together and controlled by a single knob. If resistors are used in similar positions in the set, there is no reason why several instruments cannot be controlled in this way.

Volume controls other than resistors have been used sometimes. In one case, a copper tube was arranged to slide over the primary of one of the radio-frequency transformers. This method supplies a noiseless volume control; but it changes the characteristics of the primary and, through this, the secondary. Of course, this affects the tuning and is not suitable for single-control sets. Other methods have been suggested from time to time, but resistors in one or more of the positions outlined above are usually employed. In most cases they are quite satisfactory, and they are much simpler than the others.

"The Beginner's Three"

(*Continued from page* 30)

but in most cases the click from the secondary is weaker than that from the primary. It may be better to use a "B" battery for testing the audio transformer, so that the click will be louder. If no click can be heard, the transformer is defective. In testing condensers, the click is very weak and no continuous noises are heard. In some cases, as in the variable condensers, it is necessary to disconnect the part from the set; because the coils or other apparatus are shunted across the condenser and it will appear to be short-circuited.

If the trouble is not found by these tests, it is advisable for the novice to call some one in who is more familiar with sets and their troubles, in order to locate the difficulties. It is well, in fact, to have any installation checked by an older head. The above suggestions should not keep any one from undertaking the "Beginner's Three"; as the possibilities of encountering trouble in a set of this type are very slight, if the instructions are followed exactly. They are merely given so that if the omission of something causes trouble, the reader will have home means of locating it before calling for outside assistance.

"A.C. Screen - Grid DX-er"

(*Continued from page* 24)

the best thing to use when you have no back yard, or if you have one, but don't care to dig up a ton of earth. Some readers of RADIO NEWS will recall the extroardinary ground system used by a boy in Providence, R. I., who has heard practically every station on earth with a two-tube set. (See the issue of March, 1928). He buried old wash boilers, bathtugs, automobile radiators, and many other odd pieces of junk, and watered them all as regularly as if he were keeping a flower garden.

USE A VOLTMETER

Practically all power transformers designed for modern A.C. sets are intended for use on 110-volt power lines. However, the voltage in particular places may be considerably higher or lower than this figure—a fact many a service man will sadly verify. If the voltage is higher (as it usually is) you may experience no end of trouble from blown-out filter condensers and short-lived tubes.

The one and only way to determine whether the line-voltage is correct, and whether the tubes are receiving the proper filament voltages, is to use an A.C. voltmeter. The most popular instruments have three-scale readings: 0-4 volts, 0-8 volts, and 0-150 volts. Thus the one meter will read the filament voltages of all types of receiving tubes, incuding the rectifiers, and also the voltage of the line.

The D.C. voltages developed by the "B" power pack can be read accurately only with a high-resistance voltmeter. Oridinary, small battery voltmeters are worthless; as they require for their own operation almost as much current as will be drawn by the plate circuits of all the tubes, in the average set, and therefore give a reading entirely too low.

A model receiver assembled from a kit was tested by members of the RADIO NEWS staff both in New York City and in a farm house near Peekskill, New York. In both locations it produced unusual results.

The farm house was, naturally, the better location, because of the absence of the troublesome factors that make city reception so uncertain. During one evening of listening almost a hundred different stations were logged, two being on the West Coast. The Chicago statiions figuratively "tore the roof off;" while those in San Francisco and Los Angeles were weak, though understandable. The quality was all that could be asked, the tuning sharp, the sensitivity very high. More could hardly be expected of any set, regardless of price; and this outfit can be build for less than fifty dollars.

"Junior Hi-Q 29"

(*Continued from page* 20)

The wires should not be pulled taut after being passed through the holes. All potential sources terminate in the cable-connector plug.

OPERATING THE "HI-Q 29 JR."

With respect to the receiver's operatioin, special directions are unnecessary. In view of the use of only two stages of radio-frequency amplification, accurate resonance in each stage is necessary and accurate adjustment of the tuning dial is likewise essential, for both selectivity and tone quality. It is necessary that the operator bear in mind the phenomenon of "sideband suppression"; detuning of the R.F. stages in such a system results in the loss of low notes and lack of selectivity. The aerial employed may be of any outdoor elevated type but it should not be longer than 100 feet over all.

Correct adjustment of the operating potentials will aid materially in the attainment of good reproduction and satisfactory receiver operatioin. Excessive plate potentials applied to the radio-frequency amplifying tubes will augment the degree of regeneration in the system and thus reduce its inherent stability. Insufficient plate and filament potentials in the audio-frequency systems will mar the quality of reproduction, and increase the possibility of tube over-loading.

Particular attention must be paid to the use of a 171A type of tube as the output tube. This tube draws approximately 20 milliamperes of plate current at 180 volts, and a speaker filter should always be employed, unless an output transformer is used to feed the speaker.

Dealing with Interference Inside the Building

THERE is no doubt that the following bit of information has been anxiously sought by many a harassed listener. Our contributor chanced upon a case where it was necessary that the set be located in a foyer which was within a few feet of an elevator, bringing about interference from that source, subsequently most unpleasantly apparent. After much moving about it was discovered that circumstances about the interior decorations made it quite impossible to place the set anywhere but in the foyer; whereupon invention as the child of necessity was called upon, with the following results:

An antenna coil was substituted for the loop and carefully shielded; an outside aerial erected as far as possible from the elevator. The lead-in consisted of BX (armored) cable, which was placed under the hoor, and used only as far as necessary to get outside the zone of interference! the surface of the cable was grounded. This method was employed on an extremely sensitive superheterodyne, and no doubt will function equally as well on the average receiver. The only precaution necessary is to make sure that enough BX cable is used to get outside the zone of interference, the limits of which may be found by testing the receiver in various positions throughout the home until the position is found where the noise is no longer picked up; it may then be taken for granted that this is the limit of the zone.—*Edward R. Jahns.*

(*Continued from page* 26)

emanations from this ground current. (*Several of our readers who have obtained good reception on ground alone have expressed the theory that radio waves travel "the low road" and come up instead of down, into the set from the ground. It might be hard to square this with the excellent reception which has been obtained on aircraft high in the air and having no connection with the earth.*—EDITOR.) Apparently these currents, following the path of least resistance—the earth itself being inferior as a conductor to iron—strike the separated pipes and are conveyed thereby through the set; and the use of an aerial, in place of helping them, impedes them to a certain extent.

This is not a matter of freak reception for one night, but of continuous reception. I have noted that, on connecting one of these grounds directly to the aerial—so that I have on one side a direct ground, and on the other a combined ground and aerial—changes the reception not the slightest; but the moment one of the grounds is disconnected, the volume drops appreciably.

I wish it were possible for me to do some experimenting in transmission; for I would like to know what th eeffect of transmitting directly into the ground without an aerial (at two points some hundred or so feet apart) would be.

The set used is of the simplest construction. Forty turns of No.18 D.C.C. wire on a tube 4 inches in diameter, 5 inches long, tapped on each 10th turn and controlled by a 4-point inductance switch; a 23-plate variable condenser, a .005 fixed condenser and a fixed Carborundum detector.

