January, 1926

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RADIO REVIEW

Reg. U.S. Pat. Off.

A Digest of the Latest Radio Hookups

Edited by S. Gernsback

Containing

Illustrated

Radio Encyclopedia

See Page 81

Published by the
CONSRAD CO. Inc.
NEW YORK CITY

HOW TO MAKE YOUR OWN Speech Amplifier

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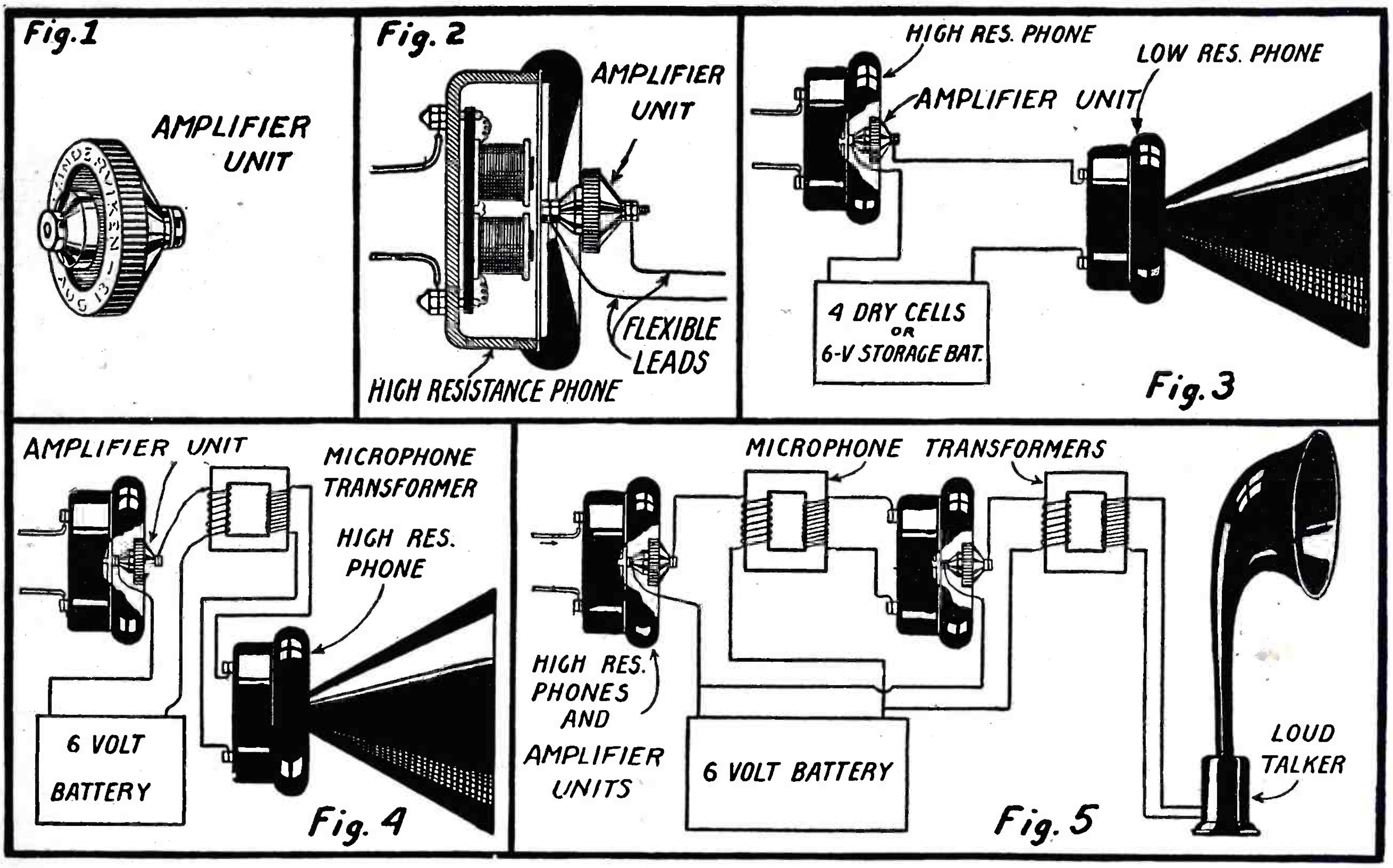

FIG. 1 shows the amplifier unit, actual size.

FIG. 2 shows how the unit is attached to a telephone receiver. The first procedure is to mount the unit on the diaphragm of a telephone receiver, which usually is a high resistance telephone, either 1,000 or 1,500 ohms.

Next we select the loud speaking telephone. If a low resistance telephone is available, it should have for maximum efficiency an impedance equal to the resistance of the amplifier unit, or about 10 ohms; it is connected up as shown in Figure 3. A 5 ohm telephone receiver is used in this circuit with a 6-volt storage battery.

Two telephones taken from a good double head-set of 2,000 to 3,000 ohms which do not rattle on strong currents, are employed in Fig. 4, one at the receiving end, the other as loud talker. In this hook-up there is one instrument which must absolutely be used with this combination, the transformer. As stated before in connection with Fig. 3, the impedance of the telephone, if used in direct connection, should equal the resistance of the unit. But as the impedance of the telephone in Fig. 4 is much higher than the resistance of the unit, it may be 200 times as great, a transformer having a step-up ratio is used to match up the resistance of the unit with the impedance of the loud speaking telephone. In other words, the primary coil of the transformer should have an impedance (which is sometimes called "A. C. resistance") equal to the resistance of the unit, or about 10 ohms, and the secondary coil should have an impedance equal to the impedance of the high resistance telephone. This transformer may be purchased in any Radio Store and is called a microphone transformer or modulation transformer, designed primarily to use in radio transmitting sets. A 6-volt battery gives the best results. The current passing through the unit will vary from .1 to .25 ampere.

FIG. 5 shows a circuit for further increasing the volume of sound. This is simply two of the circuits, such as shown in Fig. 4, linked together. This arrangement is highly sensitive and the telephones on which the units are mounted should be packed in a box of cotton, as the slightest vibration or sound in the room will be picked up and heard in the loud talker. Any sensitive radio loud talker may be used in this particular circuit.

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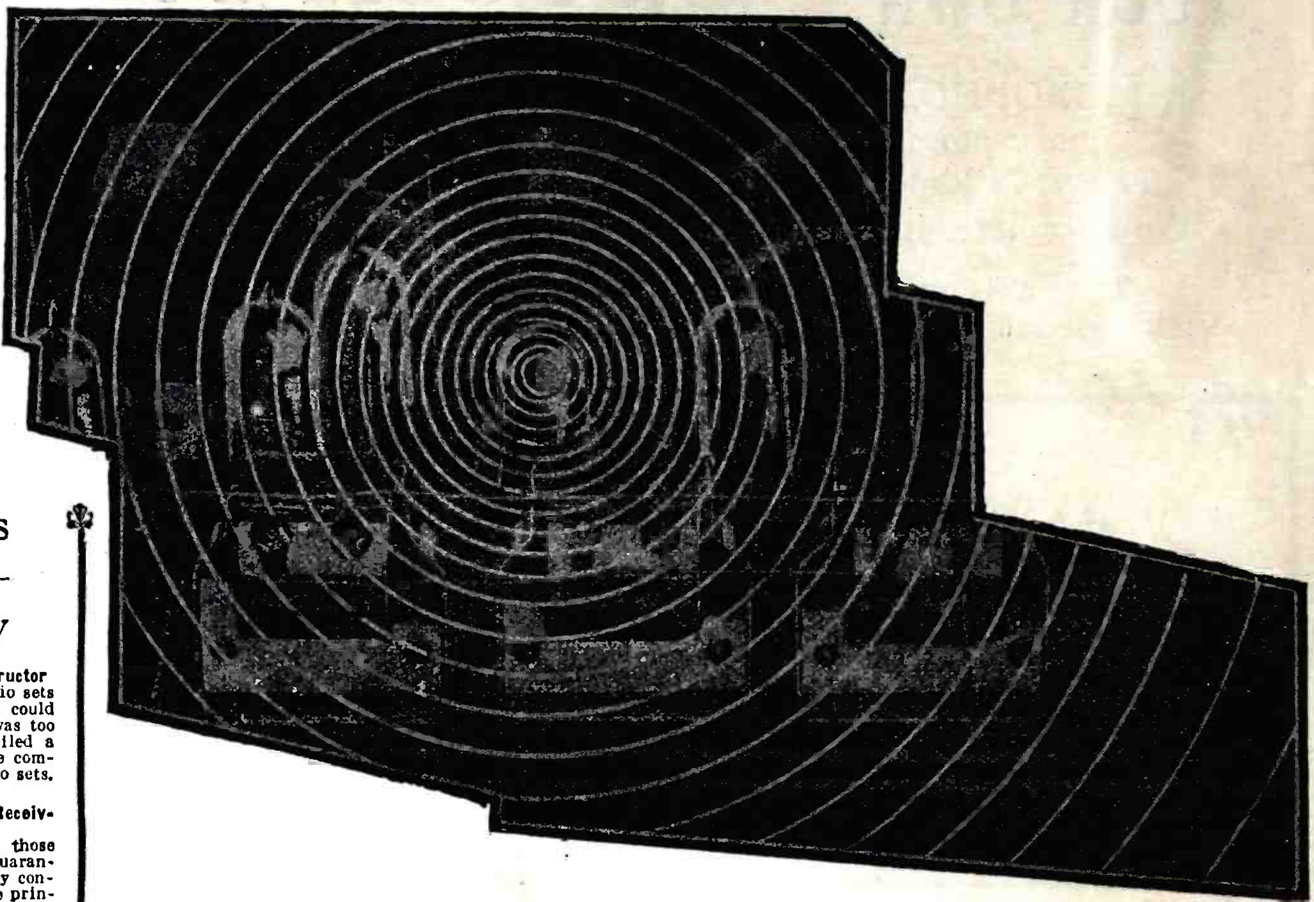

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THE E. I. COMPANY, Inc.

233 FULTON STREET NEW YORK, N. Y.

RADIO REVIEW

REG. U.S. PAT. OFF.

A Digest of the Latest Radio Hookups from the Radio Press of the World

In This Issue

S. GERNSBACK'S RADIO ENCYCLOPEDIA

Seventh Installment

ANNOUNCEMENT

ANOTHER forward step in the continued expansion of RADIO REVIEW is herewith announced to our readers. Beginning with the February number, this magazine will appear in a new and enlarged guise, in which, however, we shall merely be presenting to our readers two old friends in a new, and we hope welcome, union.

¶ Because we have found that our two present publications, RADIO REVIEW and the RADIO LISTENERS' GUIDE AND CALL BOOK, are used by an identical group of readers, we have decided, for the greater convenience and service of these, to combine the two in a new undertaking including all the well-known features of both in one magazine.

¶ The plan of the new magazine provides for four issues a year—namely, in February, May, September and December. The price will be 50 cents, and it will consist of 192 pages.

¶ The new RADIO REVIEW will be composed of the following four main departments:

Section 1. Reviews of radio features and constructional articles.

Section 2. Radio listeners' information, and articles on matters of timely interest and practical use to owners of radio sets.

Section 3. Directories of radio phone stations in the United States and foreign countries, radio logs, reports on current activities among broadcasters, illustrations showing views of the best-known and most interesting of the big stations, etc.

Section 4. Radio Encyclopedia.

¶ All of our subscribers will of course receive 12 issues of the new RADIO REVIEW, in accordance with their subscription for the old publication.

¶ We aim to make the new, amplified magazine even more of a success than its predecessor, and, offering as it does such an unrivalled array of features of proved popularity and merit, we feel that it should be of even greater value and interest to our readers. No cost or effort will be spared to make it one of the best and most complete publications in the whole radio field.

The Consrad Co., Inc.

233 Fulton Street PUBLISHERS New York, N. Y.

RADIO REVIEW

Reg. U.S. Pat. Off.

A Digest of the Latest Radio Hookups

Volume I — Number 7

JANUARY, 1926

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RADIO REVIEW, JANUARY, 1926 — VOLUME I, NUMBER 7

Published monthly by The Consrad Co., Inc., 233 Fulton Street, New York, N. Y., telephone number Cortland 7777; H. Gernsback, President; S. Gernsback, Vice President and Treasurer; R. W. De Mott, Secretary. Price 35c a copy; subscriptions $3.50 a year in the United States of America, Canada and all countries within the domestic postal zone; elsewhere $4.00 a year, payable in advance. Subscriptions only acceptable in U. S. currency or stamps. No foreign currency or stamps. Checks and money orders should be drawn to the order of THE CONSRAD CO., Inc.

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Entered as second class matter, March 10, 1925, at the Post Office at New York, N. Y., under the Act of March 3, 1879.

PRINTED IN THE U. S. A.

General Advertising Department
53 Park Place
New York City

Western Advertising Representatives
Finucan & McClure
720 Cass St., Chicago, Ill.

Pacific Coast Advertising Representatives
A. J. Norris Hill Co.
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RADIO REVIEW

SIDNEY GERNSBACK, Editor.
W. G. MANY, Associate Editor.
Offices, 233 Fulton St. New York City.

Vol. I JANUARY, 1926 No. 7

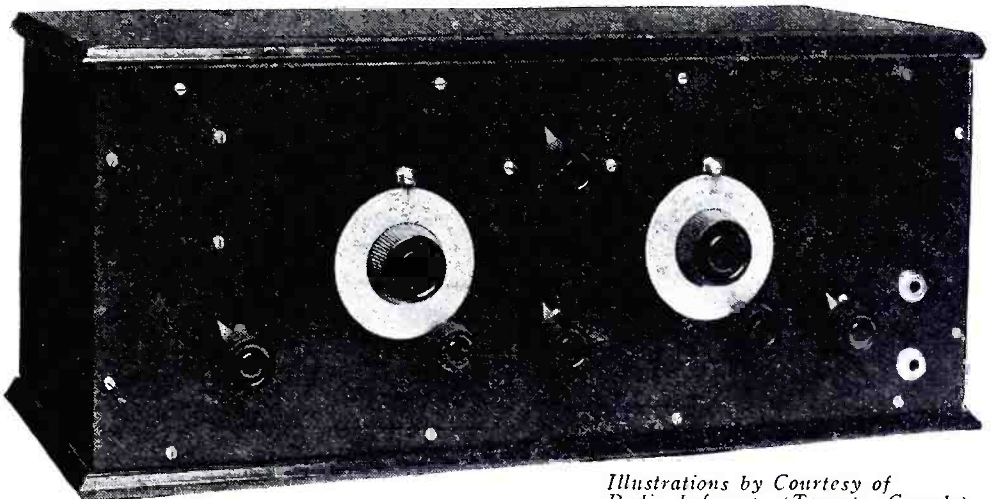
A Dependable Four-Tube Set

Capable of Unusual Selectivity, Distance and Tone Quality

AMONG the more popular of the radio broadcast receivers today, the tuned radio frequency set is undoubtedly the leader. Such a receiver employs one or more stages of radio frequency amplification, in which the signal is amplified prior to detection, and the devices for coupling the various tubes are tuned. The couplings usually take the form of transformers with the secondaries shunted by variable air condensers. This type of coupling is much more efficient than the old type untuned transformer. In fact, the efficiency is so much greater that tuned amplifiers are rather difficult to stabilize.

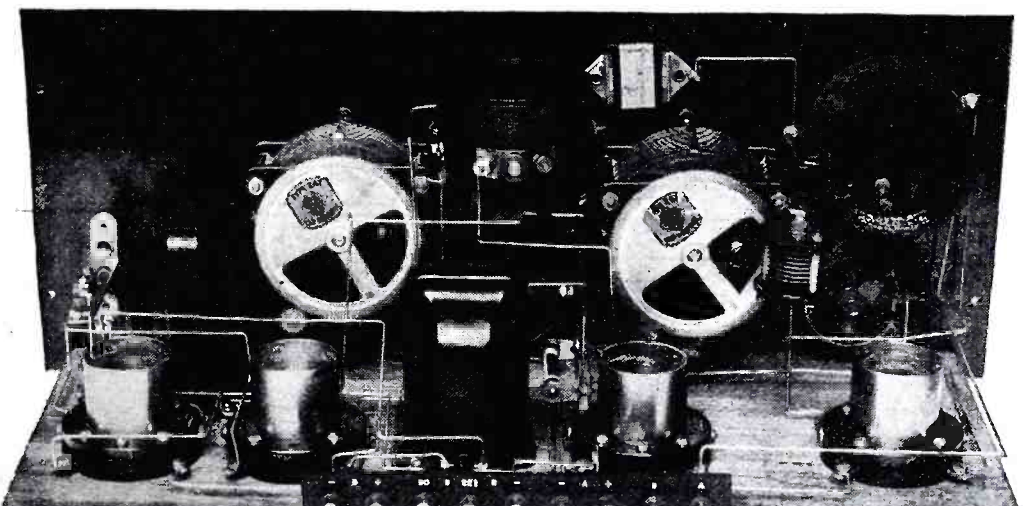
A set covering the principles of these features in design and which can be depended upon for satisfactory reception is that described herewith from the *Radio Informer* of Toronto, Canada.

Engineers have attempted for several years to combine radio frequency amplification and regeneration in successive tubes of an amplifying system, but were not successful until the means



Illustrations by Courtesy of Radio Informer (Toronto, Canada)

The completed four-tube set presents a pleasing appearance. The two large dials are the principal controls used in tuning.



A back panel view of the set showing the layout and wiring. All standard parts are used throughout.

was found to neutralize or balance out the plate to grid capacity of the vacuum tube. With this combination it is possible to duplicate the performance of a five-tube tuned radio frequency set, which does not employ regeneration, with four tubes.

With the advent of the Neutrodyne, developed by L. A. Hazeltine, interest in tuned radio frequency amplification rapidly increased. Today we have a score of tuned radio frequency circuits, most of which employ the Hazeltine principle in some manner.

The set to be described has four tubes, a stage of tuned radio frequency, a regenerative detector, and two stages of audio frequency amplification. It is similar in many respects to such popular receivers as the Browning-Drake and the Roberts set. It is intended for use with an outdoor antenna having a length of 40 to 100 feet, but may be employed with a small indoor aerial satisfactorily.

The parts for the receiver are of standard type and the major ones are all manufactured by the General Radio Company. However, the small tubes may be used with adapters, or the set may be equipped with small sockets if desired. There is a slight advantage in using the larger tubes, in that the tone quality on strong signals is considerably better. This is due to loading in the small tubes which makes the signal thin or scratchy.

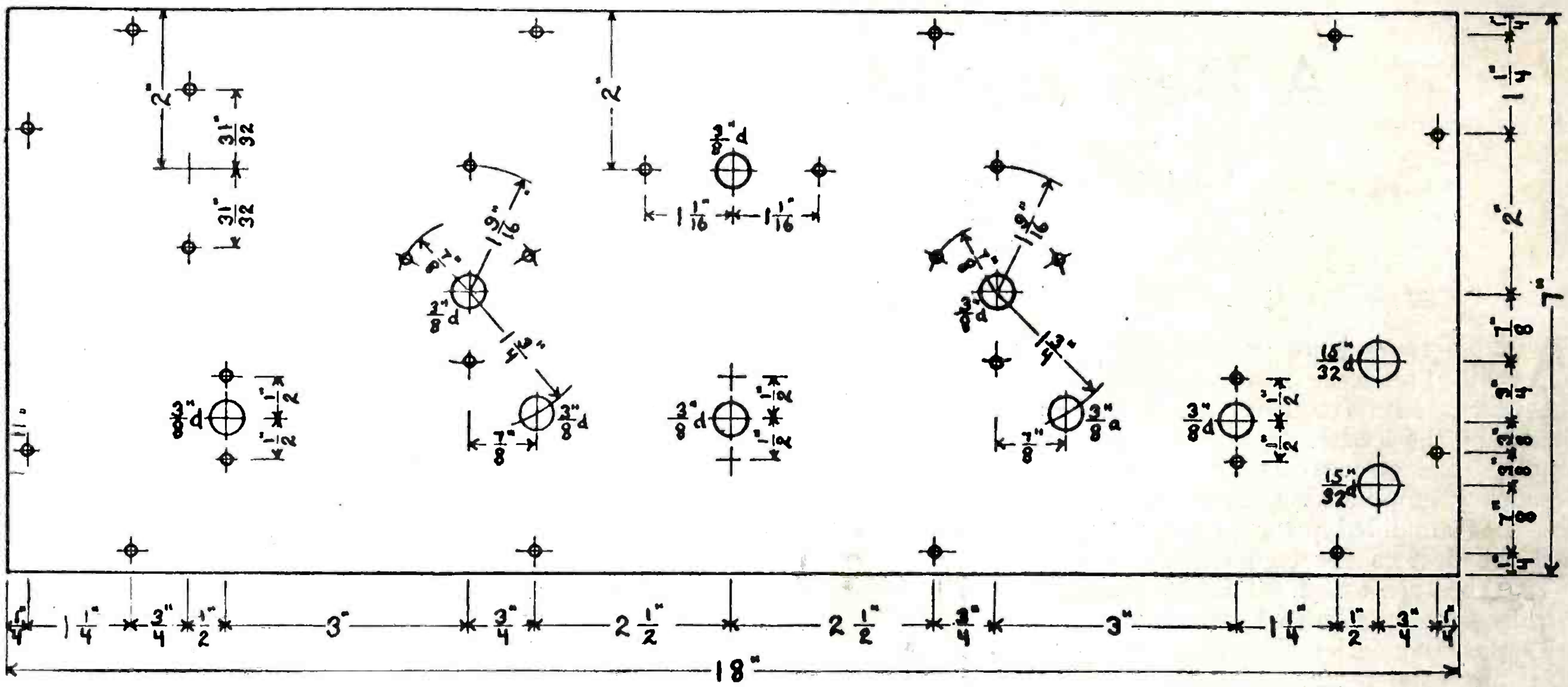
One type 277-D coil will be required for the antenna coupling coil. This consists of two windings indicated at L-1 and L-2 in the circuit diagram. The method of connection is obvious from the diagram.