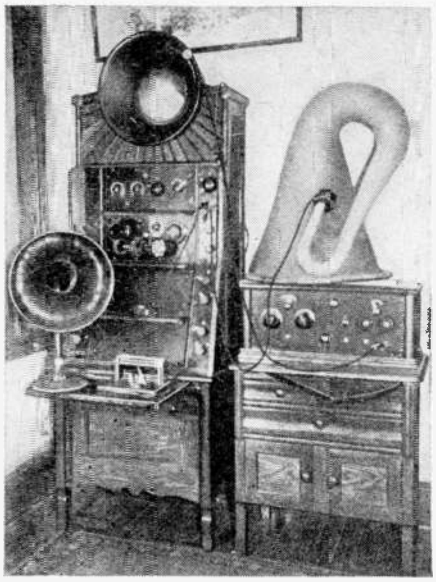
H. J. WALTERS,
Box 670, *Havana, Cuba.*

(*It is obvious that the phenomena described do not agree with the perfect-ground theory. The set operates o nthe difference of potential across two metal systems, separated some distance; and which are separated by a considerable resistance. (See the article on "Short-Wave Aerials and Grounds," in last month's* RADIO NEWS.) *In the tropics, atmospherics or "static" are far more intense than in northern regions; and the advantages of a buried aerial are more pronounced. In addition to this, it is quite possible that one or both pipe systems have an insulating joint between house and street. Mr. Walters uses a simple crystal set; a receiver with tubes, and consequently an electrical supply, should never be connected to a gas pipe. However, it goes to show that you can't tell what is the best antenna system in your location till you have tried. We are often asked,"What is the best antenna to use with my set?" That is a question which cannot be answered at long range. As for transmission, where high power is involved, there would certainly be a considerable loss of power between the two lines. A transmitting aerial is strung as high and clear of surrounding objects as possible, to increase its "effective height," and consequent range.*—EDITOR.)

"BLOOPLESS" ALTERATIONS

Editor, RADIO NEWS:

I have built the "Bloopless" one-dial set, out of spare parts, and wish to state that, properly built, it can't be beat. Using only



Mr. Harrington has a very compact experimental layout, as appears above. It is designed to promote interchangeability of sets.

a 25-foot inside aerial, it has brought in KNX, KFWB, KPM, KFI and KOA; this by plugging in its output into the audio amplifier of my five-tube set through a tube-base adapter. I had KRLD, Dallas, yesterday morning until they signed off at ten o'clock.

I made a change that I want you to pass on. Instead of using the 100,000-ohm antenna resistor, I used a home-made choke coil. It contained about a hundred turns of No. 26 enamelled wire in a ½-inch slot in a spool(¼-inch core) jumble-wound. With an aerial not over forty feet in length, this coil peaks at about 500 meters, with a consequent amplification almost equal over the broadcast band. Also, instead of an 8-turn primary on the three-circuit coil, I used one of 25 turns. In this locality such a large primary does not cause too much lack of selectivity. Also, I use a CX-300A detector tube in the first stage, instead of a 301A.

T. H. MILLER,
c/o C. & W. C. Ry., Greenville, S. C.

AN EXPERIMENTER'S CONSOLE

Editor, RADIO NEWS:

I have made a large cabinet with four panels 7x16, as shown in the photo, for experimenting. It is very handy to change hook-ups, but rather unhandy to change plug-in coils. So I plan to wind short-wave coils up to 90 meters on 1½-inch tubes and from 90 meters up to 2-inch coils, and amount them on a turntable with level gears; so that I can change from one to the other by turning a bevel gear with a knob on the panel.

The panels slip into the cabinet on shelves, and connect to the wiring, the same as a Ford coil box.

LOUDER HARRINGTON
319 *Pennell St., Chester, Pa.*

A FINE COMBINATION

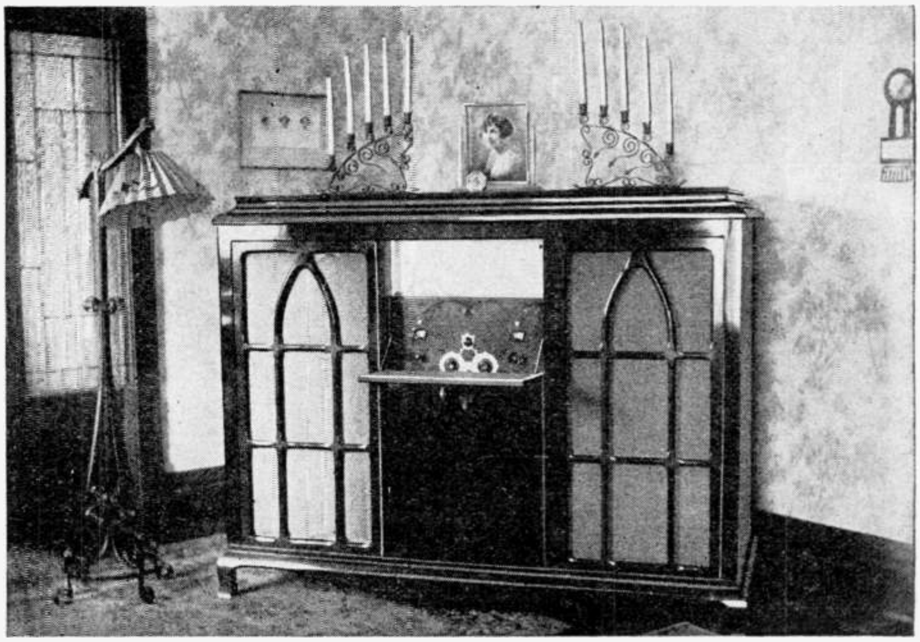
Editor, RADIO NEWS:

I built the entire console shown in the photograph (reproduced below), receiver, power amplifier, and all art features shown, in my own workshop. The receiver is an eight-tube superheterodyne, the last tube being a 250 wired in connection with a 450-volt power pack, giving enormous volume with wonderful tone quality. The left side grill conceals the loop; the center upper compartment contains the receiver, with the power amplifier below it; and the right grill the dynamic speaker. I have received all important stations in the United States and Canada with volume and clarity unbelievable to the sceptical radio fan.

The construction of such an elaborate receiver would no doubt tax the ability of the average home set builder; yet it may fit the ambition of some really energetic fan with lots of patience and mechanical ability to tackle a real job.

E. H. REED,
114 *West Liberty St., Elgin, Ill.*

(*Continued on page* 94)



Mr. Reed's constructional ability includes cabinet-work. This self-contained receiver has everything, including a loop in the compartment on the left, that could be desired and will excite the envy of the less ambitious.

The "Explorer Eight"

(*Continued from page* 55)

power-supply device which may be constructed to furnish the necessary "B" potential to the receiver when the 171A tube is used in the power output stage. These illustrations are self-explanatory; it being necessary only to follow the layout and wiring arrangements shown to obtain satisfactory results.

In Fig. 2 the two condensers at the top of the figure, which shunt the "B+45" and "+135" terminals on the voltage divider R18, though not shown as such, are contained within the "B" block C16 and are each of 1-mf. capacity.

When the "L45" power tube is used in the "B" power-supply unit it will be necessary to substitute for the line transformer T5, one that will deliver greater voltage to the rectifier unit. The S-M 327 power transformer will not only prove satisfactory for this purpose but in addition it will furnish the necessary 2.5 volts for the filament of the 245 tube, from its extra filament windings.