A variocoupler, type 268, will also be needed. An extra winding is placed on this coil, which then serves as the radio frequency transformer and also to provide regeneration through the rotor. The stator of the coupler is shown at L-4 in the diagram and the rotor at L-5 with the extra winding at L-3. As indicated, the extra winding is placed at the filament end of the stator coil. It is wound in the same direction as that of the main or stator winding.

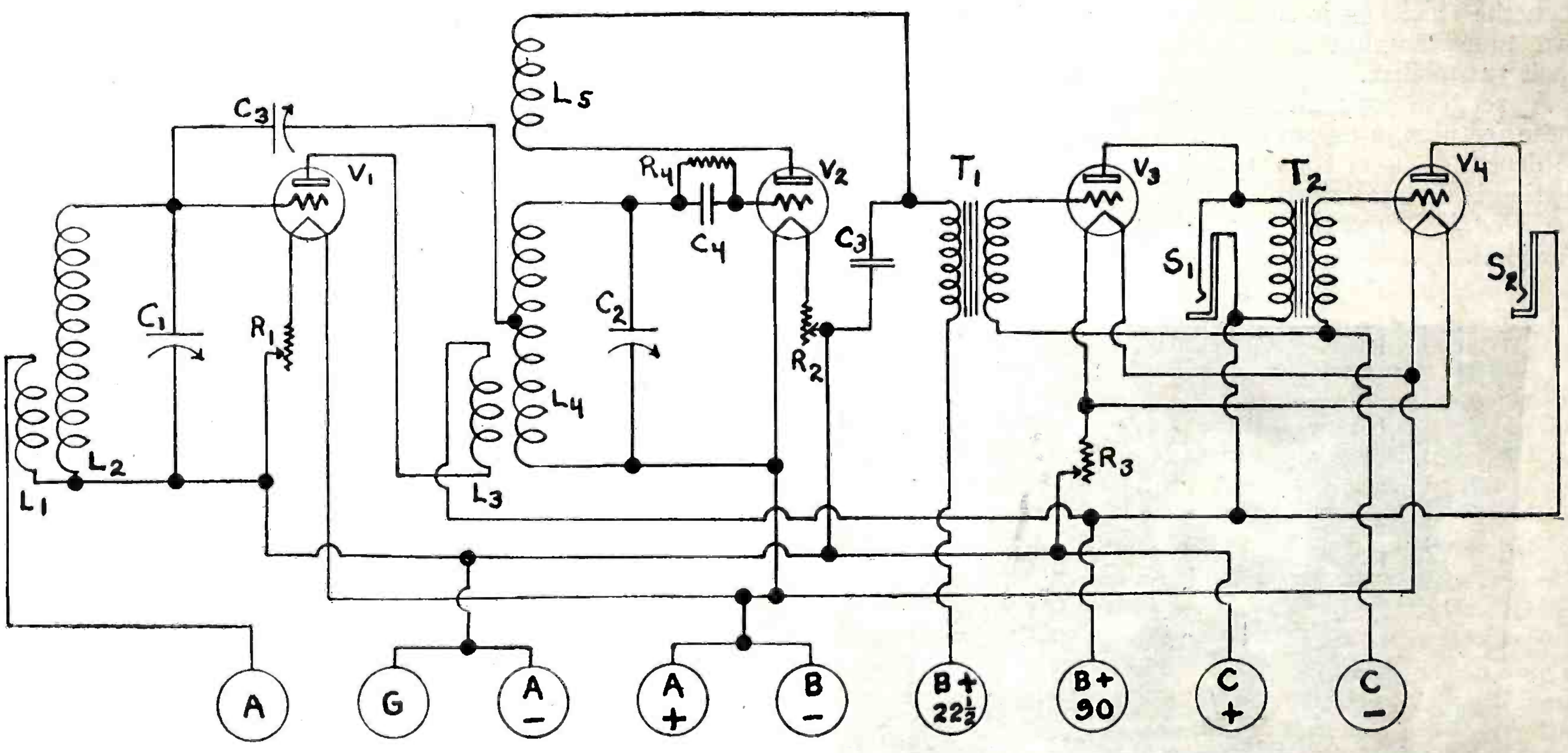
The primary L-3 of the radio fre- as possible. The writer used No. 36 double silk covered.

A variable air condenser, type 247-H, is indicated at C-1. This condenser is of the low loss type, with a maximum capacity of 500 micro-micro-farads and with plates so shaped that the wave-length calibration in a radio circuit is practically a straight line. This makes it possible to tune easily at the shorter wave lengths as well as tune over the entire range of wave lengths provided the associated inductance in the coil is correct. This is provided in the stator of the vario-coupler.

T-1 is an audio frequency transformer, type 285, which has a turn ratio of approximately six to one. The reproduction obtained by the use of this transformer is truly remarkable for the low tones are brought out full and clear as they are in few amplifiers.



Panel layout of the dependable four-tube set giving all dimensions for drilling the necessary holes.



Wiring diagram. Care should be taken to connect the various parts as shown.

quency transformer consists of 12 turns of fine wire wound closely and directly over the filament end of the stator of the vario-coupler. This coil should be insulated from the main winding and separated by approximately one-sixteenth of an inch by means of heavy writing paper or other form of insulation. Fine wire should be used for this coil in order to reduce the capacity to the secondary as much the longer ones. That is, it tends to separate the stations at the low end of the scale. Another make of condenser may be employed in this position, in which case the constructor must be sure that the space allotted to it is sufficient.

The condenser at C-2 is a type 247-M, which is similar to the one at C-1, but has a capacity of 250 micro-micro-farads. The capacity is sufficient to

T-2 is a low ratio audio coupling transformer, type 285-L. It is not good policy to employ two of the high ratio transformers in this set due to the possible overloading of the second audio stage and consequent distortion.

C-3 is the neutralizing condenser which should have a maximum capacity in the vicinity of twelve to fifteen micro-microfarads. There are several

(*Continued on page 8*)

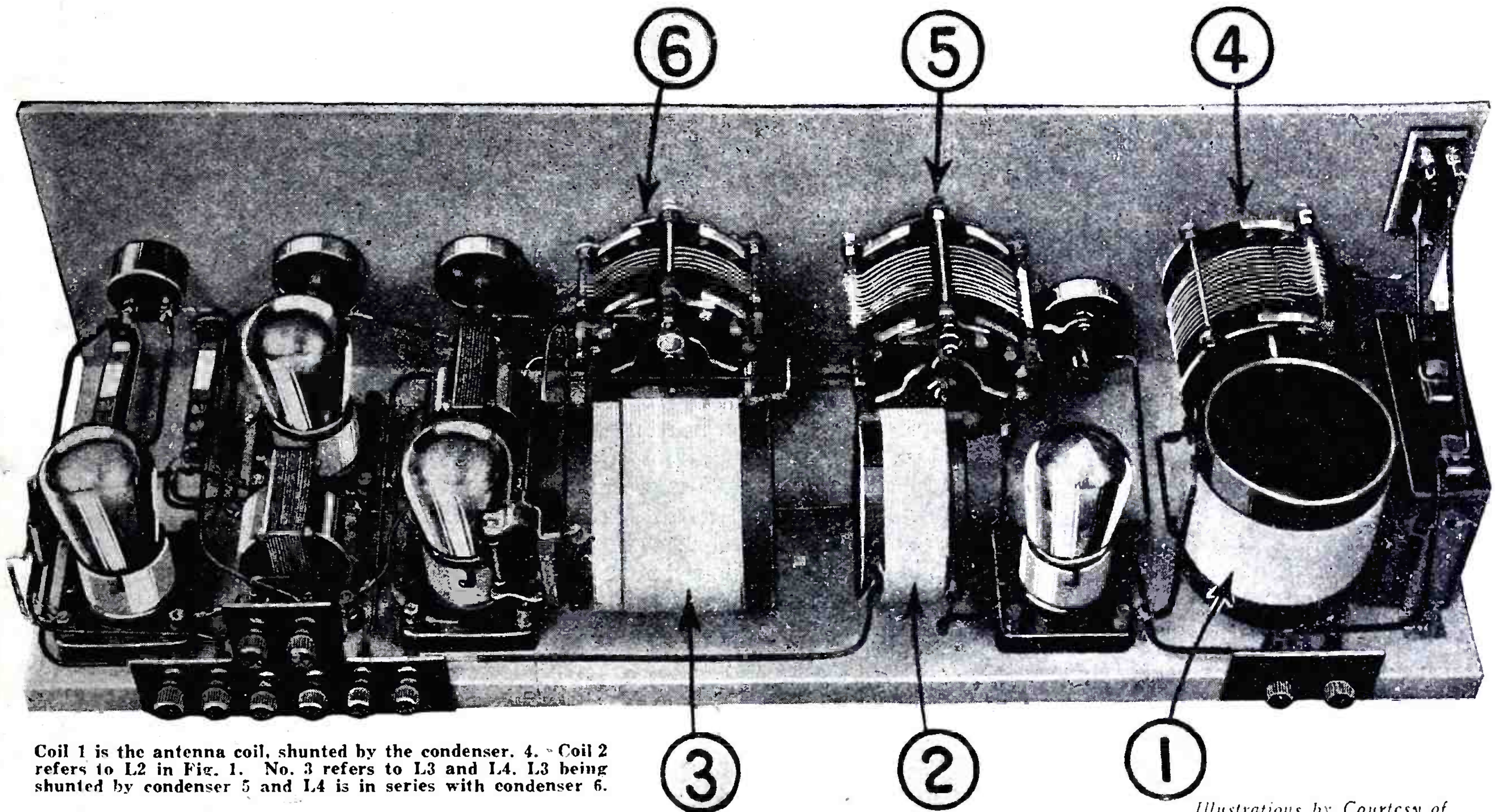
The Reactodyne Circuit

Employs an Excellent Method of Eliminating Oscillations and Controlling Regeneration

ONE of the most difficult combinations to effect successfully in radio engineering is that of radio frequency amplification and regeneration. Those experimenters who have endeavored to combine these two types of circuits will fully appreciate the difficulties that have to be overcome before the circuit is free from annoying oscillations. *Arthur Reed* describes a receiver in *Radio News* which greatly solves this problem, and as the accompanying photo shows, the assembly is comparatively simple. Standard parts are used throughout and the constructor can readily wire the set from the diagram. Mr. Reed describes this receiver as follows:

There have been many solutions offered to the problem of eliminating oscillations and controlling regeneration. In some circuits a potentiometer across the "A" battery terminals with the movable arm connected to the grid of the radio frequency amplifier tube causes the grid bias to have a positive value. There are many other ways to cut down oscillations, all too numerous to be mentioned here.

In the circuit diagram of Fig. 1 there is another method shown for reducing oscillations to the desired minimum. The coupling inductances, L2 and L3, are very loosely coupled, in fact, there is at least two inches between the ends of the two coils. Regeneration is obtained by the .00025 mf. variable condenser that is in series with the plate inductance, L4, and the plate of the detector tube. This is by no means a new method of regeneration, but it is a good one when the tuned circuit to which it is added is loosely coupled, as is the case in this receiving circuit.



Coil 1 is the antenna coil, shunted by the condenser. 4. Coil 2 refers to L2 in Fig. 1. No. 3 refers to L3 and L4. L3 being shunted by condenser 5 and L4 is in series with condenser 6.

Illustrations by Courtesy of Radio News (New York)

The first tube is used as a radio frequency amplifier and is tuned by a single-coil-condenser system, shown in Fig. 1, by the inductance L1 and the .0005 mf. condenser that is shunted across it. This inductance coil is wound on a three-inch tube and consists of 45 turns of No. 22 D.C.C. wire. There is connected between the ground and the coil, L1, a "C" battery for the stabilization of the circuit. This battery is unnecessary for some types of vacuum tubes, so a switch is provided for connecting the grid of the tube to the negative side of the filament battery. This "C" battery should be a different one from that which supplies the bias to the grids of the amplifier tubes.

In the plate circuit of the radio frequency amplifier tube there is connected an inductance coil, L2, which couples the radio frequency to that of the detector. This coil consists of 20 turns of No. 22 D.C.C. wire wound on a three-inch tube, and is placed at right angles to the coil, L1, in order to avoid any inductive effects. The inductances, L3 and L4, are wound on the same three-inch tube, which is placed in inductive relationship to L2, but at least two inches distant. The coil, L3, has 45 turns of No. 22 D.C.C. wire and is wound on the same tube; as close as possible to L3 is the fixed tickler coil, L4, which consists of 20 turns of No. 26 D.C.C. wire. A 23-plate variable condenser (capacity .0005 mf.) is shunted across the inductance, L3, and tunes the input circuit to the detector tube. In series with the coil, L4, is a variable condenser, having a capacity of .00025 mf., for controlling regeneration in the plate circuit of the detector tube. This method of controlling the regeneration is made possible only by the extremely loose coupling between the coils, L2 and L3.

The balance of the circuit is an ordinary transformer-coupled audio frequency amplifier. In order to reduce distortion to a minimum and also to reduce the drain on the "B" batteries there is introduced a "C" battery, as shown in Fig. 1, having its positive terminal connected to the negative side of the filament battery. This battery gives the proper negative bias to the audio frequency amplifier tubes.

ing, however, may be critical and to overcome oscillations in the radio frequency tube it may be necessary to reduce the filament current of that tube and also to reduce the plate voltage. For the higher wave-lengths a longer

ly the same setting and if there is no signal heard, they are moved simultaneously until the familiar regenerative whistle is detected. This regenerative whistle is then increased by turning the two dials until it is at a

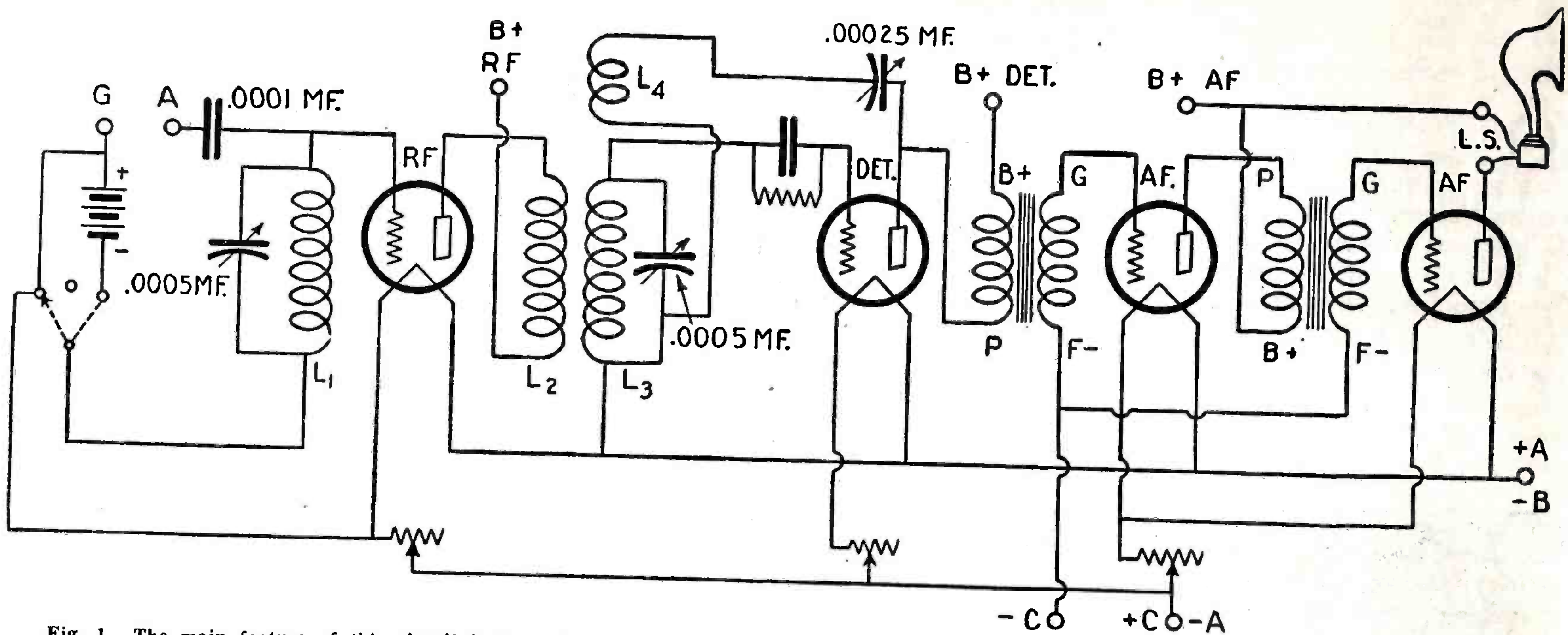


Fig. 1. The main feature of this circuit is the extremely loose coupling between the inductance L2 and L3. Regeneration is controlled by the .00025 mf. variable condenser in the plate circuit of the detector tube.

Antenna System

The Reactodyne circuit will operate rather successfully on any type antenna, the length of which affects the sensitivity of the set at the upper and lower wave-lengths, the selectivity and the calibrations of the dials. The settings of the condenser dial that tunes the grid circuit of the detector tube is little affected by the length of the antenna or its location, but the condenser in the radio frequency stage is greatly affected by any such variations. With an antenna that is from 10 to 20 feet in length the circuit is extremely selective and is very efficient on the lower broadcast wave-lengths. Tuning, however, may be critical and to overcome oscillations in the radio frequency tube it may be necessary to reduce the filament current of that tube and also to reduce the plate voltage. For the higher wave-lengths a longer antenna is recommended, but for all-around broadcast reception an antenna, either indoors or outdoors, about 100 feet in length is about right. This may be modified somewhat in congested districts and an antenna about 50 feet in length will give very good results.

For local stations there is no need to use any antenna at all. The ground wire is attached to the antenna binding post, the only difference in tuning being that there will be an increased selectivity of the set.

Tuning the Receiver

The tuning of the Reactodyne is fairly simple. The two 23-plate condenser dials are placed at approximately the same setting and if there is no signal heard, they are moved simultaneously until the familiar regenerative whistle is detected. This regenerative whistle is then increased by turning the two dials until it is at a maximum strength and then the variable condenser that is in series with the plate coil of the detector tube is moved until the whistle just disappears. This is the point at which the circuit is functioning at maximum efficiency, as the detector tube is just below the point of oscillation.

The tubes that may be used in this circuit are either the UV-201A type or the dry cell tubes of the UV-199 type. In case the dry cell tubes are used, it is necessary to replace the coil in the plate circuit of the radio frequency amplifier tube, L2, with one having 50 turns of No. 32 D.C.C. wire. It is perhaps unnecessary to note here that the larger type of tubes will give an increased amount of volume.

A Dependable Four-Tube Set

(*Continued from page* 6)

of these condensers made expressly for the purpose of neutralizing condensers in neutrodynes or other sets of the type.

A standard grid condenser with grid leak clips will be necessary and is shown in the circuit diagram at C-4. The grid leak, R-4, is preferably variable, but the cartridge type of resistance may be used here.

C-5 is a by-pass condenser which should have a capacity of .00025 mfd. By removing half of the rotor winding of the vario-coupler, the regeneration is kept fairly constant over the whole band of wave-lengths covered by this receiver.

S-1 and S-2 are open circuit jacks. This type of jack is simple to wire and fully as effective as the double variety where loud speaker reception is of primary interest.

Considerable care should be taken to prevent any appreciable magnetic coupling between the coils. If the panel lay-out shown herewith is used, the coil L-1, L-2 should be stood out from the panel one-half inch.

In any case a radius of the coupler, parallel with the panel should pass through the length of the coil L-2 midway of its length and also through its axis. The coils should be at least six inches apart to prevent any stray couplings.

The set constructed as in the photos is eighteen inches over all. The base board, seven by seven by a half-inch. These dimensions are extremely small for a four-tube set employing the large tubes. This is especially true with tuned radio frequency, for we often see the advice to make the set long and "skinny."

The 1926 "Diamond of the Air"

Full Description and Constructional Details of a New and Improved Receiver

"WHAT a receiver will accomplish depends a great deal on the way it is wired. Granting the same hookup is used, and the set wired well in one case and poorly in the other, the possessor of the badly constructed receiver may well wonder at the cause of excitement over the hookup while the other fan sits back, thrilled by his marvelous set."

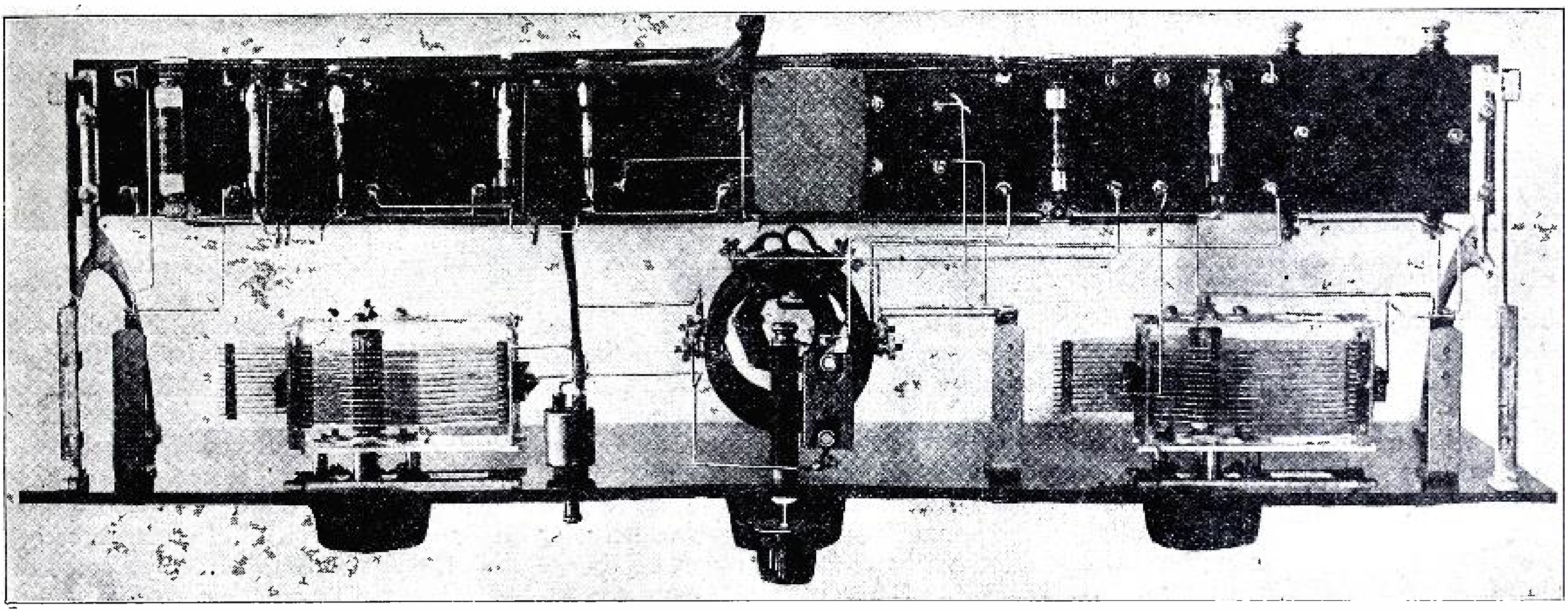
While this introduction to an article in *Radio World,* New York, by Mr. *Herman Bernard,* the genial editor of that contemporary radio journal, may appear somewhat commonplace at first glance, it actually contains much truth. We have all tried a set at some time or another and wondered just what occasioned the enthusiasm, when the fault really lay in the manner of arranging and wiring the receiver. To the fans who have constructed or contemplate building the justly renowned "Diamond of the Air," we advocate a careful study of this instructive article by Mr. Bernard. The balance of Mr. Bernards story follows:

It is characteristic of the hookup of the 1926 Model Diamond of the Air, so long as the wires are run to the right places, and the antenna, ground, tubes and batteries are in fairly good condition, that satisfactory results will be obtained. But that should not be the goal. Mere satisfaction is little enough to expect from the receiver. Results that surpass those obtainable from most sets, quality that reaches the very pinnacle and which is not a whit less than that produced by the new orthophonic Victrola, and astonishingly great receiving range, even on a loop, should result in every case where local conditions permit. Against the barrier of shielding by steel buildings, unaccountable dead spots and other strange and annoying effects, the Diamond has nothing to offer, but will do as much under adverse conditions as any other set. If an outdoor aerial is used the receiver will about equal a Super-Heterodyne on a loop, if the Super is made in the most approved style.

Stray Feedback Avoided

One of the harmful effects experienced in receivers employing tuned radio-frequency amplification, if the set is poorly made and badly wired, is stray feedback due to magnetic coupling. Against this vice little relief is offered save by the reconstruction of the receiver, or the introduction of shielding which otherwise would be wholly unnecessary. It pays to rewire a set if you have run into any of the troubles that stray magnetic coupling induce. They include poor selectivity, not enough volume, lack of sensitivity, body capacity effects and very critical tickler adjustment.

The manner of placing the coils is important, for they may be tilted at such an angle or so mounted in respect to each other that there will be no feedback discernible even on reading a sensitive meter. There are several ways of accomplishing this. The angle may be of the popular Neutrodyne inclination, 57.3 degrees, or the coils may be placed with circumferences atop each other at one point only, or right-angle mounting may be utilized. The Neutrodyne method of former days is not standard for all sets but depends on following exactly the specifications of the particular makes of Neutrodynes to which the angle was to apply. The end-on-end method interferes somewhat with the wiring scheme in the present instance, hence the right-angle manner was selected. This is very effective because of the inherent distance between the two coils. There is no coupling between stages in reverse fashion, which this objectionable stray feedback amounts to, whereby the current that should flow only with the oscillatory circuit otherwise is sent back in part to its point of origin in the set.



Illustrations by Courtesy of Radio World (New York

A view of the completed set looking at the bottom. Note the short and neat wiring.

Where Magic Is No Good

The antenna coupler, L0L1, being mounted horizontally and the interstage coupler, L2L3L4, being mounted vertically, the problem is easily solved, and the loop effect is at a minimum. In fact, with antenna and ground disconnected it was found by laboratory tests that the receiver picked up no energy, even from powerful broadcasting stations near by, and this is electrically sound. It is indeed somewhat on the order of legerdemain to be able to astound guests at one's home by operating a receiver without aerial or ground. The tincture of uncanniness that characterizes this radio potion is confirmed by the expression "phantom input" sometimes used in connection with such theatrical-like performances. Histrionically this stunt may be delightful, but from an engineering viewpoint it is very bad, because it proves that the inductances in the receiver are functioning as loops, which they should not do. A set should pick up energy only from sources external to the tuning coils—that is, either from an outdoor or indoor antenna, the latter class including the coil antenna or, as it is better known, the loop. One reason is that the same condition that facilitates

When the relative coil positions were reversed it was more difficult to pick up any energy even with the R. F. tube and aerial coupler functioning (without antenna or ground) than in the previous test.

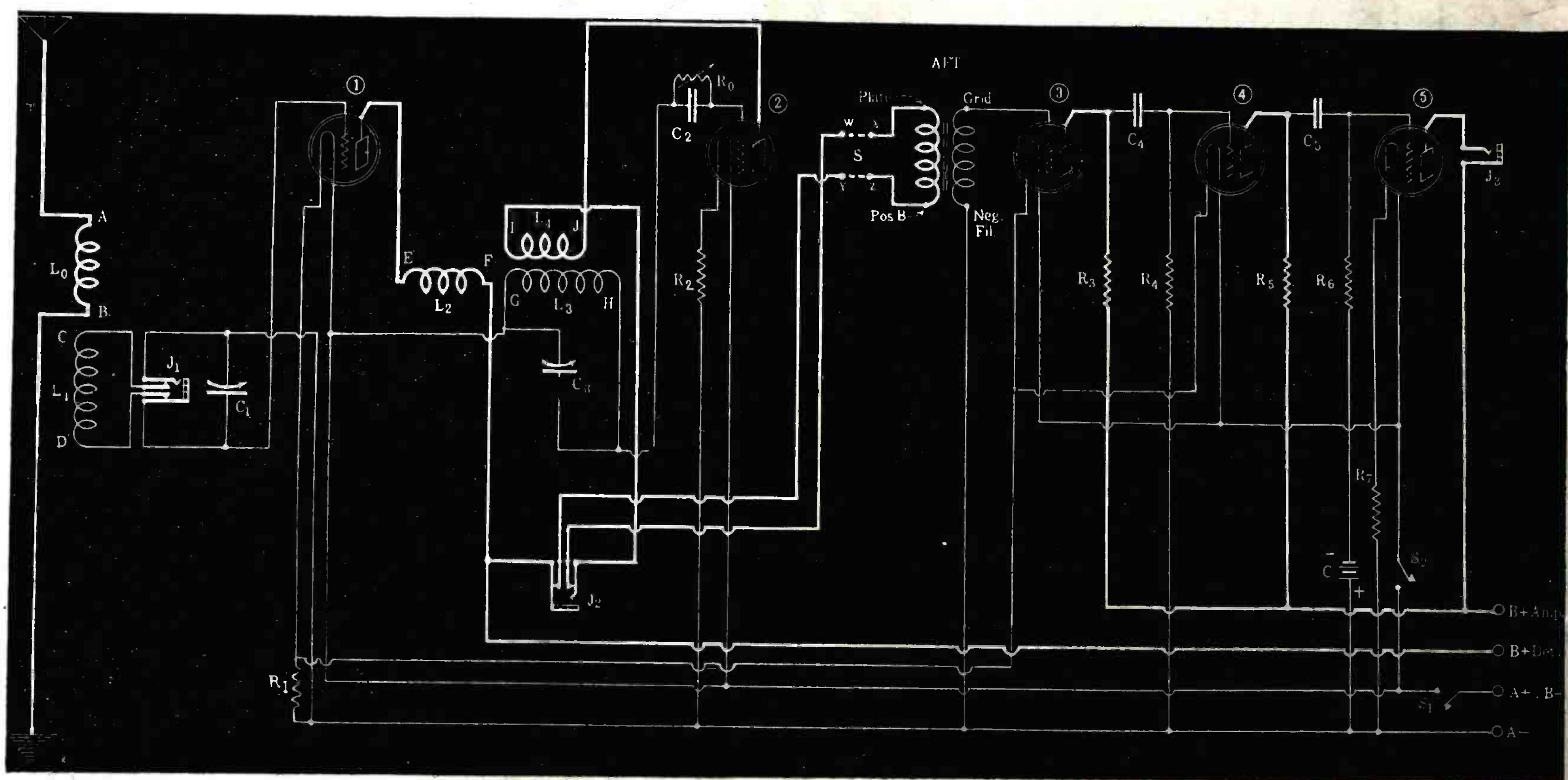
The Capacity Test

The fact that no magnetic coupling effects were produced—in fact, no injurious effects at all—in the right-angle mounting method previously described, cast the burden of proof upon the capacity coupling. Inside of every tube are the terminals of the filament, grid

not suffer self-oscillation when "B" batteries are used over-oscillate when a "B" battery eliminator is used, for the resistance of the "B" battery block has been taken out of the circuit.

Neutralization

The circuit, as shown in the diagram, has no neutralizing condenser, because none is necessary. Stray magnetic coupling being avoided, the circuit is rid of its worst possible nuisance. If the set were subjected to so-called neutralization by means of a small capacity between plate or grid of the detector



The circuit diagram of the 1926 model "Diamond of the Air" shown in schematic form with coil terminals designated by letters.

phantom reception aids squeals getting into neighbors' sets.

When placing a coil in a receiver it is well to keep in mind that if the field of the windings is in the same direction as the incoming waves from given stations, then the inductance may function as a loop. The horizontal method of mounting a solenoid puts the coil in most favorable condition for functioning as a stray loop. Naturally, if two coils are to be mounted at right angles one of them will be in a position favorable to the introduction of this vice, and although there is divided opinion on the subject among the authorities, it was found by careful laboratory tests that the detector input coil had better be mounted in the position least favorable to loop-like reception. That the burden of the problem rests here was shown experimentally by making a Diamond in such fashion as to introduce the highest possible loop effect at both points. Then, when the effort was concentrated on the interstage coupler, it was possible to receive some locals, faintly of course, without any tube being in the radio-frequency socket, indeed even with the aerial, ground and antenna coupler removed.

and plate, constituting four in all, and these are joined at the stem to the respective tips that make contact with the socket prongs. Between these elements —that is, between filament and plate, filament and grid and between grid and plate—there exists a capacity effect. It is enough in most cases to transfer quite an appreciable amount of chance energy. This is what causes self-oscillation in tubes in R. F. amplifiers, and it is this condition that the neutralizing condenser commonly corrects. But there was no injurious capacity coupling due to the R. F. tube elements in the 1926 Diamond subject to test, and no need to balance out self-oscillation, as the tickler coil that governs feedback in the detector tube also automatically functions as a stabilizer of the R. F. tube. This is due to the detector tube not functioning as an independent bulb but as a detecting device already greatly influenced by the tube ahead of it. The orthodox coupling, by means of L2L3L4, aids this effect, while the connection of the plates of both tubes to a common block of "B" batteries is an important item, too, functioning as a resistance or balancing agent. That is why some sets that do

tube and grid of the R. F. tube, and magnetic coupling existed, the set would be unstable, would radiate, despite the delicately adjusted neutralizing condenser, and would be subjected to losses. There is no objection to neutralization when stray magnetic coupling is avoided, but it is rather difficult properly to neutralize some receivers, and the set may be deprived of some of its keenness due to neutralization for some lower wave-length, like 250 meters, which is common, causing a somewhat lower efficiency on the higher waves.

Amplification of 10

The amplification produced by the tuned R. F. stage will be about 10, if the laboratory set is followed closely. This is, of course, independent of the amplification attributable to the tube, which may be rated at 6. The construction of the aerial coupler, or radio-frequency transformer, governs the coupling amplification. The coil should be low-loss, with terminals connected to proper points. The diagram of the wiring identifies these terminals by letters, but the diagram is not to be read pictorially, since the aerial coupler is shown vertical for convenience in draughtsmanship, and the interstage coupler horizontally, the opposite course being followed in actual construction.

The right-angle method of coil mounting is further justified by the experiment of removing the R. F. tube from its socket while all the rest of the set is in operation. With WEAF, 3,500 watts, only five miles away, and WNYC, 1,000 watts, about the same distance from the point of reception, no signals whatsoever were heard with the R. F. tube removed. This guarantees the absence of stray magnetic coupling. The minimum amount of capacity coupling, due to the elements of the R. F. tube, may be gauged by putting a piece of paper on one of the filament springs of the R. F. socket, and inserting the R. F. tube, which will not light under such circumstances. It was scarcely possible to hear any signal, even when earphones were used at the final output, J3.

The two stations, WNYC and WEAF, also were used in a selectivity test. Any receiver that establishes a silent point between these two stations at this particular location is bound to be selective enough for the needs of the day, and this accomplishment was easy with the Diamond. Even the low-wave-length stations, hard to separate in New York City, were cut in and out individually, without cross-talk or distant stations and by the reception of stations near by that for shielding or dead spot reasons otherwise come in very faintly, if at all. Two of these

LIST OF PARTS

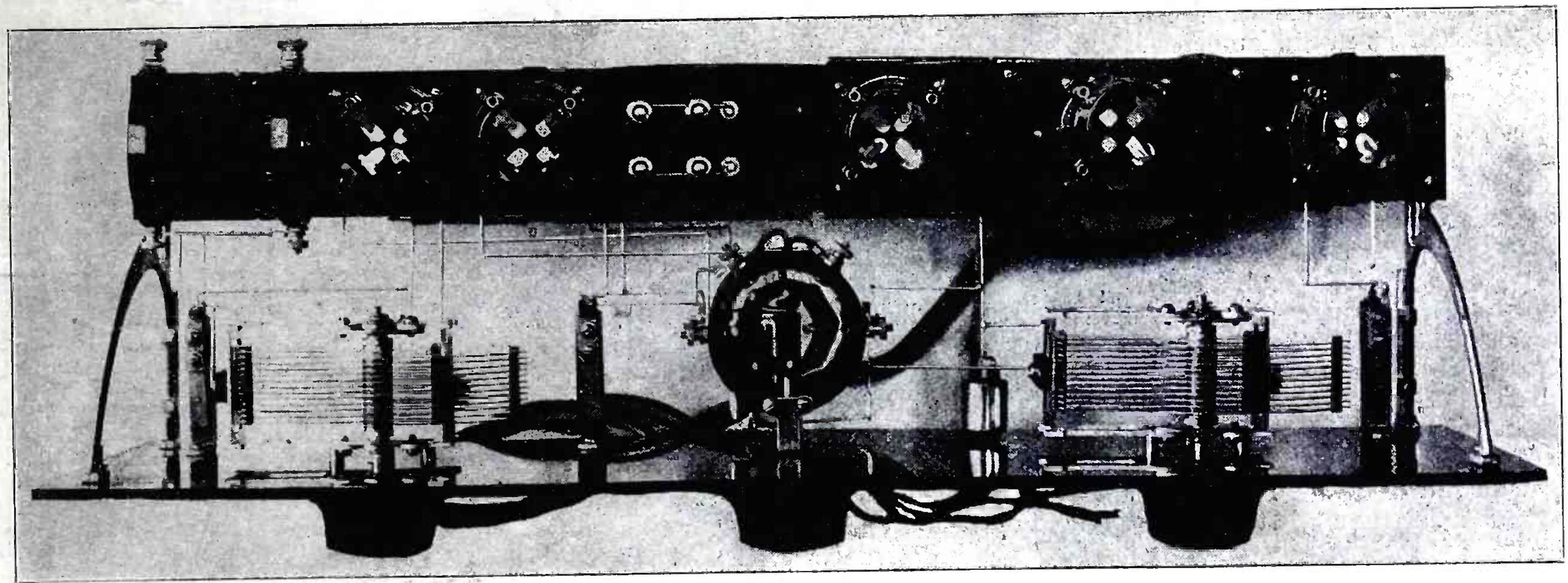
- 1 antenna coupler, L0L1 (Bruno 99 R.F.).
- 1 3-circuit interstage coupler, L2L3L4 (Bruno 99).
- 2 .0005 mfd. S.L.F. condensers, C1, C3 (Streamline).
- 2 ¼-amp. ballasts, R2, R7 (Amperites, type 1-A).
- 1 3½-to-1 A.F. transformer, A.F.T. (Thorardson).
- 1 ¾-amp. ballast, R1 (Veby).
- 2 0.1 meg. resistors, R3, R5 (Veby).
- 1 1.0 meg. leak, R4 (Veby).
- 1 0.5 meg. leak, R6 (Veby).
- 1 variable grid leak, R0 (Bretwood).
- 3 4" moulded Bakelite dials (Kurz-Kasch).
- 2 double-circuit jacks, J1, J2 (Preferred).
- 1 single-circuit jack, J3 (Preferred).
- 1 7x24" drilled and engraved panel.
- 5 standard sockets (Na-ald).
- 1 socket shelf and brackets (Bruno) (Cortland).
- 2 0.25 mfd. fixed condensers, C4, C5 (Aerovox).
- 1 5-strand multi-colored battery cable (De Luxe).
- 2 battery switches, S1, S2.
- 1 .00025 mfd. fixed grid condenser, C2.
- 4 binding posts, W, X, Y, Z.
- 5 battery cable markers.
- 10 lengths of busbar (Cornish).
- 2 flexible leads for "C" battery.

Screws, nuts, spaghetti.

Rheostats Omitted

You will notice that no rheostats are used in the model as presented. The old model was described in the September 12, 19 and 26 issues of *Radio World*, and those desiring to construct this set may consult the information therein contained, but embody the present changes. That set used two rheostats, however, and it is in the interest of simplification to omit these, and to adhere to the list of parts as published herewith. The circuit is fundamentally the same in both cases. Notice that the jack J2 is a listening post for the detector, while the detector is coupled to the audio transformer through binding posts W, X, Y and Z. By removing the bus bar from points W and X and points Y and Z it is possible to hook in an external detector at points X and Z, to use only the audio circuit of the Diamond to afford speaker volume for any other set. In that event remove tubes 1 and 2. This feature was incorporated originally and provides a ready audio hookup for experimenters who want to put some set of the moment to the audio test on the speaker.

Some fans found that volume was not quite enough when an extra resistor was placed in the plate circuit of the last tube and a condenser used to couple the tube's output to the speaker, one terminal of which went to the con-



A top view of the "Diamond of the Air" showing how the parts are mounted in the front panel and sub-panel.

other interference, except that in two instances the whistling caused by the wave of one station beating against that of another was heard. This was not due in any way to the receiver but either to the fact that the stations were too close to the point of reception, geographically speaking, to allow the spreading effect at the transmitter to settle down, or, more likely, because one or both of these two stations were off their assigned frequency.