So much of data and diagrams is available from manufacturers, concerning the correct construction of a satisfactory high-voltage "B" power-supply device, that instructions governing its construction will not be given here. Suffice it to say that, in general, the circuit diagram will be similar to that shown in Fig. 2. The only difference will be in the electrical values of the various parts employed, depending, of course, on the maximum output value that is desired.

The several photographic illustrations accompanying were taken from the author's later set-up, wherein the L45 tube was used, together with an S-M 850 dynamic loud speaker; the set beng powered from a National "B" supply unit and a Tobe "A" supply device.

In later issues some further suggestions will be given for the constructor who desires to increase sensitivity on weak DX signals by the use of a booster unit or tuned aerial stage at the expense of an added control—as may do, notwithstanding the very high amplification and keen selectivity already obtained with the four following tuned stages. Some other optional changes will be suggested as well; as, for instance, a 250-type amplifier, should the volume desired be greater than that required for the ordinary home.

LIST OF PARTS

The following were the components used in the original receiver, here illustrated:

Two Hammarlund "Battleship" two-gang condenser units, type BSD 50, 0005-mf. (C1-C2, C3-C4);
Two "Tinytobe" fixed condensers, one .00025-mf. (C5), one .001-mf. (C6);
Six Tobe by-pass condensers, type No. 300, 1-mf. (C7, 8, 9, 10, 11, 12);
Three Tobe by-pass condensers, 0.1-mf. (C13, 14, 15);
Four Aero "Universal" R.F. transformers, type U4 (T1, T2, T3, T4);
One Electral "Tonatrol," type A, 0-500,-000-ohm (R1);
Eight "Amperites," one type 622 (R2), six type 1A (R3, 4, 5, 6, 7, 8), one type 112 (R9);
One Durham grid leak, 5-megohm (R10);
One Durham "Powerohm," 2,500-ohm (R11);
Three Durham plate resistors, 100,000-ohm (R12, 14, 16);
Three Durham grid resistors, two 0.5-megohm (R13, R15), one 0.25-megohm (R17);
Eight Durham single-resistor mounts, for the above;
Eight Silver-Marshall sockets, type 511;
One Hammarlund R.F. choke, 85-millihenry, type 85 (L1);
One National Drum Dial, type F;
One Yaxley Battery switch, No. 10;
Two Yaxley cable receptacles, No. 660;
One Lignole panel, 7x21x3/16-inch;
One baseboard, 12½x20½x⅞-inch;
Three boxes Corwico solid "Braidite";
One National tone filter (TF)—unless dynamic speaker is used;
Four Electrical wire-wound grid suppressors, 300-ohm, to be used at "X" only if required. as explained above;
One CeCo "RF22" tube, V1;
Three CeCo "AX" tubes (V2, V3, V4);
One Ceco "H" detector tube (V5);
Two CeCo "G" high-mu tubes (V6, V7);
One CeCo "J71" power tube (V8).

POWER SUPPLY

One Silver-Marshall power transformer, type 329A for 71-type tube, or type 327 for 45-type power tube (TS);
One Silver-Marshall "Unichoke" type 331 (L2);
One Electrad "Truvolt" voltage divider (R18);
One Tobe "B" block, type 760, 2-2-8-1-1-mf. (C16);
Two Tobe filter condensers, 1-mf. (C17, C18);
One Silver-Marshall UX socket, type 511;
One CeCo "R80" rectifier tube (V9);
One baseboard, 8x12x¾-inch;
One box Corwico stranded "Braidite";
One Tobe "A" supply unit.

WINDING SPECIFICATIONS

Diameter of solenoid	2 inches
Number of secondary turns	76
Number of primary turns	15
Size wire (sec.)	No. 20 D.C.C.
Size wire (pri.)	No. 24 D.C.C.

The primaries may be wound on forms slightly smaller in diameter than the secondaries so that they can be inserted at the filament end of the secondary coil; or the primaries may be wound on the same form as the secondaries, a space of 3/16-inch being left between the two coils. The direction of winding for both coils must be the same.

These specifications are for .0005-mf. condensers. Should the constructor desire to use .00035-mf. instruments, he should use 86 turns on each secondary and 20 on each primary.

Beginner's Amplifier - Power Supply

(*Continued from page* 32)

condition, the battery should be tested and finally the parts themselves should be checked over. The transformer should be tested with a battery and pair of phones, as described in the article last month, and condensers should be tested after they have been disconnected from the circuit. It is necessary to disconnect the condensers from the circuit since some of them are shunted by coils or other apparatus which would apparently show a short circuit. If, after checking over all of these points, no defects are discovered and the set still does not function properly, it is best to call in someone who is more familiar with the operation and construction of sets rather than continue further.

In testing the "B" power unit and amplifier, a slightly different procedure should be followed. The wiring should first be tested with the "C" battery and a pair of phones, after the unit has been disconnected from the line and receiver. A loud click will be heard from the power transformer windings and a subdued click will be heard from the audio and output transformer. In testing the filter condensers, a battery should be connected across each of the condensers for a few seconds. A piece of wire should then be used to short-circuit the terminals of each condenser and if it is in good condition, a spark will be noticed when the connections are first made. If no spark is noticed when the condenser is short-circuited, it is more than likely defective. If the condenser is short-circuited, a spark will be seen when the battery is touched to the condenser terminal and it should be immediately disconnected in order to prevent the battery from being injured.

This method of testing condensers is only suitable for large condensers, such as those used in the filter circuits of B power units, etc. The small fixed and variable condensers employed in the tuned circuits of a radio set will not give a spark in this way. The voltage divider can be tested with the battery and phones in order to be sure that there is a contact between all of the taps and between the ends of the resistor. The click will be reduced to some extent when the full resistance or most of the resistance is in the circuit. (This will be noticed when the two ends of the resistor are connected to the battery and phones or when the tester is connected between the higher voltage taps and the negative end of the resistor.)

As in the case of the set itself, the first thing to suspect in case of failure, is the tubes. Both the 171 and the Raytheon tube should be taken to a dealer or service man to be thoroughly tested. Next the wiring should be checked over and finally each piece of apparatus should be tested in the manner suggested above.

These suggestions for testing and locating trouble are not given with the thought in mind that trouble will be encountered. They are merely given to help those few readers who are unfortunate enough to encounter defective apparatus or who make some mistake in building their units.

Wenstroms Mutiva-Receiver

(*Continued from page 75*)

ful," again came through with weak loudspeaker volume. WOR, WJZ, WABC and WNYC of the New York area came in clearly, as did WGY at Schenectady and WICP at Bridgeport. The short wave coils were not used in this test, but on the small antenna they would undoubtedly have done better than the broadcast coil.

These tests seem quite pleasing where we remember the simplicity of the set. Simple though it is, a more reliable and versatile receiver would be hard to find.