Fine DX Reception

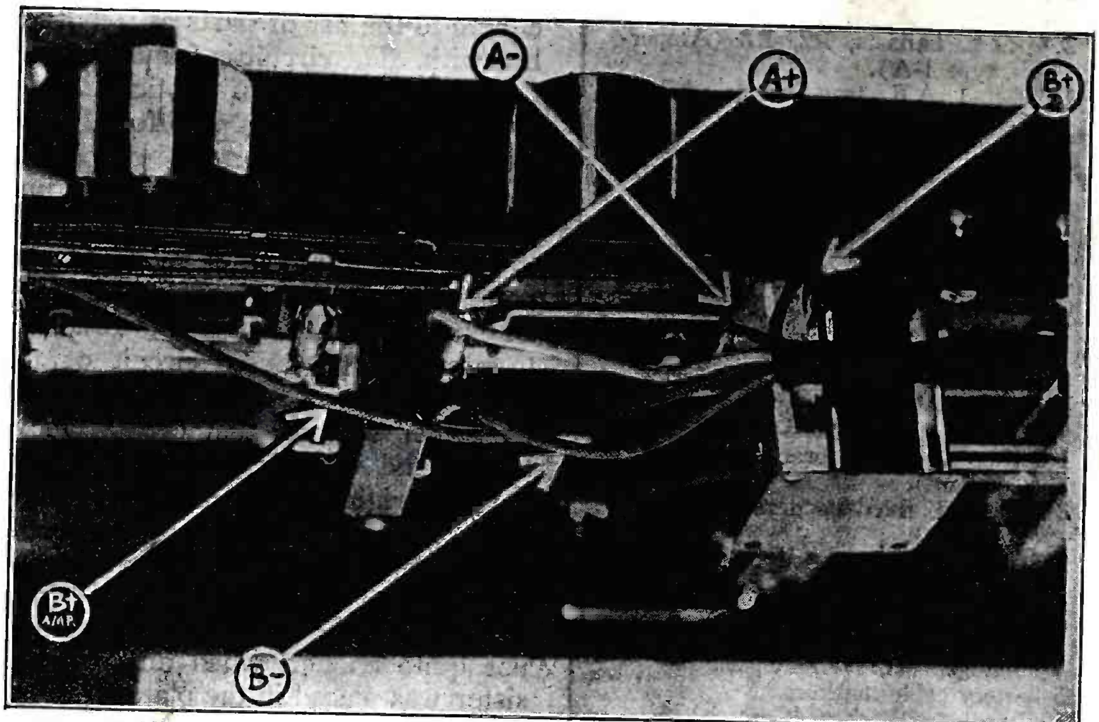
The selectivity question was settled definitely by the record of reception of are WJZ and WGBS, both of which were heard on the 1926 Diamond with good speaker volume, although most receivers will fail to pick them up at all.

The hookup as shown in the circuit diagram was found to work with splendid efficiency and proved once again that the answer to the question of adding another stage of R. F. must be no. That extra stage will introduce trouble, not benefit, unless both stages of R. F. are neutralized, in which case the extra tube simply makes up for the losses introduced by neutralization. In other words, the set as shown is superior to the regenerative Neutrodyne.

denser, the other to A minus. This is a good hookup, if the "B" battery voltage on the plate resistor is high enough, say 150 volts or more, but for fans who do not want to go that high in the investment field the standard hookup is shown in the circuit diagram on page 10.

"B" Battery Voltage

The audio hookup as shown is fairly better than the other because it has a "C" battery in the grid circuit of the last tube, an item the other hookup was intended to avoid. With the plate "B" battery voltage on in the last tube encountering only the impedance of the speaker windings and of the plate element of the tube, the net effective voltage on the plate is very much higher than if a plate resistor were used, as in the other method. Hence this high net voltage at the plate, necessary for adequate volume and quality, must be met with a correspondingly high negative bias, otherwise distortion or poor volume or both will result, due to tube overloading. Also, the actual drain on the "B" battery in milliamperes is cut down. The plate resistors, R3 and R5, in the cases of the two other audio tubes, render unnecessary the use of a "C" battery there. The 135 to 150 volts represented by B+ amp. actually amount to about 45 net effective volts at the plate, due largely to the voltage drop in the 100,000 ohm resistors. However, the current drain is no greater, usually, than by other methods of audio amplification.



The cable leads are soldered direct to the most convenient points on the set. A— goes direct to the Neg. Fil. post of the audio transformer and from that point the lead is carried by bus bar to the resistors. A+ and B— are connected to the switch S1, the glistening object shown in part beneath the by-pass condenser. B+ detector goes to the AFT post, while B+ Amp. is carried farther to the left than any of the other leads.

The B+ Det. lead should be connected to about 45 volts on the "B" battery block, and the same voltage used on the detector plate is all-sufficient then for the R. F. plate. But do not use a tube that functions best at very low "B" voltage as a detector, such as the 200, 300 and DV5. The 201A or equivalent are to be preferred for sockets 1 and 2, while in the interest of avoiding overloading the first and second A. F. tubes, sockets 3 and 4 had better be occupied by hi-mu tubes.

In the last socket one may use the UX112, the new power tube, or the 261A, the Western Electric power tube, which is hard to get. The "C" battery connections in the last stage of audio render the inclusion of the UX power tubes very convenient, and the solitary Amperite used to govern the filament heating of this tube alone enables one to use a tube requiring any filament voltage of 5 or less. Hence the less expensive so-called power tube, the UX120, drawing .06 ampere as compared with the .25 ampere of the UX112, and requiring only about 3 volts at the filament, is easily available. Instead of the 1-A Amperite, R7, the 6v-199 Amperite is used for the UX120, and an adapter is purchased for a few cents, so that the standard base of the last tube socket, in conjunction with the adapter, receives the UX base tubes.

On the subject of the two new power tubes, UX112 and UX120, the manufacturers in the circulars enclosed in the boxes containing these tubes recommend negative biasing of the grid that has proven by tests to be somewhat excessive. For instance, 22½ volts negative bias is recommended by the manufacturer for the UX120, while a negative bias of 12 volts proved best in a given case. The test was made by placing a milliameter in the plate circuit of the last tube, disconnecting one speaker cord for that purpose, and re-establishing the connection through the meter. At 12 volts the needle ceased to fluctuate, thus showing that the tube was not overloaded, whereas increasing the negative bias caused the volume to drop and the needle to wiggle. The best rule regarding negative grid bias is to do your own experimenting, using only your ear, if no meter is handy, as it seems that tubes vary in this respect, and the manufacturers' best intentions as to guiding the tube purchaser sometimes cause more hindrance than help.

Those who have no milliameter may use an ordinary voltmeter as a makeshift. The resistance of meters differs, of course, due to the difference in manufacture, but a fair though broad assertion would be that one registered volt would approximate two milliamperes. The voltmeter has to be connected in a given direction, otherwise the needle will deflect to the minus zero point, instead of giving a positive reading. Reverse the connections from the terminals of the meter. That is, the terminal you had connected to the speaker cord should go instead to the jack and the one that went to the jack should go to the free speaker cord. Then the positive reading will be obtained. The volume of the signals will drop slightly, due to the inclusion of the meter in the circuit.

The Audio Circuit

The audio circuit in the 1926 Model Diamond of the Air consists of one stage of transformer coupling followed by two stages of resistance coupling. The audio circuit comprises the main point of difference between the 1925 Diamond and the 1926 model. The gain is a good one, since the public today is showing a fine appreciation of qualitative audio amplification, which leads it away from the conventional two steps of transformer coupling.

The cable leads are tagged by metal markers at the battery ends.

Cone vs. Horn

Such good quality does this audio hookup produce that one may use the cone type of speaker without fear. Usually the cone speakers come in for condemnation from persons who do not understand the principle of their action nor the results that they are designed to produce. A cone speaker of the better type will reproduce the audio output with faithful impartiality. If the receiver is delivering fine, clear signals, such is what you will hear. If the receiver is distorting, the cone speaker will show up the distortion. In this way it differs from the horn type, which is designed to subdue distortion effects due to two-stage transformer shortcomings and produce a net result that sounds pleasing. But the cone speaker does not disguise the output.

The design of audio-frequency transformers of the better class—and that means higher price—has improved considerably within the last six months or so. But it is still characteristic of all transformers of the conventional type that they behave well on the middle band of audible frequencies but are not so good on the upper and lower frequencies. When one couples two transformer stages the defect is cumulative. It is hardly possible to achieve faultless reproduction using any two transformer stages of audio, even if the transformer in the last stage is of very low ratio.

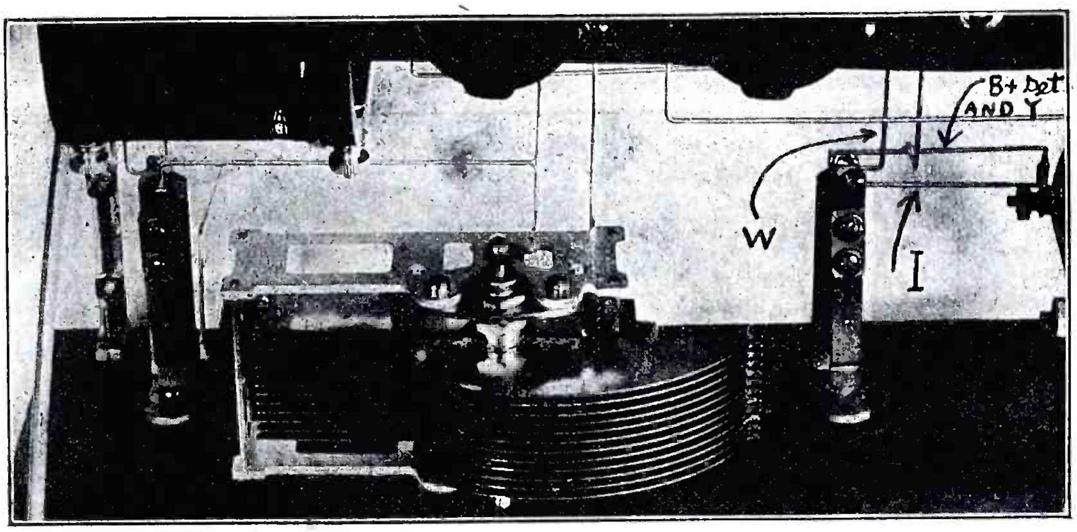
Great Amplification

Now, even where only one stage of transformer coupling is used the result still is that the lower and upper notes are not handled as well as the middle ones, but there is a great gain in volume by using a transformer in the first stage. Followed by two resistance steps, this produces quality such as to delight the ear. By meter tests, with proper tubes, resistors and coupling condensers, three resistance stages would give a flatter curve and less volume, but not show such a difference that the average ear could detect it, hence the enjoyment is just as keen and the amplification, even with ordinary tubes, is very great. With 201A tubes used throughout the audio amplifier, the last grid properly biased, the amplification is more than 450, while with 201A in the first A. F. stage, hi-mu in the second and a power tube in the third it is more than 1,000. This is a very considerable increase in volume. It may be further enhanced, without fear, by using a hi-mu tube in the first transformer stage.

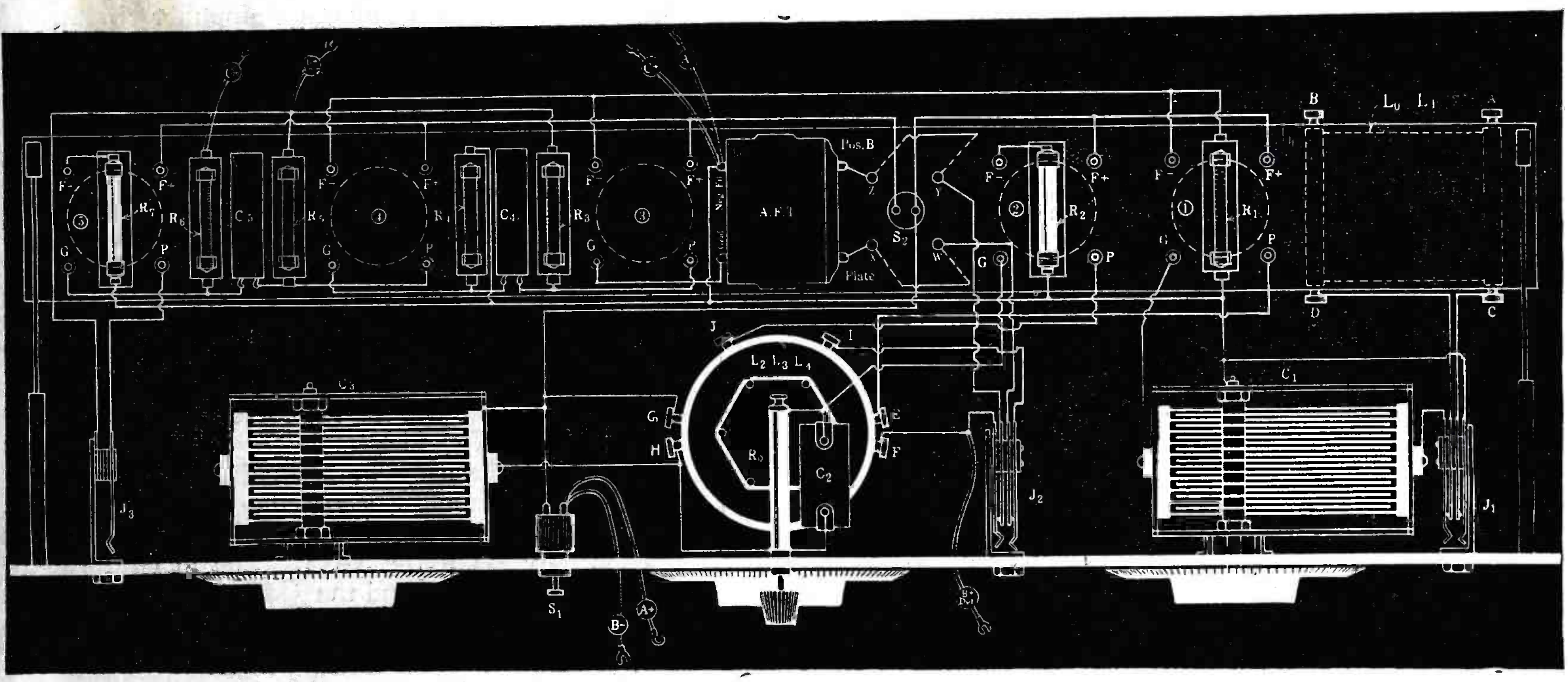
The transformer method therefore becomes risky only where two such stages are used, so that the second stage contributes its own shortcomings while amplifying those of its predecessor.

There is no volume control in the set. No rheostats are provided and hence these may not be used for volume control, nor should they ever be, so long as they are connected to govern the heating of the tube filaments. If a rheostat is used in series with a plate circuit that might be a different story.

But in the present case, assuming correct bias on the final grid, and preferably the use of a power tube in the last stage, such as UX112, 6 mu, Western Electric 216A, VT2 or UX120, the set will handle all the volume easily. It is assumed that most persons want to have the signals as loud as possible without distortion, and such can be accomplished by this set. The volume is particularly attractive when one listens to orchestras and bands, for if these are subdued they lose their zest. The volume, therefore, will depend on the intensity with which signals are receivable from given stations, and this will vary even among local stations, while it will be possible to hear on the speaker any station that one might hear on earphones plugged into the detector output.



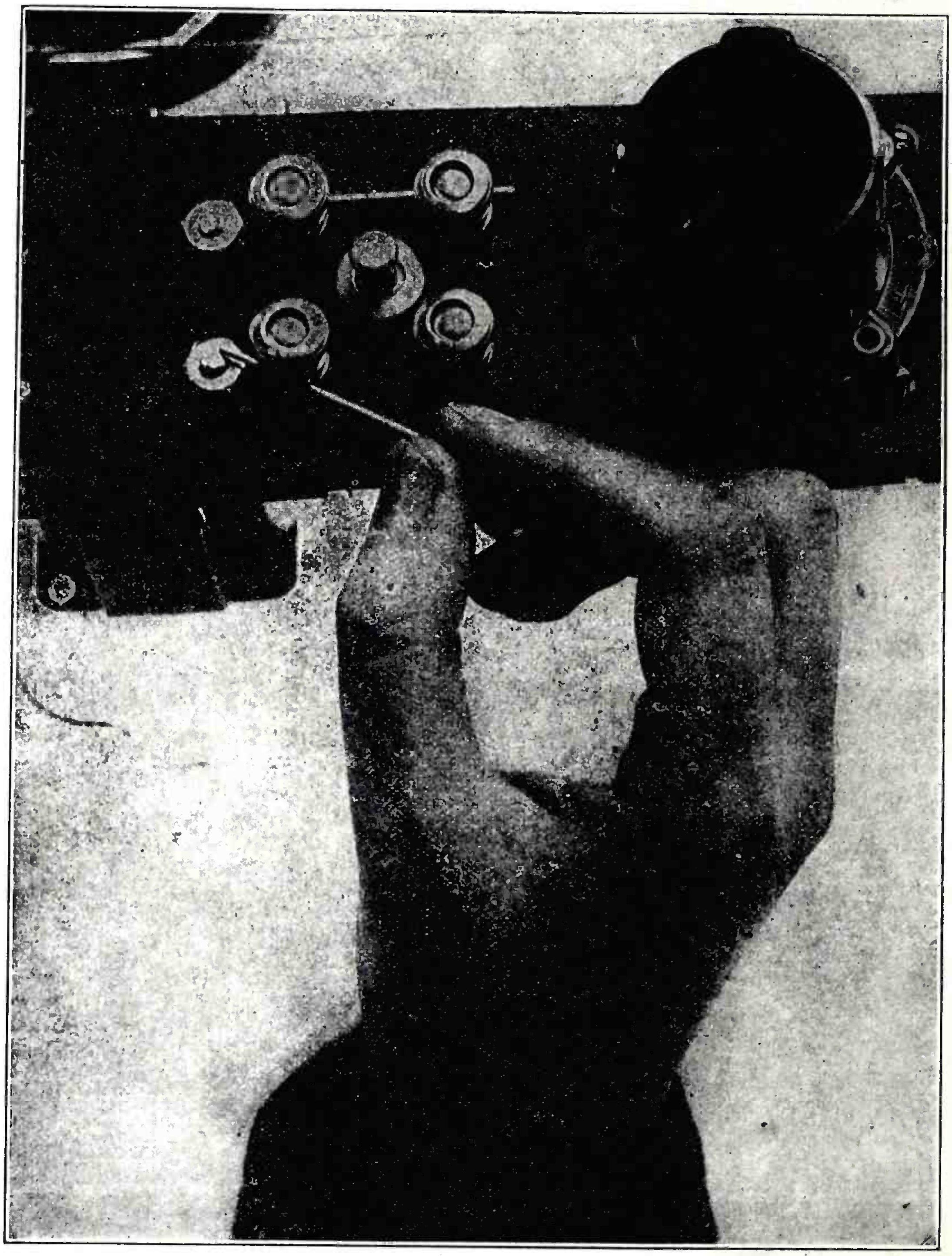
Detail showing how jack J2 may be wired with only three connections instead of four.



A blackprint showing the layout and wiring. Connections are marked for indication.

Capacities Important

In keeping with the design of the audio hookup along quality lines the coupling condensers, C4 and C5, shown in the schematic wiring diagram in blackprint form on page 10 and layout wiring diagram, should be large. The capacity often used for this purpose is .006 mfd., but this is not large enough, since a lower impedance is necessary, to avoid consequent distortion. At the lower audible frequencies the .006 mfd. coupling condenser will show a steepness in the curve of voltage amplification plotted against frequency. The use of too low a capacity here has given rise to the belief that resistance amplification is not the enemy of distortion that it is advertised as being. We are on the safe side, indeed, if we use 0.25 mfd. It is wrong to venture below .05 mfd.



A sectional view of the set described herewith. The strap of bus bar across binding posts Y and Z is being removed. The switch S2 is shown in the center of the four binding posts. The other switch S1 (not shown) which controls the entire set is mounted on the panel.

The Resistors

The resistors used in the plate and in the grid circuits (called leaks in the latter instance) must be of good manufacture. The plate resistors serve the purpose of providing a means of maintaining a potential difference, so the audio fluctuations may take place. The audio signals are, of course, alternating current. A value of 0.1 megohm (100,000 ohms) is correct here, and the same value prevails in any step of resistance coupling. The resistance must be high enough to establish a sufficient divergence in potential and yet not so high as to whittle down the effective voltage applied at the plate to well-nigh the zero point. The voltage drop in 0.1 megohm resistor is large enough. Reckoning the direct current resistance of the plate of the tube along with the resistor's resistance, the total impedance is sufficient to cut the net B voltage, as applied to the plate of the tube, by almost 75 per cent. This is not to be rated as a total loss, since the entire difference is not dissipated in the resistor.

The Leaks

As for the leaks in the audio circuits, these are fixed, and they are R4, which is 1.0 megohm and R6, which is 0.5 megohm. The higher resistance is used in the first stage so that the leakage path will be less, because in this stage little or no excessive voltage is to be expected, while in the last stage the lower resistance is used so that the leakage path will be more rapid. If both of these leaks were less than the smaller of the two, say 0.25 meg. (250,000 ohms), there would be a still more rapid grid-to-filament leakage in both stages, the volume might be a little less, but there would be no impairment of quality. Thus any one having leaks of a lower order than those specified may embody them in the circuit in line with these suggestions as to the right direction in which to proceed. Do not use higher value resistors than those specified, however.

The Grid Bias

The biasing battery in the final grid circuit of the audio hookup is important, as the milliameter test, or makeshift voltmeter test, described previously, will prove. The sharp voltage reduction due to the plate resistors, and the presence of the two leaks, eliminate the necessity of otherwise biasing the first and second audio bulbs. The final plate, however, has no such resistor in its circuit, hence, if 135 volts are used for B plus amplifier, the same general rules for biasing will obtain as in the case of any other amplifier circuit. If a power tube is used the bias will have to be greater. The manufacturers give data on the subject in the circulars they enclose in the tube boxes, but as pointed out previously, these data are not always controlling, especially in regard to the UX120.

The Correct Amperite

The Amperite, R7, which governs the filament heating of the last tube, if a UX120 is used in that socket, should be the 120, style Z, mounted, while for the UX112 the correct Amperite is the No. 112, style Z, mounted. Those desiring to use either of these tubes should specify the correct Amperite. The 216A requires the No. 1 Amperite, (not the 1-A). The general run of hi-mu and mu (last stage) tubes takes the 1A Amperite.

Transformer Connection

In connecting the audio circuit, although the transformer shows a designation "Neg. Fil.," the lead should not go to the negative filament but to minus A. The diagrams show the correct connection. The leak R4 helps keep the second AF grid slightly negative, the bias being equal to the voltage drop in between the two ends of the leak. As there is no resistor in the grid circuit of the first AF tube, it is well to take advantage of this slight biasing effect by establishing the potential difference across the secondary of AFT.

Use With External Detector

The audio circuit of the 1926 Diamond may be used in connection with any external detector circuit, or the earphones may be used at the detector output of the Diamond, and the audio tubes extinguished by means of the switch S2. This switch is located on the socket strip, in the center of the four binding posts W, X, Y and Z. A view of a section of the receiver shows the first AF socket at right with the binding post arrangement between this socket and the audio transformer. A short length of bus bar is used to connect W and X and another piece for connecting Y and Z. As the set nearly always will be used to run a speaker, these "straps" of bus bar are left in that position, not to be removed unless some external detector circuit is to be incorporated for test purposes. This feature was included as an aid to experimenters who, trying out some hookup new to them, would like to hear how it sounds on the speaker. If a crystal rectifier is used in this experimental detector circuit, then both straps would be removed in every instance. But if a tube detector is present in the test hookup, the B plus connection thereto may be used right from the Diamond, only the strip WX need be removed, the plate of the experimental circuit being joined to X.

When the audio circuit is used in conjunction with another detector circuit the two tubes in the RF circuit of the Diamond will have to be removed from their sockets (1 and 2). As this experimental feature will not be used steadily it was not necessary to incorporate another switch just to "put out the lights" in these two instances.

Wiring Kinks

Even the novice should have no trouble in constructing the 1926 Model Diamond of the Air. The chief difficulty to be expected might be magnetic interplay, but the arrangement of parts prevents this, and the diagram as shown pictorially herewith should be followed exactly. You can see where each wire goes. Moreover, the parts appear just as they are in the same relative positions as on the original laboratory model. Except for elucidation of a few points the fan can go right ahead with utter safety. The results obtained by others can be duplicated by any one, under like conditions, simply by following the pictorial plan.

Coil Terminals Explained

The coil terminals in the schematic diagram are clearly designated by letters, the same ones used in the picture diagram shown on page 13. These should be followed without alteration, except that I and J may be interchanged. The coil terminals are as follows:

A is the beginning of the aperiodic primary Lo, in the antenna circuit and is connected to aerial.

B is the end of that winding and goes to ground.

C and D should be watched carefully, as their source may be lost in the confusion of jack wiring. C is the beginning of the secondary L1, and is that terminal of the secondary which adjoins the end of the primary Lo. In the laboratory receiver the Bruno coils were used, and these have binding posts on them, to which the coil terminals are secured. The wire terminals are not brought to the nearest binding posts, but the wire is turned back, so that the winding is thus given added support, hence this is something to watch in determining the beginning and the end of a winding. It is easily done at a glance, but might be overlooked unless attention were called to it.

C is the beginning of the secondary winding and goes to that inside spring of the jack which ultimately connects to minus A when the jack is closed.

D is the end of the winding and makes connection to the other inside spring of J1, which ultimately goes to grid. Trace this carefully. Note that the rotor plates of C1 connect to that terminal of the coil which goes to A minus, i. e., terminal C.

E is the beginning of the RF plate coil L2 and connects to the plate of tube 1.

F is the end of L2 and connects to B plus 45.

G is the beginning of the detector input secondary L3 and connects to positive A. The rotor plates of C3, the only other tuning condenser used, go to this lead, too.

H is the end of the secondary winding and goes to one side of the grid leak-condenser combination. The other side of this combination goes to the grid post of the detector socket. An excellent precaution is to connect the grid post of the socket to the lug of the Bretwood variable grid leak farthest from the panel, while the lug close to the panel goes to the other side of the grid condenser and to the stator plates of C3. This is shown in the picture diagram herewith. The H terminal goes to the stator plates of C3, the connecting point being a lug on the insulation strip on the right-hand side of the tuning condenser. The connection to the rotor plates of C3 is made by soldering the lead from G direct to the condenser frame.

As for the tickler coil, since its angle of variation is very wide, there need be no special precaution about this wiring. As the flexible tickler leads on the coil are easily reversible, one may wire the tickler either way, reverse as a test, and retain that manner of connection which affords best results. Normally the same effect may be had with either method, because the reversal of current flow can be accomplished by turning the tickler out of its positive angle of variation into the negative angle.

The panel view of the 1926 "Diamond of the Air." The layout of the tuning controls, jacks and battery switch is evenly balanced.

The Binding Posts

The schematic diagram on page 10 may be slightly confusing on one point. The binding post switch method used between the detector and the audio circuit calls for the joining of two pairs of posts by two separate little pieces of bus bar, called straps.

The diagram shows the bottom view of the set, as all the wiring is underneath, except for the two straps, so these are so shown projected from dotted lines. The binding posts referred to are W, X, Y and Z.

The jacks are shown mounted sideways. This makes it easier to read the connections. Also, the actual construction by that method will make it possible to tell at a glance whether there is a short in a jack, which would be hard, indeed, to find out by the aid of the eye alone if the jacks were mounted conventionally.

Reconciliation

The battery cable leads that project in the foreground of blackprint diagram, of course, actually are brought to the rear and through a hole in the cabinet to the proper battery connections. They are shown forward because to bring them across the wiring would obscure the diagram.

"C" Battery

At extreme right and left are the brackets. The socket strip is not wholly supported by these but would sag in the middle were it not for the support contributed by the audio transformer.

The C minus lead is shown emerging from the same point where A minus is introduced through the battery cable. The distance between C minus and C plus may be cut down, if desired, by making the C plus connection at some point farther to the left in the diagram. C plus and C minus are shown with lug connections, but these are not necessary, the bare ends of wire, where the insulation has been scraped off, being just as good.

Wiring Directions

Join A plus to one side of the switch S1, the other side of that switch to the one side of the switch S2. The other side of S1 goes to the F plus post of the R. F. and detector sockets (1 and 2). A minus goes to one side of R7, to one side of R2 and to one side of R1. The other side of R7 goes only to the F minus post of the last audio socket (5). The other side of R2 goes only to the F minus post of the detector socket (2). But the other side of R1 goes to three points. They are the F minus posts of the R. F., first audio and second audio sockets (1, 3 and 4). The open side of S2 goes to the F plus posts of the three audio sockets (3, 4 and 5).

This completes the "A" battery wiring, but as grid returns go to these leads, connect them next.

Coil Connections

C terminal of L1 goes through the jack J1 to minus A. Do not connect this to F minus on the socket. G of L3 goes to A plus at any convenient point. This may be even to F plus on any socket, since A plus and F plus are the same, there being no resistor in the positive leg in any case. The end of the transformer secondary, marked Neg. Fil. on the instrument, goes instead to negative A battery, as shown in the diagrams. The leak R4 goes to negative A, also, while R6 goes to minus C. The plus C post is joined to minus A.

Connect antenna to A, ground to B. That disposes of Lo. Connect C to one inside spring of the jack J1 and D to the other inside spring. Then carefully see that the outside terminal of the jack that contacts with C goes to minus A and to rotor of C1, while the other outside terminal goes to grid of the socket 1 and to stator plate of C1.

Connect plate of the R. F. tube (1) to E, the beginning of L2, while the end of L, marked F on the diagrams, goes to B plus detector voltage. This is normally 45 and may be made to the frame of the jack J2. G terminal of L3 goes to A plus, H to one side of the grid condenser C2. The other side of the grid condenser is connected to the G post of the detector socket (2). G also connects to the stator plates of C3, the rotor plates of which go to A plus. The variable grid leak Ro is connected across the grid condenser, the lug near the panel being joined to the H post of the coil and the other leak lug to the grid condenser, on the side of that condenser other than the one joined to the socket post.

The plate of the detector tube (2) goes to one terminal of the tickler L4, the other terminal of L4 to the only remaining outside spring of the jack J2. The other outside terminal of the jack went to B plus detector.

The inside spring of J2 that contacts with the outside spring that went to the end of the tickler coil goes to binding post W. The inside spring of J2 that contacts with B plus detector goes to binding post Y. The gaps between W and X and between Y and Z are bridged by two separate short pieces of bus bar tightened under the bolt of the post. The dotted lines project those bus bar strips in the diagram. The straps are atop the socket strip. All the other wiring is beneath, which accounts for the right-to-left order.

Post X is joined to the plate post of AFT, while post Z goes to the B post. Grid of AFT connect to grid of the first A. F. tube (3) while the end of the secondary, marked Neg. Fil. on the instrument, goes not to negative filament but to A minus. This particular lead was established previously.

The plate of the first A. F. tube (3) goes to two points. They are one side of the plate resistor R3, and one side of the blocking condenser C4, which is of the bypass type. The other side of R3 goes to B plus amplifier, normally 135, while the other side of C4 connects to the open end of the leak R4, and also to the grid post of the second A. F. socket (4).

The plate of this socket is connected to one side of R5 and to one side of C5, while the other side of R5 goes to B plus amplifier voltage and the other side of C5 to the grid of the final tube and to the open side of R6. The closed sides of R4 and R6 previously were connected, the one to minus A, the other to minus C.

The plate of the last tube (5) goes to one side of the single-circuit jack J3 and the other side of that jack goes to B plus amplifier.

Uses of Fixed Condensers

MANY radio fans do not appreciate the importance of the small fixed condenser, and too often dismiss it as a mere accessory when constructing or installing a radio receiver.

The fixed condenser, unimpressive and diminutive as it may appear, is really an extremely necessary device and often occupies strategic positions in a circuit. Its absence or incorrect use at certain points may, in fact, seriously handicap an entire receiving set.

The most common use of the fixed condenser is in the grid wire of the detector tube of a receiver. This application every radio fan is familiar with, but there are other important usages which are not quite as well known.

A fixed condenser connected directly in the aerial circuit will invariably cure a condition of strange silence that many regenerative sets suffer from on short waves. The phenomenon is due to a peculiar resonance effect of the aerial on the low waves, and what the condenser does is to artificially reduce the electrical size of the antenna so that the effect cannot appear on the broadcasting wave-length range. The device should be .00025 mfd. in size or smaller and is most conveniently placed between the ground post of the set and the ground wire itself.

In a neutrodyne or similarly tuned radio-frequency set condensers of one-half of 1 mfd. value, wired between the bottom ends of the transformer primaries and the plus wire of the "A" battery, help greatly in making the set stable and free of undesired oscillation. Many receivers of this type, which ordinarily squeal and whistle badly, are quieted down immediately when such condensers are inserted in the circuits.

The quality of many amplifiers can often be noticeably improved with the aid of a few fixed condensers placed across the primaries or secondaries, or both, of the amplifying transformers. —*N. Y. Herald Tribune.*

The Arkay Radio Frequency Set

Employs One Stage of Tuned Radio Frequency for Distance and is Selective for Local Reception

REQUESTS from many radio set builders to give a detailed description of the new Arkay four-tube receiver have been received, and in response to this request we are giving herewith a description and constructional details of the Arkay set as written by *Albert E. Sonn* in the *Newark Sunday Call,* Newark, N. J. This circuit was developed by John Ruckelshaus, a radio engineer and inventor of Newark, and was published some time ago in newspaper radio sections. Important changes and several improvements in the old circuit have been made and the information is passed along for those who want to build an excellent receiver for the home. The outfit will give volume equal to any five-tube receiver and is very sensitive to weak signals. Mr. Sonn describes the set as follows:

A stage of radio frequency, detector and two of audio are employed in this circuit. No "trick" wound coils are employed. Single layer inductances which can be constructed at home are ample. The two dials may be logged and after a short time the owner should be able to pick up many stations throughout the country. The set is quite selective and it has been possible during the tests to log DX through a great many locals.

The following stations were logged on an improved Arkay circuit by William Stoll of Bloomfield, N. J. This will give some idea of the range of the receiver during the cooler weather. Mr. Stoll employs an indoor aerial 30 feet long in the form of a 6-inch 4-wire cage in his attic.

WCK—St. Louis, Mo.
KFKV—Butte, Mont.
WLCL—Northfield, Minn.
KFKX—Hastings, Neb.
WABI—Bangor, Me.
WBAP—Fort Worth, Tex.
KFI—Los Angeles, Cal.
KFNF—Shenandoah, Iowa.
WOC—Davenport, Iowa.
WFAA—Dallas, Texas.
KFKB—Milford, Kan.
WDOD—Memphis, Tenn.
CKCL—Toronto, Canada.
WMBF—Miami, Fla.

Another radio fan in Maplewood reports picking up KDKA, WBZ, WGY, and a Chicago station during the afternoon. The writer actually tuned in KDKA and WGY on a loud speaker at 3 o'clock in the afternoon on this set. Conditions for reception and the location were ideal at the time.

R. F. Input Circuit

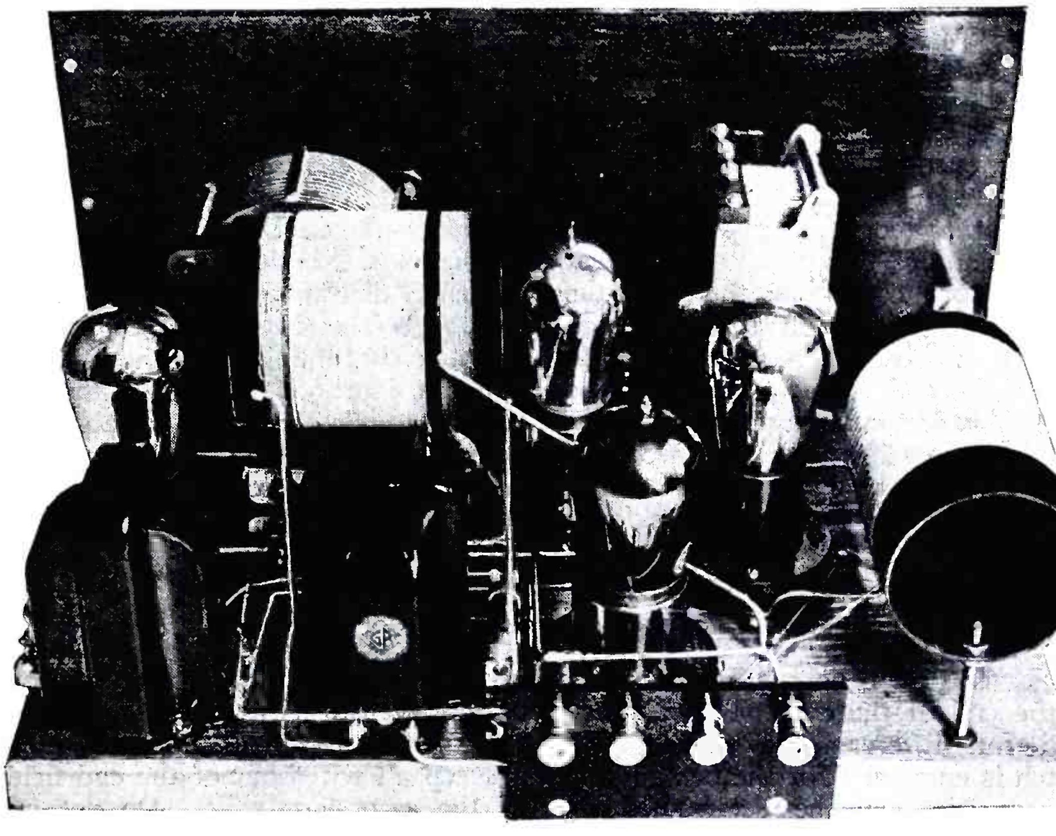
Unlike the majority of tuned radio-frequency receivers of the neutrodyne type which make use of an "untuned primary" coil underneath or alongside of a secondary, the improved Arkay circuit, which is being described, employs a tuned primary coil directly coupled to the antenna circuit through a series condenser. In this manner a greater radio-frequency amplification per stage is obtained than with the untuned primary coil. The latter system is not as efficient as the former, due to the losses which occur in coupling. The single circuit idea appears to have considerable merit, and actual comparisons seem to favor this form of tuning for R. F. work.

Radio fans who were owners of single tube "single circuit" receivers will recall the remarkable distances covered with this type of set compared with a receiver making use of a coupler having separate primary and secondary winding. The former outfit, while not much on selectivity, certainly took the prize for sensitiveness. This circuit employed as a R. F. amplifier carries with it the efficient qualities of the one-tube set.

Following is a list of parts required to complete this set. The choice is left to the builder, although the parts employed in receiver shown in photo are listed.

1 Panel, 7x14 or longer.
1 Baseboard to suit panel.
5 Binding posts.
2 General Radio .0005 variables.
4 G. R. 201-A sockets.
2 G. R. audio transformers; 1-6 and 1-2.
1 Daven mount and ½ ampere resistance.
4 201-A tubes.
1 Micadon .00025 and 5 megohm leak.
1 Micadon .002.
2 3-in. tubes, 4½ and 3½ inches long.
1 Binding post strip.
2 G. R. 30-ohm rheostats.
1 Single jack, filament control or cut-off switch.
6 lengths of bus bar wire.
2 4-in. dials.

All of the above parts are considered very high grade and have proven highly efficient in the set shown herewith.



Illustrations by Courtesy of Newark Sunday Call (Newark, N. J.)

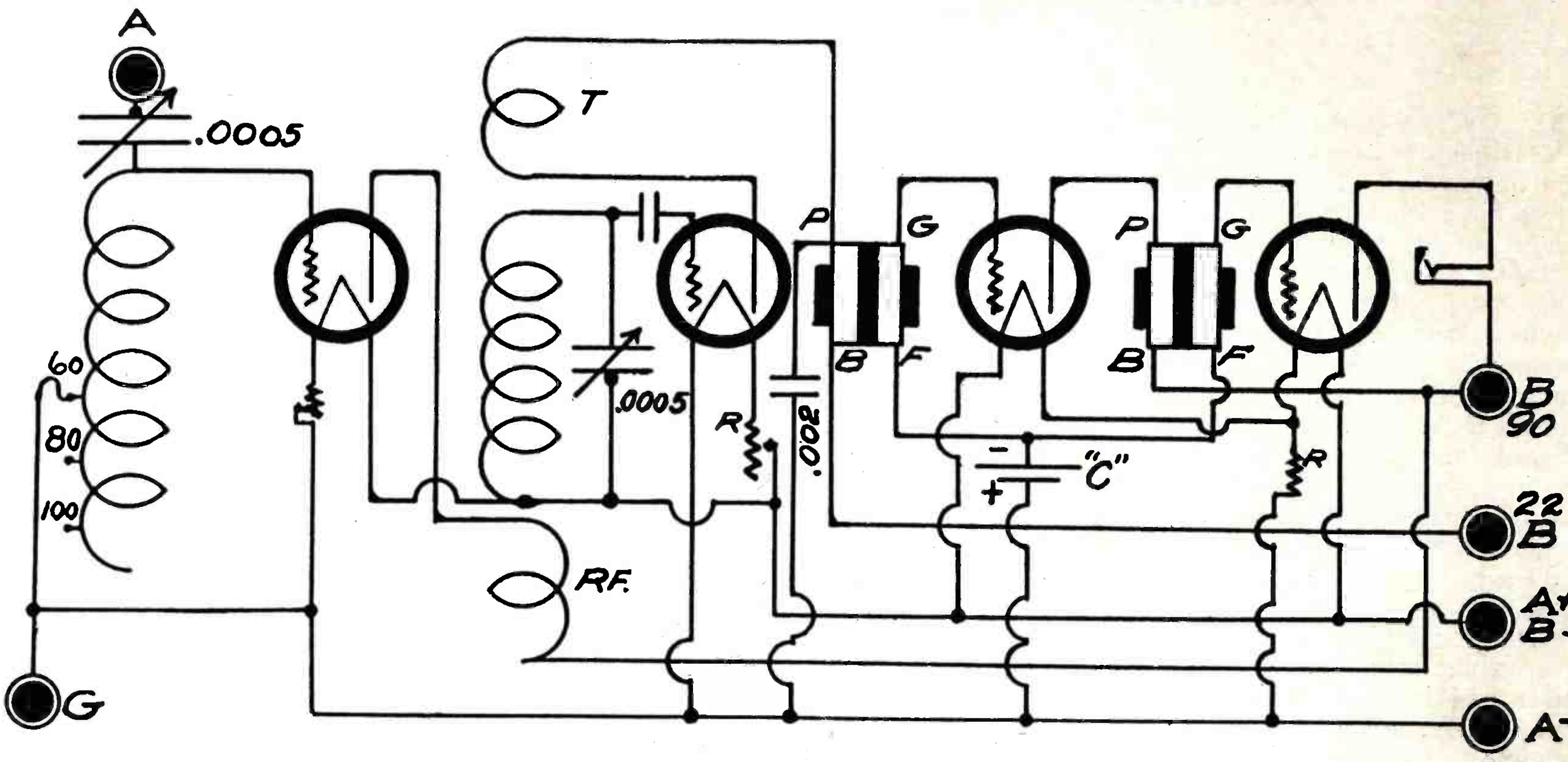
Back panel view of the Arkay set showing how the parts are assembled and wired. It is advised to follow the same layout, as it appears to be the most satisfactory arrangement.