Radio Wrinkles

(*Continued from page 76*)

desired and then shifting the coils until the correct relation is secured. After the coils have been placed in the required positions, the machine screw at the top is tightened, to keep them in place. By employing some other method of securing the rod to the baseboard of sub-base, which will allow the coils to be removed more easily, this scheme can be used also for plug-in short-wave coils.—*Contributed by William H. Dobson.*

The "RE 29 Receiver"

(*Continued from page 35*)

LIST OF PARTS

Two Hammarlund .0005-mf. "Midline" tuning condensers (C1, C2);
Six Sangamo .00025-mf. fixed condensers (C3, C4, C5, C8, C9, C10);
Two Acme "Parvolt" 0.5-mf. by-pass condensers (C6, C7);
One Sangamo .001-mf. fixed condenser (C11);
One Lacault B1 antenna coupler, with base (L1);
One Lacault B2 oscillator coil, with base (L2);
One Lacault F2 intermediate-frequency transformer with base (L3);
Two Lacault SG intermediate-frequency transformers, with two bases (L4, L5);
Two Lacault CL radio-frequency choke coils (L6, L7);
One Sangamo type A (3-to-1 ratio) audio transformer (T1);
One Lynch "Equalizer" No. 22 (R1);
Three Lynch "Equalizers" No. 4 (R2, R5, R6);
Two Carter 25-ohm fixed resistors, with a tap on each at 15 ohms (R3, R4);
One Carter filament switch (SW);
Six Benjamin sockets (V1, V2, V3, V4, V5, V6);
Three Carter tube shields;
Three "Peewee" clips;
Two National Type E dials, with dial lights (DL1, DL2);
Three "Alcoa" aluminum stage shields;
Two binding posts, "Antenna" and one "Ground," with 1 x 3 inch bakelite strip and two brackets;
One Jones "Multiplug," 10-wire;
One 7 x 24-inch bakelite front panel;
One 12¼ x 25½-inch baseboard;
One Fritts cabinet (Cat. SS24);

The Constructor's Own Page

(*Continued from page* 87)

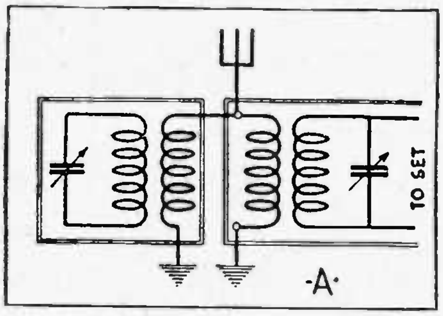
WHAT'S IN YOUR CELLAR?

Editor, RADIO NEWS:

Few people realize the importance of a good ground. A special ground installed by me brought in Davenport, Iowa, just as strong as KYW was coming in (at Kenosha, Wis., which is 50 miles north of Chicago) on a water-pipe ground. With a two-tube Harkness reflex I received all stations of any importance from Denver, Ft. Worth, Nashville, Atlanta, New York City, Springfield, Mass, and all on the speaker with good volume. All this is due to excellence of the ground.

B. R. MEDLEY,
Milwaukee, Wis.

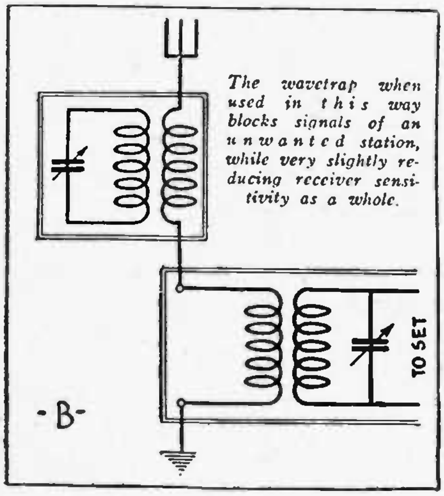
(*The ground system sketched by Mr. Medley comprises a number of copper plates buried in a hole 4⅛ feet deep and 8 inches in diameter dug under the celler floor. This is just the thing where it is practicable; but we can hardly see ourselves, here in New York, blasting through the* steel and concrete floor of the cellar of a 14-*story apartment house. However, those more fortunately situated will find a ground along these lines an excellent help. Such grounds have been more than once illustrated in* RADIO NEWS.—EDITOR.)



AN AERIAL TUNER

Editor, RADIO NEWS:

I have been experimenting with the unit shown schematically in Fig. A, and have had the same connected to different sets,



The wavetrap when used in this way blocks signals of an unwanted station, while very slightly reducing receiver sensitivity as a whole.

Mr. Keulman found this arrangement of a wavetrap, with a second aerial as described, a device much wanted by his customers.

both battery and A.C. I find that it increases volume, selectivity and the distance range of the receiver to which it has been attached.

The unit is made of the following parts: an inside aerial of about forty feet, one end to be attached to the aerial post of the set in use, and the other end to the primary of the coil in the unit. The secondary is tuned by a .00035-mf. condenser. The parts used are 50 feet of aerial wire, a socket, a Dresner plug-in coil, a Remler condenser and a vernier dial.

I have put these parts in a case similar to a mantel clock, which gives an attractive appearance when put on top of the radio cabinet, or alongside the same. I have

(*Continued on page* 94)

A.C. Screen-Grid "Everyman"

(*Continued from page* 51)

the speaker which it is desired to use. The "B—" and "C+" returns are indicated by a dotted line in Fig. 1A; when this amplifier is used in conjunction with the "Everyman Five," this terminal is the same as that used with the R.F. tubes.

The writer personally and heartily recommends the A.C. Screen-Grid "Everyman" tuner, and the accompanying amplifier here described, both to the experimental fan, and to the average radio enthusiast through the medium of the custom set builder.

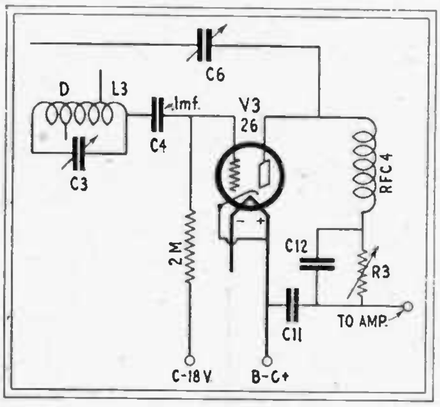


FIG. 3

The method of detection shown will be more satisfactory here; it is practicable only with a receiver having high R.F. amplification, like the "Everyman."

PLATE DETECTION

The writer, personally, recommends a further modification of the original "Everyman" design; thus providing for plate rectification in the detector circuit. This can be secured with the detector used, with practically no loss in sensitivity, yet the usual gain in quality. The circuit of this suggested alteraiton is shown in Fig. 3. The only changes are the substitution of a 0.1mf. condenser for the usual grid capacity and the inclusion of a by-passed universal-range Clarostat in the plate circuit of the detector tube. The grid leak is brought down to a negative bias of 18 volts, instead of to a positive "D" terminal. The plate resistor is adjusted for minimum hum and maximum signal response.

The Velvetone-29

(*Continued from page* 45)

the secondary being connected to the power tube or tubes, as the case may be.

When the set is completely assembled and wired, all that it is necessary to do is to line up the condensers for maximum reception at the lower end of the dial by means of the trimmers to compensate for differences in capacity due to the wiring. Connect the set to a short antenna, say twenty feet long, and tune in some weak station on the low wavelengths. Should the set tend to oscillate, change the screen-grid tubes around, as the a.c. screen-grid tubes which are at present available are not as uniform in their characteristics as the more widely used 201A. If there is only a slight tendency to oscillate, this may be eliminated by slightly decreasing the volume control. The lined-up condensers should then be slightly adjusted so that the weak station comes in the loudest or nearly so, and the receiver should then tune sharply all over the dial and have a tremendous amount of gain.