Making R. F. Coil

The radio-frequency coil is easy to make and consists of a single layer of wire wound on a cardboard or bakelite tube. The lighter the tubing, the better. The coil employed in the set built by the writer was 2½ inches in diameter and 5 inches long. As it may be difficult to get tubing of this size, it is suggested that a 3-inch tube be used in holding the wires in place. Two small holes will be satisfactory for holding the start and finishing wires. Leave at least an inch for connections.

Then skip about one-quarter of an inch and in the opposite direction wind the secondary of forty-five turns of tube both have separate 30-ohm resistances. The amplifying tubes are controlled through a Daven ½-ampere resistance unit in a grid leak mounting.

Four G. R. side wiping contact sockets were chosen for this set, one of which was used without the metal



Schematic wiring diagram of the Arkay set. Follow each and every connection carefully if best results are to be expected.

its place. Start about half an inch from one end of the tube and wind sixty turns of No. 22 D.C.C. wire, taking a tap or loop at this point. Continue winding, taking another tap at the 80th turn, completing the coil at the 100th turn. Make sure to leave about an inch of wire at the beginning and end of the coil for connections. The coil should be mounted above the baseboard of the set on blocks of wood or by means of small brass rods. The coil end should point toward the front panel and be placed to the right of the baseboard, as shown.

This coil is tuned by means of a .0005 mfd. variable condenser, which is mounted on the panel a little to the left of the end of the coil. The taps are used for different size aerials. No switch is employed for the taps, as the proper point will be determined by trial.

Secondary Coil

The secondary coil has three separate windings. On one end is the R. F. "reversed coil," in the center is the secondary, which takes up most of the space, and on the remaining end is the detector plate coil. The secondary coil as well as the other two small coils are all wound with No. 24 D.D.C. wire. A quarter and an inch separation is left between each winding on this form.

Starting one-quarter of an inch from one end of the 3-inch tube, which should be 3½ inches long, wind tightly fourteen turns of wire, making provision at the beginning and end for wire. Leave another quarter of an inch and wind in the same direction the detector plate coil of nine turns. This completes the entire inductance.

The secondary coil is mounted in the opposite direction to the radio-frequency coil and at least five inches away, so that the fields of the two coils will not interlock. Back of the secondary coil is the .0005 variable condenser used in tuning.

The coil may be mounted on the condenser end plate provided the condenser has an insulated form. The condenser used by the writer is a .0005 General Radio straight-line wavelength type, having a hard rubber end plate. Or the coil may be supported by means of the bus-bar wires which connect to the coil's six terminals.

Keep all wires out of the end fields of the secondary coils. Do not run wires through the coil or across the ends. Run them away from the windings rather than parallel or too close.

Compact Set

The set constructed by the writer is somewhat compact. It was made to take up as little space as possible. Some builders would prefer to arrange their apparatus on a longer baseboard and panel. This will not alter the set and the advantages gained by spreading the instruments out may be worth the effort. The panel employed is fourteen inches long and seven inches high. The panel contains two 4-inch G. R. dials and two 30-ohm rheostats. The radio-frequency tube and the detector shell in the radio-frequency circuit. The shell was removed on account of it being too close to the R. F. coil winding and the antenna condenser. It is a bit "risky" to insert the R. F. tube in the socket without the shell unless you are sure of the proper way to twist the tube.

Four Binding Posts

Battery binding posts are mounted on a small panel to the rear of the baseboard. There are four in number, positive B amplifier, detector B, plus A, minus B and negative A, which is also ground. The antenna post is mounted on a separate small panel away from the battery and ground binding posts. This connection is brought out on the side near the antenna-tuning condenser. The antenna connection is run to the rotor plates of the .0005 condenser.

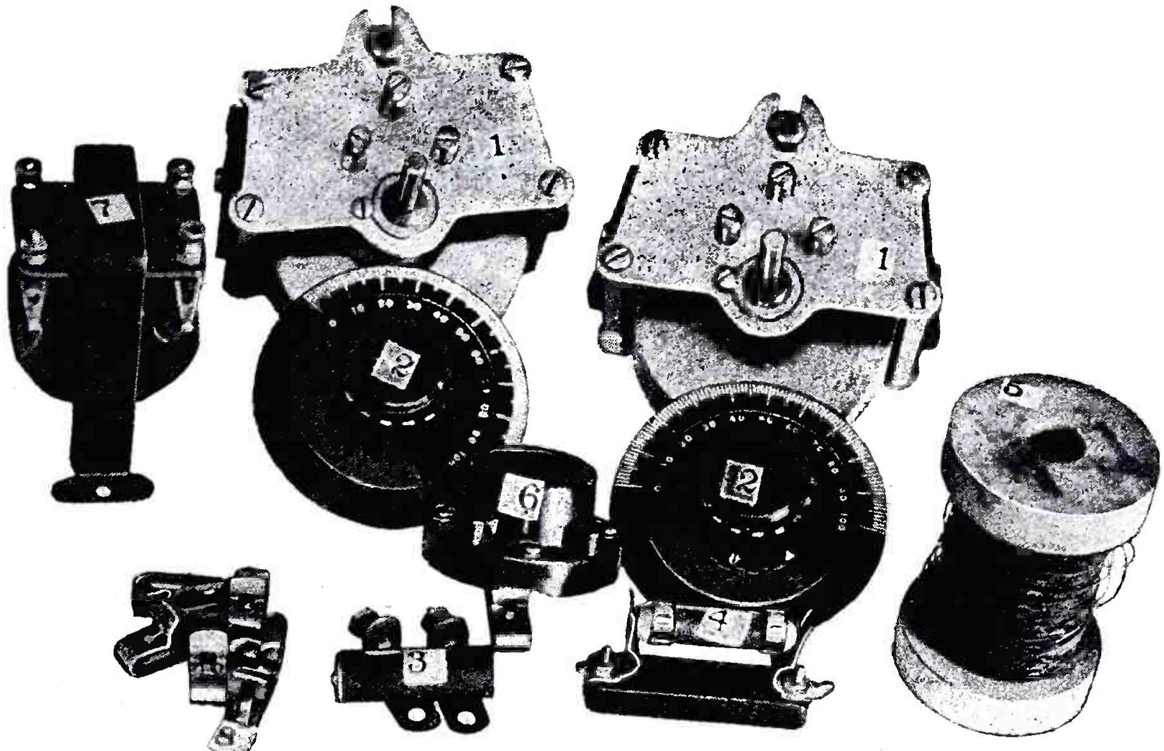
The by-pass condenser .002 is connected between the detector plate coil-winding and the negative "A" battery wire. The .00025 grid condenser is mounted close to the detector tube socket underneath the secondary tuning coil.

A single circuit jack with filament control can be employed for the output or a "cut-off switch" may be mounted on the panel for extinguishing the filaments. The two audio transformers are mounted at right angles to each other. The shielding will allow them to be placed close together in case the set is made compact. The baseboard is 9 inches deep.

The One-Tube Knockout Receiver

How to Build a One-Tube Reflex that Gives Unusual Volume

ATTEMPTS to operate a loudspeaker consistently on one tube have met with indifferent success, although a number of circuits will accomplish this result under good conditions and where the receiver is located near a fairly powerful broadcast station. We have seen so many failures along these lines that we look with a wary eye on any new ones. *Zeh Bouck,* however, in an article in *Radio Broadcast,* New York, has described a one-tube receiver that gives far more than ordinary volume. Probably our interest in this receiver is due to the fact that its designer does not make extravagant claims. You may not be able to work a loudspeaker efficiently under all conditions, but it should be no difficult matter if a broadcast station is close by, and at all times you will be assured of good volume on the phones. Mr. Bouck apparently has managed to get about everything possible from a small tube. His description of the set follows.



Illustrations by courtesy of Radio Broadcast (New York)

Fig. 1. The purchased parts that go into the construction of the one-tube knockout receiver.

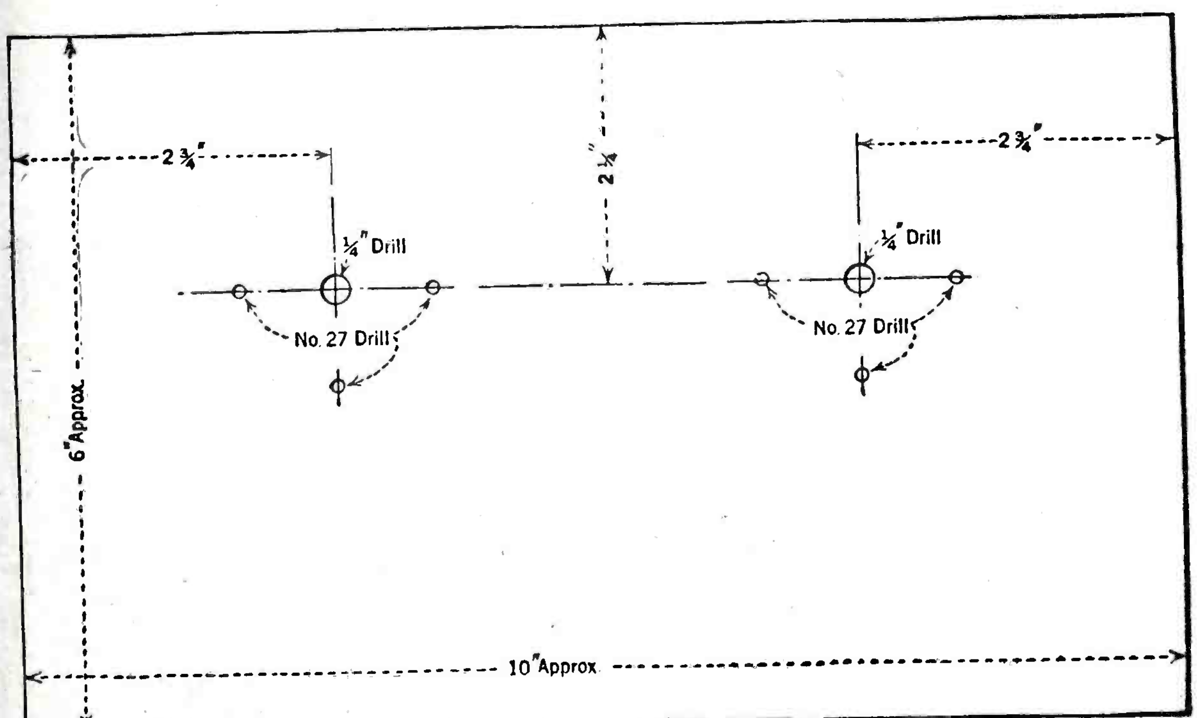


Fig. 2. The layout of the cigar box panel. The screw holes for the condenser are placed with the aid of the template furnished with the condenser.

Though this receiver may appear rather complicated to the inexperienced fan, he will not be over taxed in its design and construction. The photographs and drawings illustrate very clearly the manner in which the set is assembled, and we shall endeavor to make these points still more plain in our descriptions.

List of Materials

In Figure 1 — Description

No. 1 — 2 Variable condensers, .0005 mfd. (Hammarlund, $5.00 each)

No. 2 — 2 3-inch dials (5 and 10 cts. store at 10 cts. each)

No. 3 — 1 Crystal detector, preferably fixed (Pyratek with mounting, $1.25)

No. 4 — Rheostat, Amperite, or Daven Ballast for tube used (Daven Ballast with mounting $1.00)

No. 5 — ¼ pound of No. 22 s. c. c. or enameled wire (5 and 10 cts. store, 25 cts.)

No. 6 — Socket for tube used (5 and 10 cts. store, for UV199, 20 cts.)

No. 7 — Audio amplifying transformer, ratio about four to one, such as the Rauland-Lyric, Acme, General Radio, or Amer-Tran (Amer-Tran, $7.00.)

No. 8 — 5 Fahnestock clips or binding posts (5 and 10 cts. store clips, 10 cts.)

Cigar Box, base-board, sheet of pasteboard, a few feet of bus bar and No. 18 annunciator wire, screws.

Following the mention of the parts, the exact make and price used in the receiver we are describing in parenthesis. This represents a total expenditure of $20.00 which can be considerably reduced, if desired, by the following substitutions purchased at the five-and-ten-cent stores: Variable condensers, 22 plates, at $1.44 apiece; rheostat at $.25, crystal detector, $.20.

The Panel

Once again the cigar-box, the mechanical genius of the radio beginner, plays the combination part of panel and cabinet. A rather large box, about ten by six inches, should be secured. The hinged cover and paper are removed by soaking in water, and the wood is sandpapered to a clean, smooth finish. The bottom of the box is marked and drilled according to the panel layout in Fig. 2. The writer found it more convenient to take the box apart and re-assemble it as the parts were mounted.

Due to the number and size of the parts represented by the one-tube reflex set, the depth of the cigar-box is rarely sufficient to contain them all. Therefore, a large baseboard six inches wide, is substituted for one side of the cigar-box as suggested in the drawing, Fig. 3. After the panel is drilled, the cigar-box—or what is left of it—is built up around the base-board, three inches or so of which will project out in back of the box. The top of the box (originally a side) is nailed in place last, after the socket is fastened to it, and the condensers and coils mounted respectively on the panel and sides.

A coating of green stain applied to this woodwork will add considerably to the appearance of the completed set.

The Coils

Spiderweb coils offer a simple form of inductance to the inexperienced builder, and they were chosen in the construction of this receiver. The winding form drawn to exact size, is shown in Fig. 4. This can be cut out and traced on pasteboard, from which material the forms are cut, or the dimensions can be noted and the figure re-drawn. Two combination coils, therefore two forms, are required, designated as T1 and T2 on the wiring diagram. Two windings are placed on each form, a primary and a secondary. A small hole is punched in the cardboard, the wire inserted, and then wound over and under the spokes. This first winding is the primary. The primary of T1 has 15 turns of wire, and the primary of T2, 25 turns. At the finish of the primary winding, another hole is punched in the form and the free end of the wire slipped through. At the next spoke, just above the primary winding—a thirty-second of an inch or so—a third hole is punched, and the secondary winding begun. The secondary is wound the same way as the primary and fastened to a fourth hole at the final turn. The secondary of T1 has 33 turns of wire and that of T2, 30 turns.

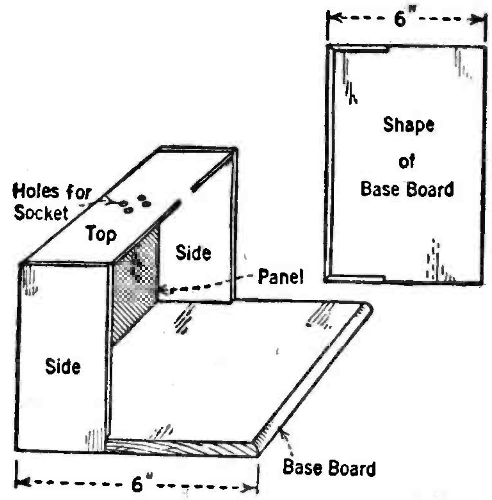


Fig. 3. Showing how the cigar box is built up about the baseboard.

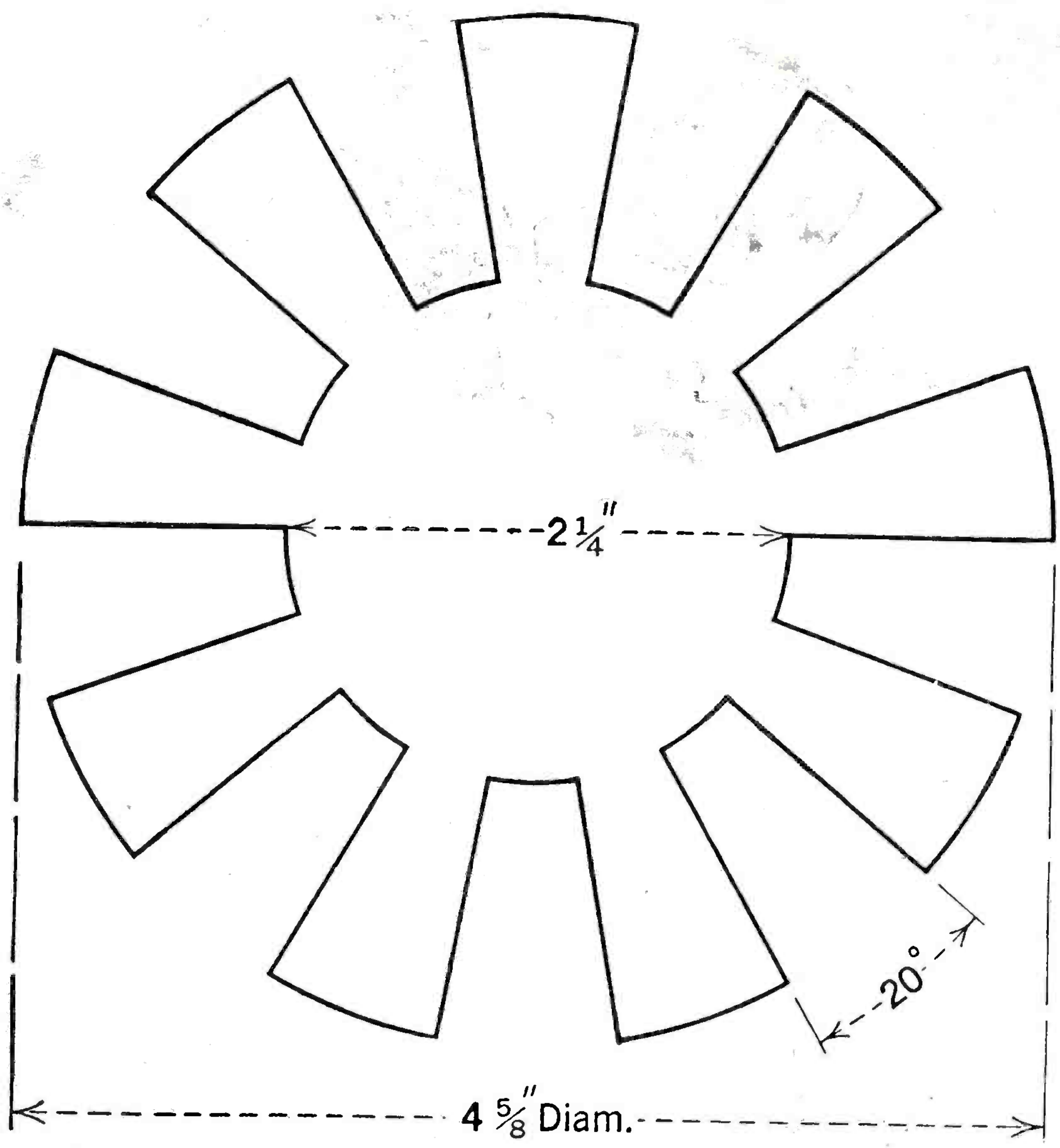


Fig. 4. Exact size of the winding form used in making the spiderweb coils T1 and T2.

Coil T1 is mounted on the left hand side of the box (looking from the front) and T2 on the right hand side. They are held in place by the wiring and by a tack, through one spoke on each coil, into their respective sides of the box.

If it is preferred, solenoid coils, such as those illustrated in Fig. 5, can be substituted for the spiderwebs. These are wound on two and a half-inch diameter winding forms. The secondaries are wound first and consist of sixty turns of wire for both T1 and T2. A layer of tape or empire cloth is placed over the secondaries, followed by the primary windings of fifteen turns on T1 and 35 turns on T2. (There are several commercial makes of transformers marketed for use with the so-called "Harkness Reflex" receiver, described in *Radio Review*, July, 1925, which can be substituted for T1 and T2.)

The socket is mounted on the top of the cabinet as suggested in Figs. 3, 6 and 7. Four small holes are drilled beneath it through which wires pass, connecting to the socket terminals. No. 18 annunciator wire is used for this purpose, the remainder of the connections being made with the heavier bus bar.

All parts, excepting the transformer, can now be mounted. From left to right in Fig. 6, the following parts are seen: Coil C2, variable condenser C2, the fixed crystal detector, the amplifying transformer, variable condenser C1, the Amperite or Daven Ballast resistance and coil T1. The Fahnestock clips, from left to right are: 1, telephone receivers; 2, telephone receivers and plus B battery; 3, minus B battery and plus filament battery; 4, minus filament battery and ground; 5, antenna.

How to Do the Wiring

The connections of the various parts are most conveniently made in the following order, with all parts, excepting the amplifying transformer T3, permanently mounted:

Filament post on socket to binding post or Fahnestock clip number 3; remaining filament post to filament resistance or rheostat, and from the filament resistance to post number 4.

Outside secondary terminal of T1 to

grid of tube and stationary plates of the C1; the inside (or beginning) secondary terminal to the rotating plates of C1: The outside terminal of T2 secondary connects to the stationary plates of C2 and the inside terminal to the rotating plates.

The inside terminal of the T1 primary connects to the antenna post of Fahnestock clip number 5; the outside or finish primary terminal leads to post number 4.

The plate of the vacuum tube is wired to the beginning of the T2 primary and end of the primary to Fahnestock clip number 1.

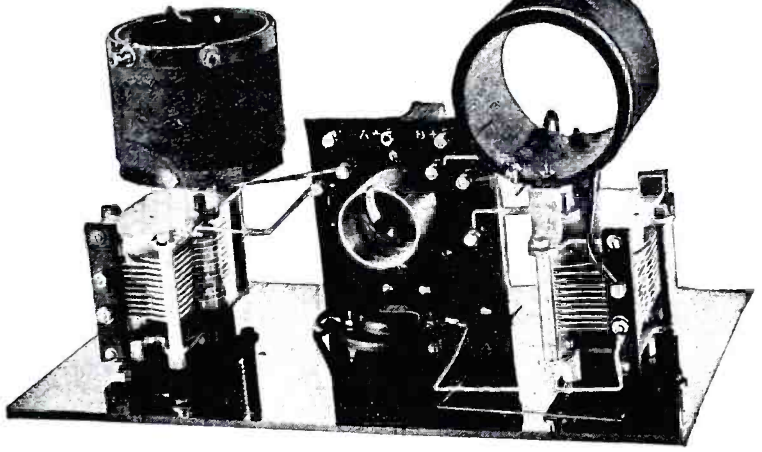


Fig. 5 (at the right). The rear view of a more elaborate layout using solenoid coils. The more experienced builder will find herein plenty of play for his talent and ingenuity.

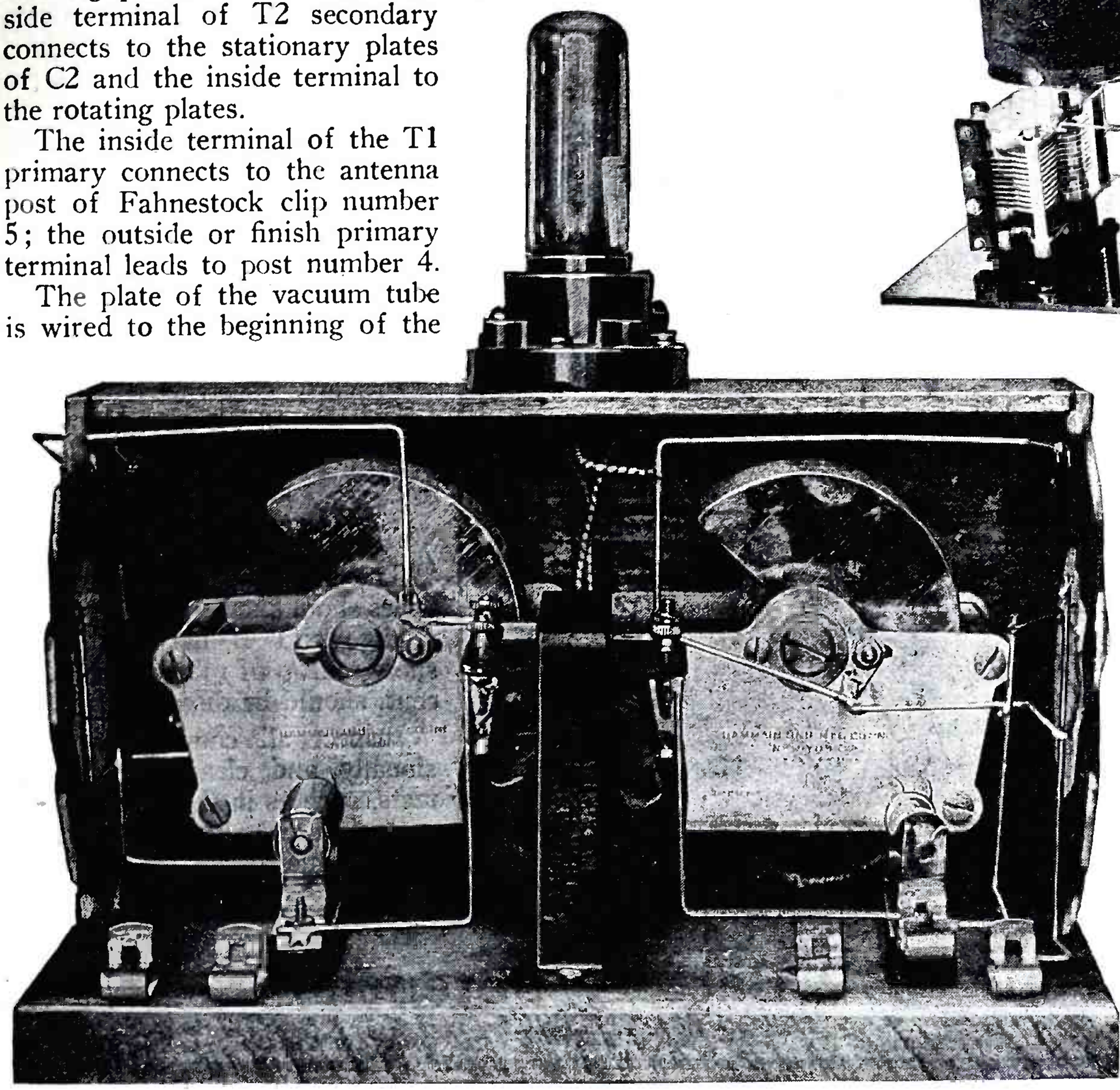


Fig. 6. The finished receiver from the rear. The transformer is mounted and wired last. Carefully note the placement of the other parts and follow the same arrangement. The leads to the socket are made with bell wire as shown.

The audio-frequency amplifying transformer, secondary to the right, is now mounted and the connections completed as follows:

The rotating plates of C2 to one side of the crystal detector, DET; the other side of the crystal detector to the P post on the primary of the amplifying transformer; the plus primary post is wired to the stationary plates of C2. The G post of the secondary runs to the rotating plates of C1 and the F post to Fahnestock clip number 4.

All joints should be soldered cleanly, and the wires bent carefully into right angle bends.

Tubes and Batteries

The receiver described is designed for use with the UV-199 type tube and an A battery of three dry cells. It will function, however, equally well on five-volt tubes of the UV-201A type, with the proper A battery and filament resistance. Ninety volts on the plate will be correct for both tubes, though still higher voltages can be safely applied to the larger tube.

How to Install the Receiver

A suitable antenna of about 100 feet long is connected to Fahnestock clip or binding post number 5. The ground lead is connected to post number 4, as well as the wire leading to the minus terminal of the A battery. The plus A battery and the minus lead of the B battery connect with post number 3. The plus B battery terminal is wired to post number 2. The telephone receivers connect to posts 2 and 1. These connections are still further explained in the wiring diagram, Fig. 8.

Operating Instructions

The tube is plugged into the socket and the rheostat turned on, or the Amperite or Daven Ballast clipped into the mounting. The dials should be set so that they

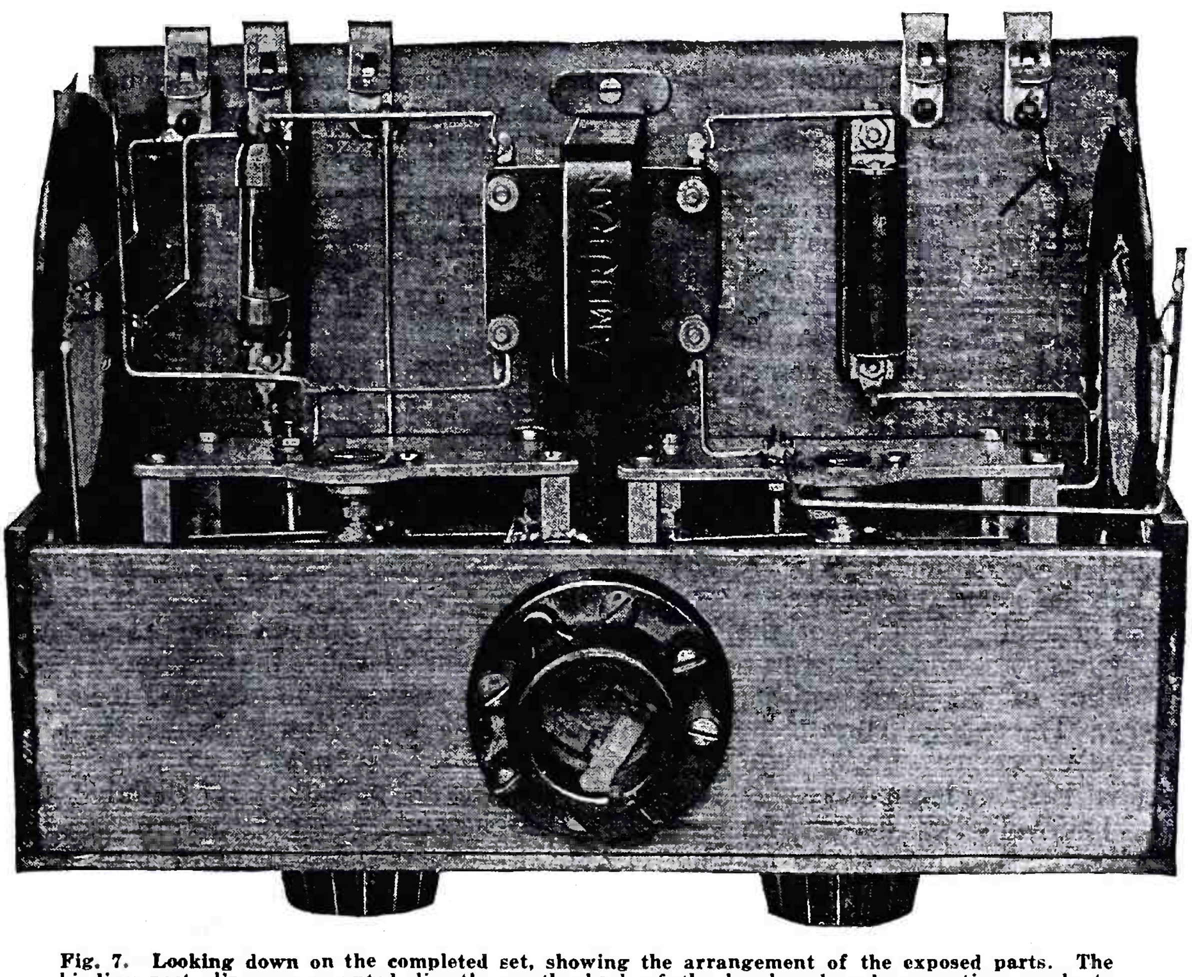


Fig. 7. Looking down on the completed set, showing the arrangement of the exposed parts. The binding post clips are mounted directly on the back of the baseboard and connections made to the screws.

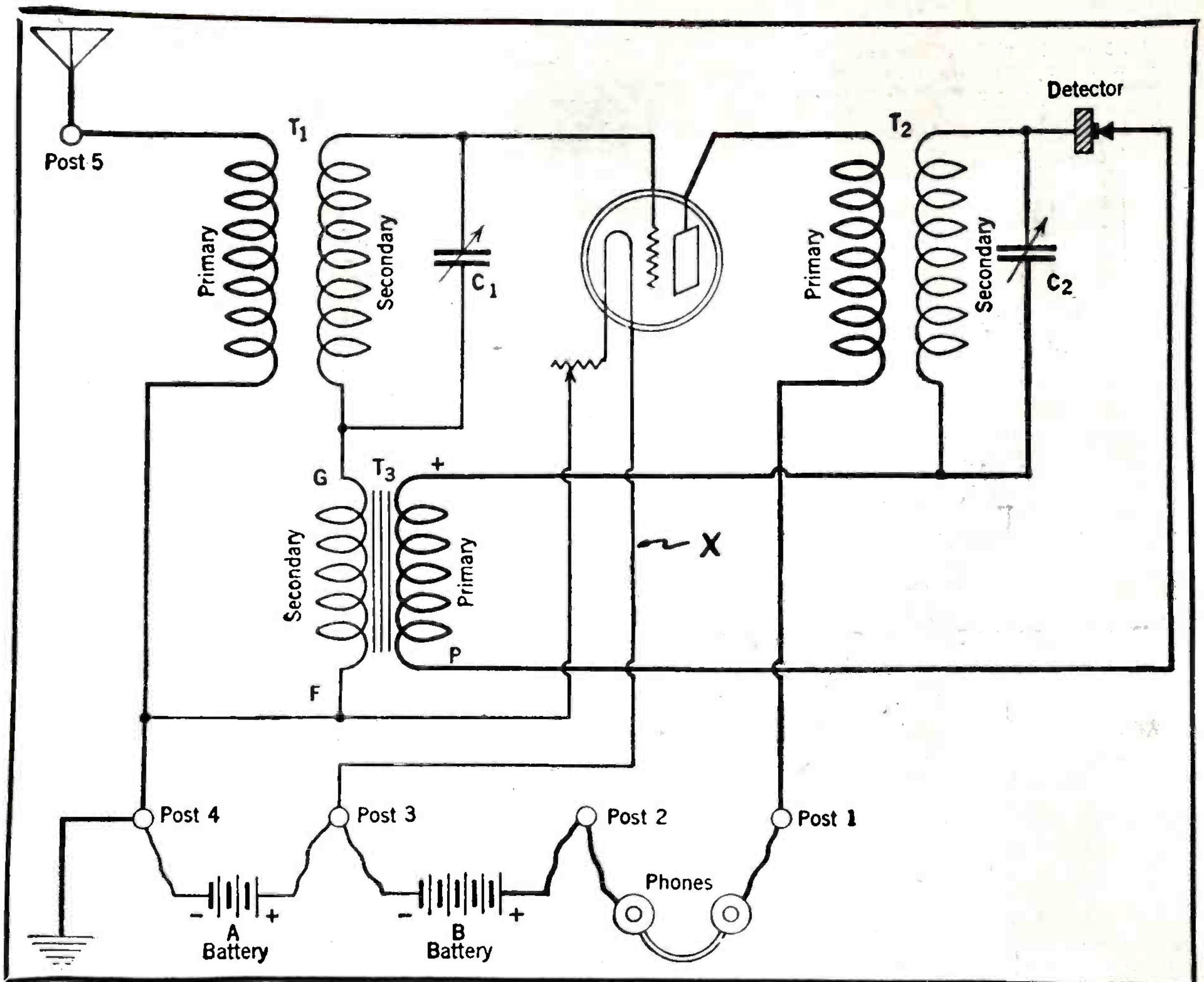


Fig. 8. The wiring diagram. If a ballast resistance or Amperite is used instead of a rheostat, the builder may find it convenient to include a small battery switch at "X".

read maximum when the rotary plates of their respective condensers are fully in between the stationary plates. The two dials are now moved simultaneously over the tuning range, keeping them at approximately the same settings. When a station is heard, the controls are carefully adjusted for maximum response. If the catwhisker type of crystal detector is used, it will require the usual adjustment. Reversing the connections to the crystal detector will often increase signal strength.

Properly constructed, this receiver should give loud speaker results on local stations.

Care and Upkeep

The filament and plate batteries should be kept at the proper voltage and B batteries which show a drop of more than 25 per cent. should be discarded.

Inspect all connections occasionally and clean wiring contacts, such as in the vacuum tube socket, in order that there will be no loss due to contact resistance.

Know Your "B" Battery Potential

WHEN vacuum tubes were first used the general impression existed among radio users that the "B" battery did not deliver any actual current, but that its sole function was to maintain a difference of potential between the plate and filament. Using, as they did, principally small one-tube sets for headphones reception and low plate voltage, "B" batteries generally lasted about as long as their shelf life. This tended to confirm the fact that the "B" battery furnished no current.

But broadcasting has changed all this. Current does flow from the "B" battery, and in the case of some modern high power receivers the "B" battery current is exceedingly heavy. The receiving set, from the standpoint of the battery engineer, is virtually the controlling device which regulates the flow of power from the "B" battery through the sound reproducer.

The general popularity of the "C" battery has somewhat helped to reduce the duties of the hard-working "B" battery. The average current drain of a five-tube receiver with 90 volts plate potential is 22 milliamperes; with four and a half volts "C" battery, the current is reduced to about 16 milliamperes. Nevertheless, the average current drain exacted from a "B" battery is still on the increase. Home-made super-heterodynes appear to be the greatest consumers of "B" battery current.

For the purpose of enabling you to calculate roughly the current drain which you draw from your faithful "B" battery, the table below gives you the "B" battery current consumption in milliamperes per tube under various conditions of service. Three factors control the current drain: The plate potential in volts, the difference of potential between the grid and the filament and the filament brilliancy. Detector tubes are usually so wired that the grid potential is slightly positive, because the grid return is made to the positive filament lead. Audio-frequency amplifier tubes are usually connected with the negative lead in such a manner that the voltage drop across the filament rheostat is taken advantage of, resulting in a small negative voltage on the grid. Still greater economy results when a "C" battery is used, giving negative bias on the grid up to four and a half volts, or more, as may be required. Radio-frequency amplifiers, if neutralized, are usually maintained at zero potential, but if a potentiometer is used to control oscillation a positive potential is applied to the grid, which usually averages three volts. This is the most wasteful form of receiving circuit.

PLATE POTENTIAL

Negative:				
Grid bias..	22½	45	67½	90
Positive:				
3	2	3½	5-¾	8½
1½	¾	2½	4-¾	7-¼
Zero bias..	½	1½	3½	6
1½	......	1	2½	5
3	......	......	1½	3½
4½	......	......	......	2

The table shows the "B" battery current consumption of a UV-201-A or similar tube in milliamperes; for dry cell tubes the readings are approximately 25 per cent less. Naturally, there is some variation from these figures, owing to the individual characteristics of tubes and the filament brilliancy with which they are used, but the table will enable you to determine with a fair degree of accuracy just what your "B" battery is called upon to do. These figures were obtained with the filament burning at normal voltage. Increasing the filament brilliancy above normal greatly increases the tube's "B" battery current consumption. Burning the tubes at as low a temperature as possible greatly prolongs the life of the "B" battery.—*Los Angeles Eve. Express, Los Angeles, Cal.*

A New Single-Control Regenerator

Application of Well-Known Mathematical Formula Proves Successful in the Design of this Set

THE ardent radio fan is always in search of new and unique ideas in the way of radio circuits, and to him we are presenting herewith a well founded regenerative circuit which has many promising features. The simplicity of this receiver is surprising considering its efficiency and general merit. It not only furnishes a reliable means of controlling self-oscillation in the three-circuit tuner without allowing amplification to drop on the longer wave-lengths, but, at the same time, makes a practical single control receiver.

Sylvan Harris describes this set in *Radio News* as follows:

The quest for an *absolute* single-control, non-radiating regenerative receiver has been going on for a long time, and a multitude of methods for controlling the tendency to oscillate have been proposed, but have not been found to be successful. It is true that self-oscillation in a regenerative detector can be prevented, but in all cases to date, this has been accomplished at the cost of reducing the amplification. The phenomenon is familiar to the owners of all so-called "self-neutralized" radio frequency amplifiers, which are built in so inefficient a manner that the regeneration never reaches the critical point. In these receivers the amplification is good on the shorter wave-lengths, but falls off considerably on the longer.