It is believed that the many radio fans who desire to build a set which combines distance and quality will be much pleased with the performance of this receiver.

LIST OF PARTS

The National MB-29 Kit comprises the following:

1 National chassis with five tube sockets
4 National R.F. choke coils
3 1.0 mfd. by-pass condensers
R1 1800-ohm resistor
R2 100-ohm resistor
R3 60-ohm resistor
R4 50,000-ohm variable resistor, special taper
R5 20,000-ohm resistor
4 National special r.f. transformers complete with self-contained by-pass condensers and r.f. choke coils
4 National type M variable condensers with zero adjustments
1 National type F drum dial
1 .001 mfd. mica bypass condenser
2 binding posts with insulating washers
Wire, hardware, etcetera.

It Happened (?)

Radio Fan (who finds the usual atmospheric conditions accompanying a demonstration of his new hook-up before company): "Gee, what a rotten night! I can't seem to hold any stations at all!"

Visitor: "Oh, the weather is nice out. Maybe the radio stations are not sending out enough ether!"—C. Walker.

Radio Methametics

Instructor: "In measurements, "micro-" means "one-millionth"; a microampere is one millionth of an ampere, and a microfarad is one-millionth of a farad. Now, can anyone give me further examples?"

Star Pupil: "Yes, sir; a micrometer is one-millionth of a meter and a microphone is one-millionth of a phone."—Bernard Ring.

Need of High Standards in Frequency-Maintenance

By Robert H. Marriott

THROUGH the history of radio development in the United States, increasing accuracy in frequency-measurement and in frequency-maintenance have been necessary developments. A simple example of the value of measurement and maintenance of frequency at the present time is to be found in broadcasting.

About ninety per cent. of the broadcast stations, at present, reduce each other's service ranges; because they do not stick to the frequencies they are assigned to. That is not so apparent in New York; because in the vicinity of New York City, there are enough stations on cleared channels to supply a variety of programs. However, less than ten per cent. of the people of the United States live around the city of New York, and less than ten per cent. of the stations in the United States are on cleared channels.

Consider two stations that are nominally on the same frequency; under present practice, one of these two can exceed its frequency by 500 cycles and the other can fall short of its frequency by 500 cycles. Two stations that are operating that way produce a beat note of 1000 cycles; which will commonly come through a radio receiver and loud speaker and affect the ear as much or more than any other note.

Suppose those two stations that are producing their mutual interference, consisting of a 1000-cycle note, are a thousand miles apart; and either of them is shut down so that the other can be heard satisfactorily for a distance of something over one hundred miles from the station. Then suppose the other station starts up, producing such a heterodyne that everybody beyond about ten miles from the two stations tunes off from those stations. Roughly, in service range, that means that each of those stations has reduced the service range of the other from about 10,000 square miles to 100 square miles, or from 100 to 1%.

Not only may stations mutually reduce their service ranges, by not sticking to their frequencies, but, if they had been putting on very good programs they may reduce their audiences from millions to thousands, or more than a thousand to one.

VALUE OF EXACT-FREQUENCY WORK

On the other hand, if both of those stations maintained their frequencies within 50 cycles of their assigned frequency, the effect would be quite different; because, with less than 50-cycle variation, the beat note will be below 100 cycles. The ordinary radio receiver, speaker and ear are comparatively insensitive to notes below 100 cycles; therefore, the low heterodyne is not heard, or is not sufficiently annoying to cause people to tune off within the normal service range of the stations.

The common opinion is that there are forty stations on cleared channels in the United States, and that those stations are therefore free from heterodyne interference. That is not the case; on some of those cleared channels there are two stations in the daytime. The continued pressure exerted by broadcasters is to put more than one station on a channel. The General Electric Company forced two stations on one channel for both night and day operation. At the present time there are, apparently, *only ten stations on cleared channels* for night and day operation.

In considering this problem, it is safer to assume that there are no stations on cleared channels and that, therefore, all broadcast stations to increase their service ranges should maintain their frequencies accurately.

Not only is frequency-maintenance of broadcast stations, to within fifty cycles, of value to the broadcasters for the purpose of increasing the number of their listeners; but it is also of value to those who make and sell radio receivers and loud speakers, because every position on the dial that brings in a squeal reduces the value of the receiving equipment.

Such accuracy in frequency-maintenance is recommended because it is of service to the listening public, of service to the broadcaster, of service to those who make and sell radio receiving apparatus, as well as another step in radio development.

MR. MARRIOTT, who has the unique honor of being the first president of the Institute of Radio Engineers, and has at present the Federal Radio Commission as a distinguished client for his technical counsel, speaks with unquestioned authority.

One of the facts which has made itself obvious in the course of broadcast regulation is that our central states are most affected by station interference. While neither the Pacific nor Atlantic coasts may suffer from the operation of two stations at once, one on each side of the United States, the complaints from the Mississippi Valley are audible at Washington.

Exact frequency-maintenance, as explained here, will create the equivalent of many new broadcast channels.

Power Amplifier

(*Continued from Page* 71)

In a general way, this unit is very similar to the National device just described; it differs essentially in that no external "B" plate voltages are available for use in operating the tubes of a tuner unit. It employs a 227 tube in the first audio stage and 245 tubes, arranged in push-pull, in the second or power output stage; the rectifier is a 280 tube. This unit is designed in different models, for use with either magnetic or dynamic loud speaker. Therefore, when such a unit is selected, it is necessary to determine the type of speaker which is to be used with it so that the correct type of output transformer is included. Combinations employing a pair of 171A tubes in the push-pull stage are also available.

The home-built combination illustrated in Figs. D and E follows rather closely the general circuit details of the National unit, but is, of course, far less compact. It is, built with a "deck" type of construction; the lower deck holds the power-supply equipment and the upper deck, the complete audio channel. If preferred, the two baseboards may be arranged side by side or end for end. The parts employed are of standard manufacture and are easily obtainable. The first stage of audio amplification has a 227 tube and the second stage, which is a push-pull arrangement, uses two 245 tubes.

The power unit not only supplies "B" potential to the audio channel above but, by means of a "Truvolt" voltage divider, located at one end of the unit, intermediate voltages are made available for any tuner unit which may be used together with this combination. In a future issue, complete constructional details of this home-made combination unit will be given.

THE SERVICE MAN

(*Continued from page* 68)

The wave from a radio transmitter is distorted by irregularities in the contour of the earth, it is reflected by buildings and is carried over power and communication circuits, to say nothing of the fact that the symmetry of a coil antenna is destroyed by coupling to these circuits.

An interference having its source in a device connected to a power circuit causes very little disturbance due to direct radiation; but can be heard for miles along the power line. This proves the theory that the wave set up by the device is *carrier radio* and not *space radio.* Hence the loop will point *parallel to the line.*

Assume interference having its source in a leaky insulator as pictured in Fig. 1 of the article referred to. The quickest way to locate it is to patrol the line and find a point where the intensity of the noise is at a maximum. This maximum is hard to determine at times; because there will be a number of peaks caused by transformer installations, coupling to lightning-arrestor grounds, and reflection at corners.

I believe that the fable of the "leaky transformer" has its origin in the peak of the disturbance at every transformer. Early investigators blamed the transformers, instead of carrying their tests to a conclusion by actually locating the source.

J. H. O'CONNOR,
Radio Engineer, Public Service Co. of Colorado, Denver, Colo.

(We have received from other engineers of lighting and power companies information as to their experiences in the practical location of interference. This will be published as opportunity affords, for the benefit of our readers; as the subject is compelling lively interest in the radio industry.—EDITOR.)

A Tube and Set Tester for Lean Purse

(Continued from page 79)

The list is submitted as a guide for those wishing to service all kinds of sets.

1 adaptor, UX to UV-201.
1 adaptor, UX to UV-199.
1 adaptor, UV-199 to UX.
1 adaptor, UY to UX, extra terminal for test cord on K.
1 adaptor, UY to UX, extra terminal for test cord on K and H—.
1 D.C. ammeter, 0-5 amps.
1 book, loose-leaf, tube chart, notes and circuit diagrams.
8 clips, spring connector.
1 cord, 4", pin-tip both ends.
2 cords, 8", pin-tip both ends.
2 cords, 8", pin-tip and spade tip.
2 cords, 8", spade-tip both ends.
2 cords, 60", pin-tip and spade-tip.
1 cord, 60", spade-tip both ends.
2 files, 5", flat, 1 handle.
1 flashlight, Ray-O-Vac, 1½ volt.
1 knife (electrician's).
1 pencil.
4 pin-tips (screws and thumbnuts).
1 pliers (long-nose and side-cut).
1 pliers (square-nose and side-cut).
1 plug (light socket service tap).
1 plug ('phone).
2 plugs, G. & P. tube prongs with lugs attached.
2 plugs, fil. tube prongs with lugs attached.
1 single head 'phone, 2200 ohms, with 18" cord and pin-tips.
1 rheostat, Pilot resistograd, 0-3 megs., with lugs for attaching to tester panel.
4 sandpaper sheets, 3½ x 6".
1 screwdriver, ⅛" x 1½".
1 screwdriver, ¼" x 4".
1 screwdriver, ⅛" x 4".
1 roll friction tape.
1 A.C. voltmeter, 7½ volt (UX tube-base plug-in).
1 A.C. voltmeter, 150 volt (service tap plug-in).
50 feet wire, No. 24 D.S.C.
4 wrenches, flat, assorted (in leather case).
1 Spintite socket wrench.
1 cloth pad to protect wiring.
2 grid leaks (spares).

Following is list of parts necessary for construction of test set, including accessories, and price of each as catalogued by a prominent radio supply house:

1 box, old Radiola III, or home made	
1 handle for box, about 3" long	.10
2 butt hinges, ½" x 1	.10
4 rubberhead nails, from Radiola III, or buy at	.10
1 panel, rubber, to fit box	.57
1 voltmeter, Jewell Pat. No. 135, 0-8-200 D.C., without push-button	5.40
1 potentiometer, Carter MW-, 6-M, 6000 ohms, for R	.73
1 dial, 2" rheostat	.21
1 switch, SPST, midget knife—for X	.09
1 switch, SPDT, midget knife—for LO-HI	.15
1 switch, DPDT, midget knife—for A-V	.24
7 jacks, pin-tip	.42
4 sockets, Pilot subpanel type, UX—for VT and adapters.	.48
1 socket, Pilot, subpanel type, UY—for adapter	.12
4 binding posts, old nickelplate style, from Radiola III or buy	.20
1 strap, short-circuiting, from Radiola III or home-made	
1 cable, 5 ft., 5 wire, from Radiola III or buy at	.50
25 feet wide, tinned hook-up, Braidite	.18
125 feet wire, silk-covered loop antenna wire for cords	.85
10 plugs, pin-tip, Carter Imp plug	.90
10 terminals, spade-tip, or improvise from soldering lugs	.02
8 clips, spring connector, Pee Wee	.20
1 adapter, UV-199 to UX	$ .44
1 tube base, UX-199, for plug AD	....
1 tube base, UV-201, for UX to UV adapter	....
1 tube base, UV-199, for UX to UV-199 adapter	....
1 tube base, UX-291, for UY to UX adapter	....
1 tube base, UY-227, for UX to UY adapter	....
1 rheostat, Pilot resistograd, for Ext. R.	.59
2 radio brackets, flat, for lugs to resistograd	.16
1 voltmeter, 7½ volt, a.c., UX plug-in base	1.47
Assorted screws, nuts and washers	.25
Note-book, loose-leaf, 3½" x 6"	.25
Total cost	$14.72

The R. E. 29—Part II

(*Continued from page 39*)

transformers and sockets. The middle terminal of the output transformer and the two primary terminals of the input transformers are left unconnected for a while.

Mount the grid bias restorer, R4, to the left of the push-pull input-transformer. Connect one side of this resistor to the center black lead on the power transformer and the other end to the midtap on the secondary of the push-pull input transformer. Mount and connect the 1 mfd. by-pass condenser, C4, across the resistor.

In the circuit diagrams of the power pack and the amplifier are some smaller by-pass condensers, not shown in the photographs. They should be mounted in front, allowing plenty of room for the binding post strip and the resistor strip. Mount the condensers so that the terminal lugs are accessible with a soldering iron after the resistor and binding post strips have been mounted. Then mount these strips.

Now run a long, insulated lead from the midtap of the push-pull output transformer to the second terminal of the second choke coil and to the top of the voltage divider, or to the top of the highest resistor strip. Connect all the resistors in series, following the instructions which accompany these strips.

Now connect up the binding posts to the appropriate taps on the voltage divider, and to the small by-pass condensers, if called for by the circuit diagra mof the power pack and amplifier.

Note that the P terminal on the primary of the push-pull input transformers is connected to a binding post on the strip and that the other (B) is connected to the 90-volt tap on the voltage divider, or to the corresponding binding post.

In connecting up the binding posts to the small by-pass condensers and the taps on the resistor strip it is best to use flexible, rubber-covered wire, because this is easier to handle than bus-bar wire and it is already safely insulated.

The 22- and 45-volt plus binding posts do not have any by-pass condensers. Of course, a couple may be introduced, but it is really not necessary, for these posts are adequately by-passed in the receiver.

When everything else has been finished and the circuit checked over for any possible omissions and errors, the primary leads on the power transformer should be wired to the cord which leads to the plug.

The completed power pack will give adequate plate power for the RE29 receiver or any other receiver requiring the same plate voltages and currents. The current supplied will be well filtered and free from ripple. The unit will also have a high grade push-pull power amplifier with output enough to load up any dynamic speaker.

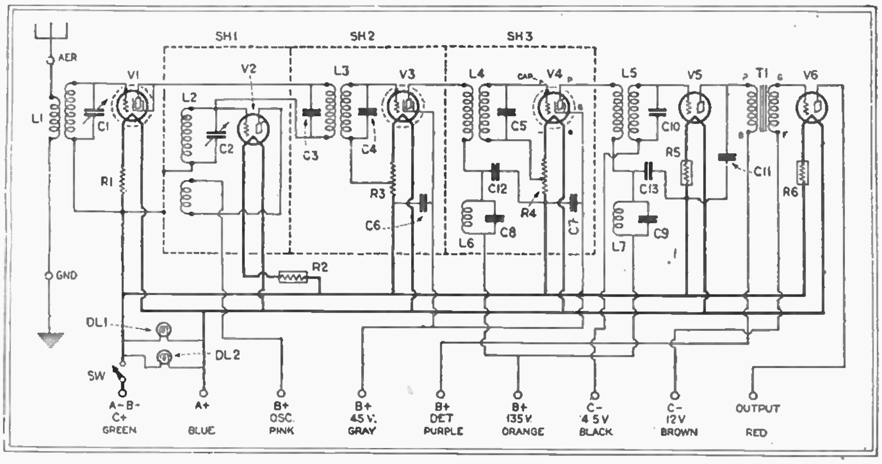


FIG. 7. *The schematic diagram is shown here. The screen-grid tubes will be seen in the modulator and the intermediate frequency circuits.*

(This concludes R. E. Lacault's article on his last receiver, the RE29, and the companion power pack. Following is information on the automatic volume control, of which Mr. Lacault left a schematic sketch, and some data on constants.—*Technical Editor.*)

In an automatic volume control for the RE-29, R. E. Lacault had in mind, just before his death, the rectification of part of the output of the push-pull stage, and the use of this rectified voltage to serve the plates of the screen-grid tubes. His laboratory notes clearly indicate what he had in mind. It was a method of automatic volume control based on the automatic variation of the plate voltage applied to the screen-grid tubes in the intermediate amplifier. The circuit diagram of this control is shown in Fig. 4. It consists of a 201A tube supplied with direct filament current from the receiver proper or from the batteries. Two long, twisted leads should be run to the set and so connected to the filament circuit that the switch therein controls the filament supply to the volume control tube. The volume control tube is connected across the loudspeaker terminals.

The tube is operated more as a detector than as an amplifier, and therefore a grid battery (S) is used for biasing. The 4 mfd. condenser is used to prevent short-circuiting the battery through the loudspeaker and the transformer winding.

A .5 megohm potentiometer is used to adjust the voltage applied to the grid of the volume control tube. By means of this the volume level may be set at some desired value and the circuit will then maintain that level. The control tube is supplied with voltage from the 135-volt tap on the power pack. The current required by the two screen-grid tubes and the control tube flows through a resistor and a high inductance choke.

The voltage supplied to the screen-grid tubes depends on the drop in the resistance of the choke and the external resistor. The control tube is biased, so that the louder the signal the greater will be the current. Hence, the greater the signal the greater becomes the drop in the voltage and the lower the voltage applied to the screen-grid tubes.

Thus, an increase in the signal strength reduces the amplification and volume is automatically maintained at a practically constant level.

A little experimentation with the setting of the potentiometer, the value of the grid bias and the value of the external resistor is recommended.

In order that the control tube shall not act so rapidly as to level out the low-frequency signals as well as the slow fluctuations in volume, the values of 4 mfd. and 100 henrys are suggested, although larger constants may be used.

LIST OF PARTS

For Power Pack

T—One American Type PF 250 power transfermer.

T2—One Sangamo Type B push-pull input transformer.

T3—One Sangamo Type D-210 push-pull output transformer.

Ch1, Ch2—Two American Type 854 filter chokes.

C1, C2, C3—Three Acme Parvolt 1,000 volt, 2 mfd. condensers.

C4, C5, C6, C7, C8—Five Acme Parvolt 400 volt, 1 mfd. condensers.

C9—One Acme Parvolt 400 volt, 4 mfd. condenser.

R—One Electrad Type B 750 ohm grid bias resistor.

One Carter resistor kit, consisting of three Type F (3,000 ohm) units, one No. 1 (7,400 ohm) tapped unit and one No. 2 (2,900 ohm) tapped unit.

Four sockets.

Eleven binding posts.

One baseboard 25½ x11¾ x ¾ inches.

(For Automatic Volume Control)

Two 4 mfd. condensers, 400-volt test.

One 100 henry choke coil.

One 500,000 ohm potentiometer.

One Lynch Equalizer No. 4.

Four binding posts.

One 10,000-ohm resistor.

One small grid battery.

One four-spring socket.

Some Experiments on Ultra-High Frequencies

(*Continued from page* 82)

resonance, and C10 and C11 adjusted until this stage may be tuned through resonance with the detector circuit without stopping the latter from oscillating. A maximum capacity of 30 micromicrofarads should be used in condensers C4 and C5 since condensers of great capacity will offer too much capacity coupling and will cause interaction between the two stages. After the two circuits are finally adjusted, it should be possible to place the detector on maximum regeneration point and then tune the radio-frequency stage through resonance without detuning or stopping the detector circuit from oscillating. The detector circuit should be calibrated and a careful curve drawn for each coil system. It will be found that the circuit will retain the calibration values indefinitely. Stations will come in at dial settings previously logged, thus avoiding "hunting" as experienced in other circuits. Variation of R6 does not affect the tuning. On the 6, 7 and 8-meter bands, it may be necessary to increase the detector voltage to approximately 60 volts in order to have full control of regeneration over the whole scale of each coil system.

It will be possible to receive certain stations on their second harmonic values. This, of course, cannot be possible where the skip distance takes places. WLL operates on 17,000 kilocycles and may be heard during daytime on 35,800 kilocycles. During daytime, the writer has received signals from the following:

Frequency	*Station*	*Location*
24,740	WQA	New York
26,350	NAT	New Orleans
26,400	RZ	Unknown
26,450	LSD	Buenos Aires
26,540	FY	Colombia
27,440	KLL	Syria
26,500	HJO	San Francisco
27,560	WGT	Porto Rico
27,740	WIY	New York
27,744	NKF	Washington
27,930	English Beam	Station
28,000	NKF	Washington
28,400	NKF	Washington
30,000	NKF	Washington
30,860	KEW	San Francisco
31,000	NKF	Washington
32,000	WIY	New York (*Rough note. Not a true harmonic.*)
32,120	NAA	Washington
32,300	NKF	Washington
32,700	NKF	Washington
34,000	NKF	Washington
35,000	WQC	New York
35,800	WLL	New York
35,910	NKF	Washington
36,040	KQJ	San Francisco
37,800	WDS	New York
38,500	NKF	Washington
40,000	NKF	Washington (*Not heard on all schedules.*)

NKF was received on fundamental frequencies, as given, while reception of other stations listed was accomplished on the second harmonic value of the main transmitting frequency. Tests from NKF were conducted at a distance of 2,000 miles, which gave good signal strength at 38,500 kilocycles, which shows that the skip distance played an important part for reception of the last-mentioned frequency.

An important feature was observed in reception of these stations—the steadiness of the signals. In fact, very little fading was ever observed.

The writer concludes by stating that the new receiver described in this article makes possible reception of frequencies from 23,000 to 40,000 kilocycles, which provides 1,700 available channels, each 10 kilocycles in width.

COIL DATA FOR THE PUSH-PULL RECEIVER

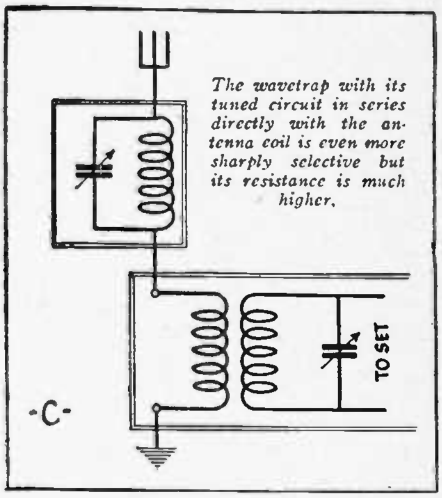
Coil No.	*Band in Meters*	*Turns Antenna*	*Turns Grid*	*Turns Grid Det.*	*Turns Tickler*	*Dia.*
1	80	6	21	21	6	2
2	40	4	13	13	6	2
3	36	4	7¾	7¾	4	2
4	20	3	5	5	4	2
5	15	2	3¾	3	32/3	2
6	12	2	4	4	4	1
7	10	2	3	3	4	1
8	8	2	2	2	4	1
9	6	2	2	2	4	¾

Grid and antenna coils from No. 1 to No. 5, inclusive, are wound 18 turns to the inch with No. 22 enamel-covered wire. Tickler coils are wound 4 turns to ⅛ inch with No. 27 enamel-covered wire. Coils No. 6 to No. 9, inclusive, use No. 22 double silk-covered wire for all coils. Wind the tickler coil close to the grid coil. For coils No. 8 and No. 9 space the tickler coil for each one so that the desired frequency range is obtained.

(*Continued from page* 90)

demonstrated this unit to a few neighbors and they all like it so well that I had to build each of them one.

On a set using a loop, you have to experiment to find out which connection gives



The wavetrap with its tuned circuit in series directly with the antenna coil is even more sharply selective but its resistance is much higher.

best results. The use of the two aerials does not broaden the receiver to which the unit is connected; but seems to affect it just the opposite way. Your opinion if the above is worth while for some manufacturer to put on the market would be appreciated.

Paul Keulman,
3005 *No. Marmora Ave.,*
Chicago, Ill.

(*This device, it will be seen, by the compact reduction of the diagram, is simply a wavetrap of the "rejector" type, coupled in parallel with the antenna coil of the set. It therefore permits the unwanted signal to leak off more readily, while maintaining the strength of the signal to which it is tuned, and therefore increases selectivity. Wavetraps in series with the antenna coil of the set, as in Figs. B and C, serve rather to tune out unwanted stations. While there are many wavetraps on the market, this may offer an excellent suggestion to custom builders whose patrons are in search of DX, and are willing to tune another circuit for the purpose. The price of increased effectiveness is increased work. A discussion of other means of increasing selectivity will be found on pages 996-7 of this issue.*—Editor.)

ALL AMERICAN CONCERTS

The programs of Station NAA (operated by the U. S. Navy at Arlington) furnished for the benefit of listeners in other American countries by the Pan-American Union, are to be sent out on waves of 9,550 kilocycle frequency (31.29 meters) to reach those below the equator; and 6,120 kilocycles (48.99 meters) for those nearer by. A beam transmitter will be used for the shorter waves, as its angle wil cover the narrow width of temperate South America; and the same program will be available to broadcast listeners in the United States on Arlington's 434-meter wave.

The Pan-American Union has invited each of the other American countries to install short-wave transmitters suitable for the same frequencies; when time can be divided equally, giving two hours a week between 6 P. M. and midnight, for each for the twenty-one republics.

NOTES AND CLIPPINGS

NOTES AND CLIPPINGS

4 SCREEN-GRID TUBES
AND POWER-DETECTION!

Screen-Grid Performance

SCREEN-GRID Tubes have opened the door to an altogether new kind of distance-performance in Radio. The new NATIONAL MB-29 Screen Grid Tuner uses 4 A.C. Screen-Grid Tubes.

Why Power Detection?

The latest and biggest improvement in Broadcasting is the use of High-Percentage-Modulation, now employed by the newest and finest stations. Soon all stations of any importance will adopt it, because of the better transmission it permits.

This improvement is not particularly noticeable with receivers using the older forms of detection. But we have just developed a system of Power-Detection especially designed to secure proper reception from stations using High-Percentage-Modulation and this is now offered for the first time, in the MB-29.

A Magnificent Chassis

With its completely shielded aluminum chassis, precision matched coils and latest NATIONAL Weld-Built Condensers,—with its modernist NATIONAL *Projector* Dial,—this tuner makes possible the construction of a magnificent A. C. receiver which combines the cleancut finish and appearance of the finest factory-built model with the quality and perfection of a custom-built job.

The Velvetone Amplifier-Power-Supply

For use with the MB-29 Tuner is the specially designed NATIONAL Velvetone Amplifier,—a complete Amplifier-Power-Supply, using two UX245s in push-pull and equipped with phonograph jack. This amplifier is licensed under patents of R. C. A. and Associated Companies and is sold fully wired and ready for use (less tubes).

The Tuner

Note the individual Coil Shields and the absolutely cleancut appearance.

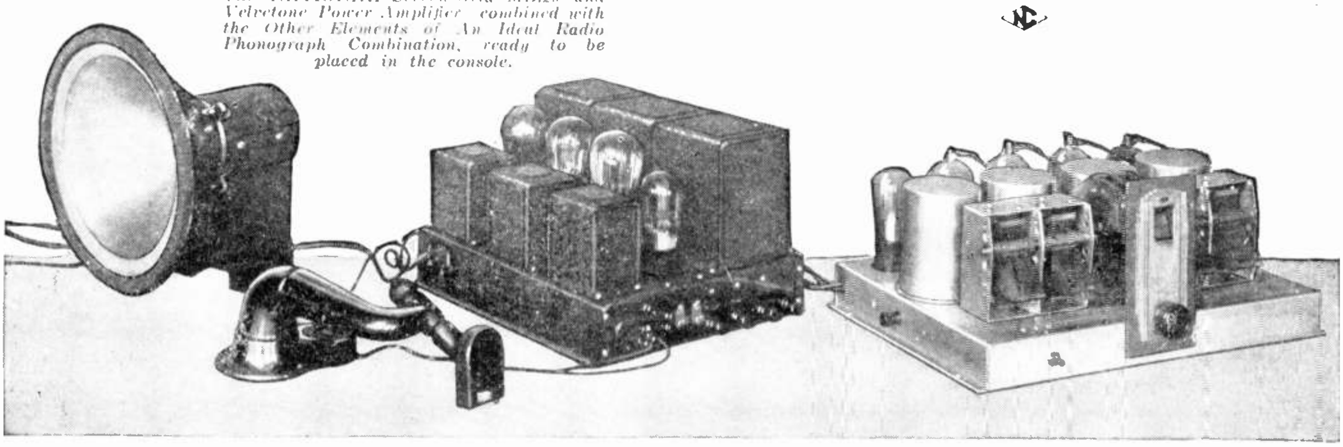
Consoles and Tables for the MB-29

There are available a selection of beautifully finished and specially priced consoles and tables for housing the MB-29 in various popular combinations.

The MB-29 bristles with new and ingenious features for your convenience and pleasure. *Write us today for full information, mentioning Radio News.*

NATIONAL COMPANY INC.
ENGINEERS & MANUFACTURERS
61 SHERMAN ST., MALDEN, MASS.
Est. 1914 . . W. A. READY, PRES.

The NATIONAL Screen-Grid MB-29 and Velvetone Power Amplifier combined with the Other Elements of An Ideal Radio Phonograph Combination, ready to be placed in the console.



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