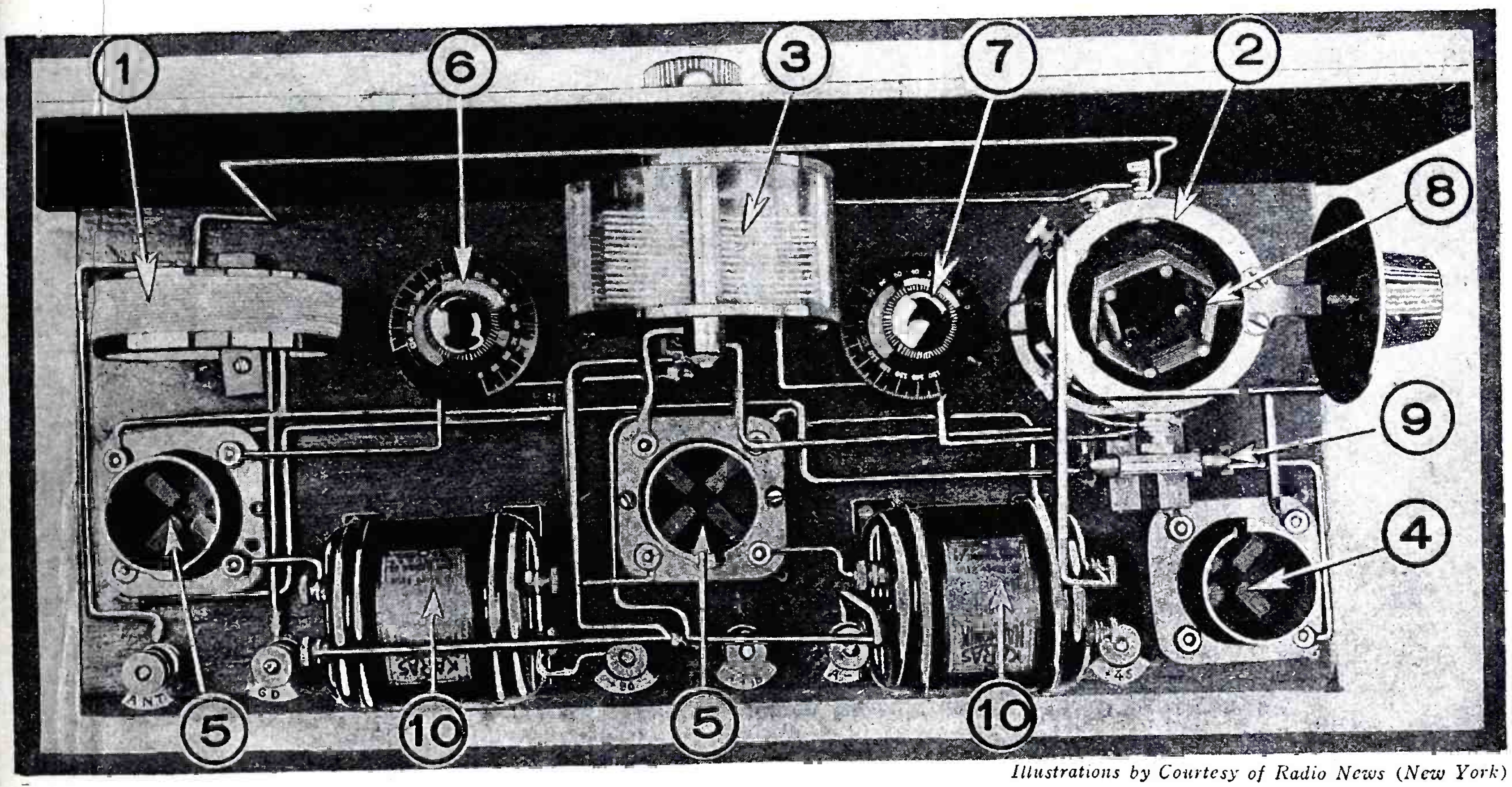
It is not necessary to go into detail concerning the evils of the radiating receiver. There is little doubt that every one of our readers have at one time or other, and in many cases, quite frequently "cussed" that neighbor who constantly "bloops" and sends out his cat-calls just at the time all ears are focussed on the umpth symphony of Rubenthoven. But not only that, there is also to be considered the fact that when the detector tube is not operating near the critical point, the greatest possible efficiency is not being obtained. There have been various circuits proposed and tried out, combining the radio frequency amplifier and the regenerative detector, but wherever this has been accomplished considerable has had to be sacrificed for the purpose of obtaining stability of the circuits and ease of control.

The author of this article, like many others, has been working for a long time on this problem, and he is glad to present in this article a method that he believes is the most successful yet found. And more than this, the very simplicity of the method will no doubt surprise the reader.

The Laws of Regeneration

To begin with, it is necessary to know the laws controlling regeneration in the tube circuit. There are two ways in which regeneration is accomplished, *viz.*, by means of inductive feed-back (through a tickler coil) and by means of feed-back through the tube capacity. We shall consider only the first of these two ways in which regeneration is accomplished, for it can be shown that the method of controlling regeneration explained here will apply only to the case of feed-back through a tickler coil. No solution has yet been obtained for the other case.

It is well known that, due to the feed-back through the tickler coil, the effective resistance of the input (grid) circuit of the detector tube is reduced, and when the feed-back becomes sufficiently great, the effect is the same as if the resistance of the input circuit had been removed. We shall not consider the theory of the matter in this article for there are many diverse opinions on this subject. However, whatever the true explanation may be, the results are always the same, and it



Illustrations by Courtesy of Radio News (New York)

A top view of the completed set. The numbers in this photo correspond to the numbers on the layout diagram on page 25.

will be found that the *apparent* reduction of the grid resistance, as far as the signal current is concerned, is re-

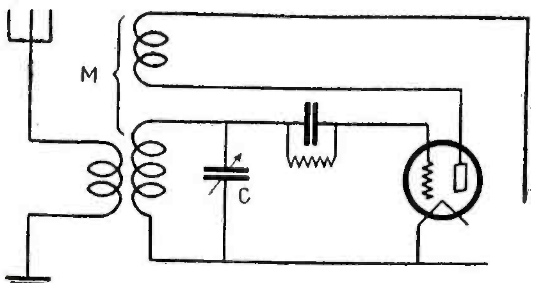


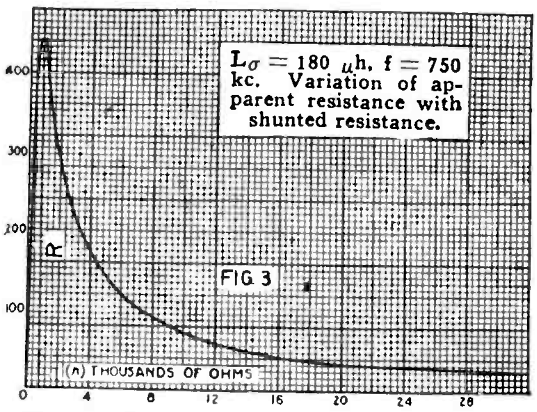
FIG. 1

The fundamental arrangement to accomplish regeneration by inductive feed-back (the three-circuit tuner).

duced in accordance with the formula

$$\Delta R = \frac{\mu M}{r_p C}$$

in which ΔR is the *reduction* in the resistance, μ is the amplification constant of the tube, M is the mutual inductance existing between the tickler coil and the coil in the input circuit, rp is the internal output resistance of the tube, and C is the capacity in the tune circuit connected to the input of the tube. These quantities are represented in Fig. 1. The derivation of the above formula is given by C. B. Jolliffe



This graph shows how the resistance between A and B in Fig. 2 changes as the shunted resistance is varied.

and J. A. Rodman in Scientific Paper No. 487 of the Bureau of Standards.

Now, if we consider that the setting of the tickler coil remains fixed, in other words, that we have a constant volume of the mutual inductance between the tickler and the coil in the grid circuit, and that we have a certain volume of inductance in the tuned circuit and a certain amplification factor in the tube, it can easily be shown that the reduction of the grid resistance is in accordance with the formula

$$\Delta R = k f^2$$

In other words, the apparent resistance of the tube input circuit is reduced in proportion to the *square* of the frequency.

Now, if we can obtain some means of increasing the resistance of the circuit *at the same rate* as it is decreased by the feedback, it is evident that the apparent resistance will remain constant and the amplification will be the same for all frequencies or wave-lengths. This is what has been done in this method. A circuit arrangement has been chosen in which the apparent resistance of this circuit increases in proportion to the square of the frequency.

In other words, we have on the one hand, the tendency of the tuned circuit to *decrease as the square of the frequency,* due to regeneration, and on the other hand, the tendency of the special circuit to have its resistance *increase as the square of the frequency,* so that the

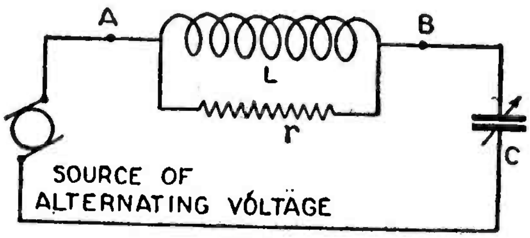


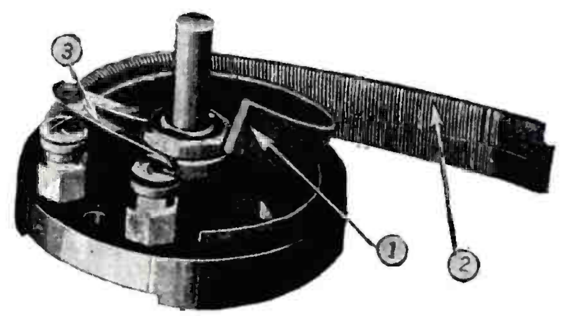
FIG. 2

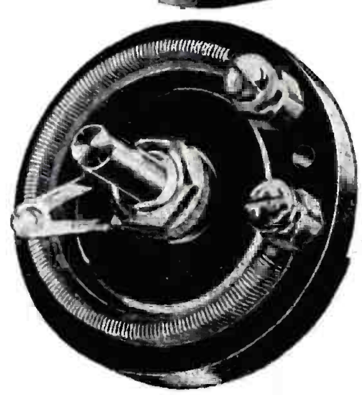
The resistance of this circuit increases at the same rate as the input resistance in Fig. 1 decreases due to the regeneration.

net effect on the apparent resistance of the circuit is *nil.* Let us see how this is accomplished.

The Fundamental Circuit

The fundamental circuit arrangement is shown in Fig. 2. Here we have a source of alternating voltage, shown in Fig. 2 as an alternating current generator, but which may be replaced by a coupling coil placed in inductive relation with a (primary) coil on the antenna circuit. In series with this emf. is a coil shunted by a resistance and a tuning condenser.





The special high resistance variable rheostat used in the circuit. Contact with the impregnated strip (1) is made through the lever (3) and the wire turns (2), which have been split. The latter is used to obtain good contact on the strip.

Now, if the impedance of that part of the circuit between the points A and B be derived, it will be found that the apparent resistance between A and B and likewise the apparent inductance will be different from the true resistance and inductance of the coil. For the sake of simplicity let us consider the case of a coil, the resistance of which is small compared with its reactance, so that its own resistance may be neglected.

The apparent inductance between A and B is changed only a very slight amount if the shunted resistance r is large, so that this effect will be neglected. Besides, the only effect this change of inductance would have would be to change the tuning slightly.

The apparent resistance between A and B (Fig. 2) on the other hand, changes considerably when r is connected across the coil, and it may either increase or decrease the apparent resistance, depending upon how large r is in comparison with the inductance L. The variation of the resistance is given by the formula

$$\Delta R = 0.0000\,395 \frac{f^2 L^2}{r}$$

when r is very large. In this formula, f is the frequency in kilocycles per second, L is the inductance of the coil in microhenries, and r is the shunted

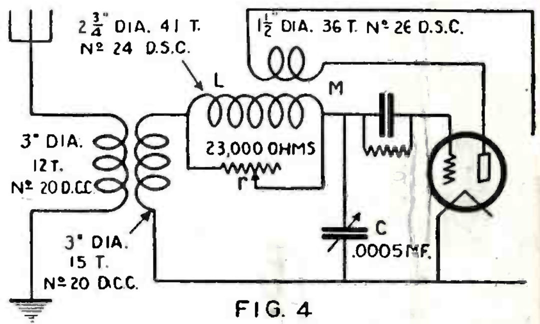
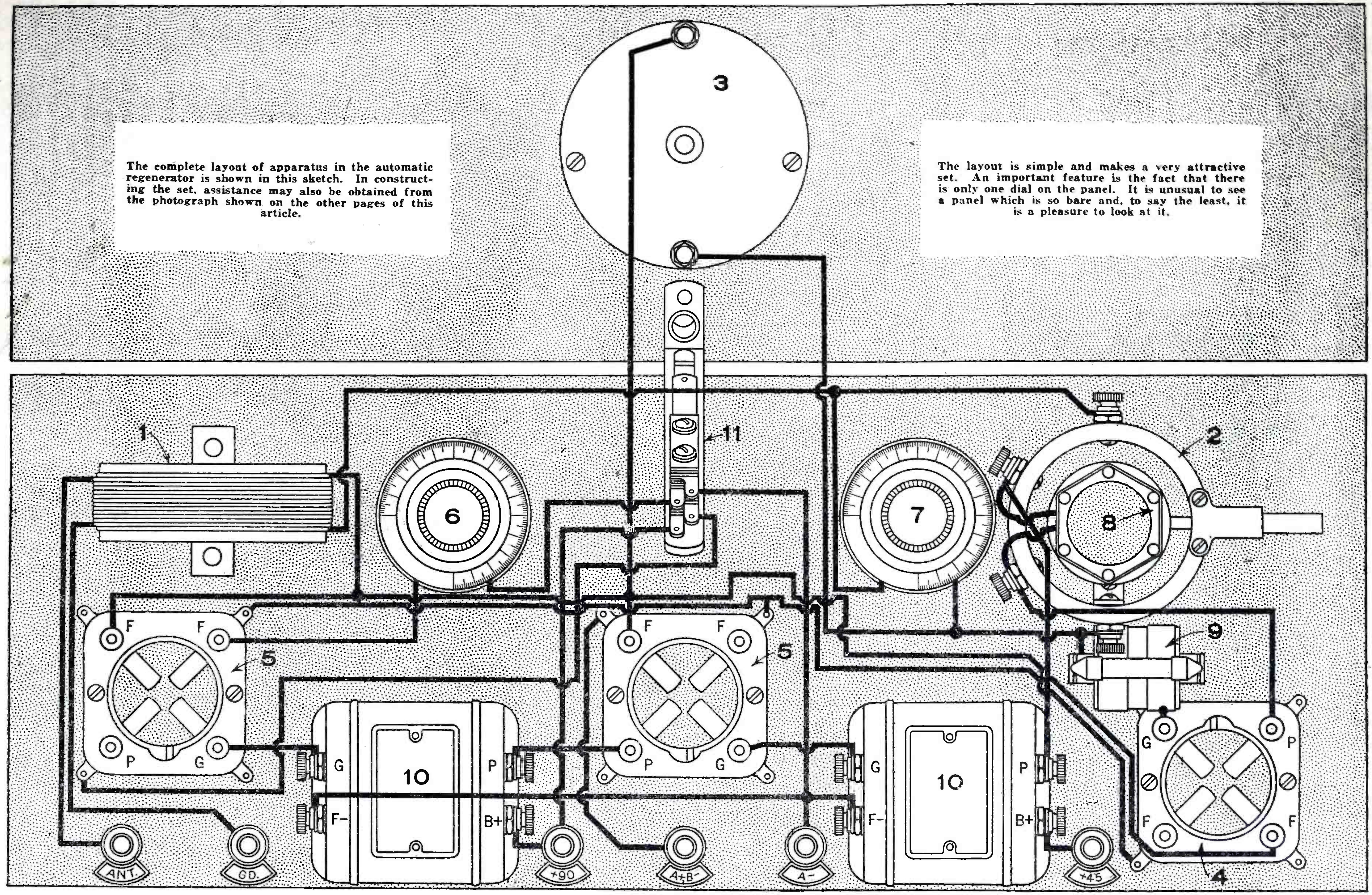


FIG. 4

Here is the final circuit evolved from those shown in Figs. 1 and 2.

resistance in ohms. The way in which the apparent resistance changes as the shunted resistance r is increased is very interesting. This is shown in Fig. 3, which has been calculated for an inductance of 180 microhenries and a frequency of 750 kilocycles per second. When the shunted resistance r is less that a certain amount, the apparent resistance increases very rapidly as r is increased. After this certain value has been exceeded, the apparent resistance decreases as r is increased. This seeming paradox of decreasing the resistance of a circuit by increasing the resistance of a part of it, may trouble many of our readers, but it must not be forgotten that we have here a parallel arrangement of parts, *viz.*, a resistance in parallel with an impedance.

However, it will be noted that this applies only for a constant frequency. We are more interested in how the apparent resistance will vary with the frequency, for it is due to the increase of frequency on the shorter wave-lengths, that the circuits oscillate more easily on these wave-lengths. The formula given immediately above shows that, for given values of inductance and shunted resistance, the apparent resistance *increases* in proportion to the *square of the frequency.* This is the same rate at which the resistance *decreases* due to the feed-back, so that



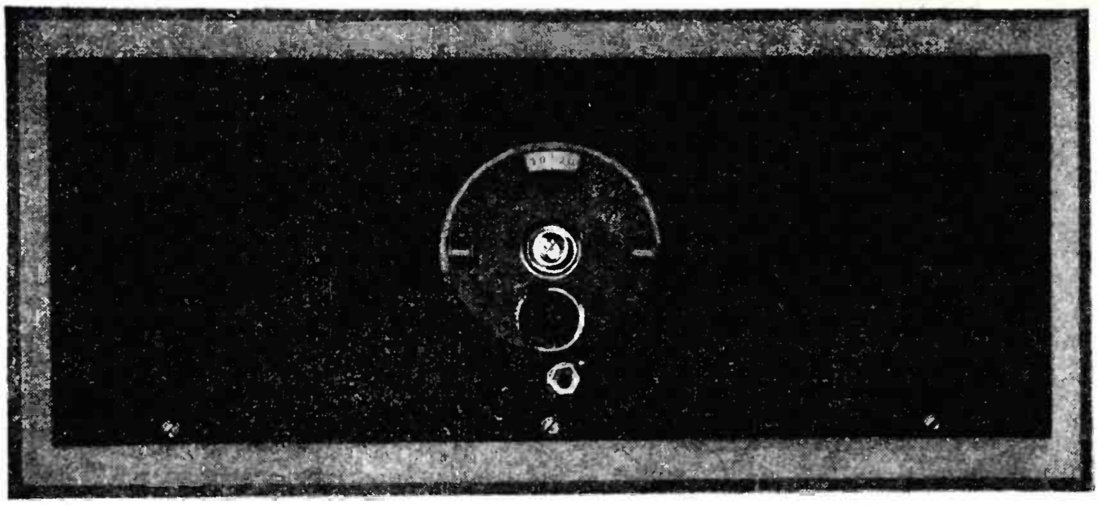
The complete layout of apparatus in the automatic regenerator is shown in this sketch. In constructing the set, assistance may also be obtained from the photograph shown on the other pages of this article.

The layout is simple and makes a very attractive set. An important feature is the fact that there is only one dial on the panel. It is unusual to see a panel which is so bare and, to say the least, it is a pleasure to look at it.

1, Antenna and pick-up coils; 2, secondary loading inductance; 3, variable condenser (.0005 mf.); 4, detector tube (201A); 5, amplifier tubes (201-A); 6, rheostat controlling all tubes at once (6 ohms); 7, high resistance rheostat, used for shunting secondary loading inductance; 8, tickler coil; 9, grid condenser (.00025 mf.) and grid leak (2 megohms); 10, audio frequency transformers; 11, single circuit filament control jack.

the two effects ought to annul each other.

This is exactly what happens, to a close approximation. There have been several approximations made in the



The front view shows a true single-control receiver—merely one dial and a phone jack. Even the latter could be hidden by using tip-jacks in back of the panel.

theory, so that it cannot be claimed that the system works perfectly. Experiment shows that the increase of resistance is *not quite* equal to the decrease, so that there is a very slight decrease in amplification on the longer wave-lengths of the broadcast range. The decrease of amplification is small, however, and is not noticeable.

Let us now consider the application of these principles to the detector circuit obtaining regeneration by tickler feed-back. As has been intimated before, the generator shown in Fig. 2 may be replaced by a pick-up coil coupled to the antenna circuit. The inductance L in Fig. 2 therefore becomes a loading coil. The remainder of the circuit is the same as in any other three-circuit tuner. The final circuit, therefore, changes from the form shown in Fig. 1 to that shown in Fig. 4. The coupling between the tickler coil and the coil L remains fixed, the only variable instrument in the set being the tuning condenser C. It will be noted that this method, besides taking care of the regeneration automatically, at the same time furnishes us with a true one-control receiver.

To obtain such a condition that the increase of resistance is equalled by the decrease, or *vice versa,* it is evident that there must be a certain constant relation between the shunted resistance r and the mutual inductance between the tickler and the coil to which it is coupled. This relation is expressed as

$$r = \frac{K}{M}$$

where r is the shunted resistance and M is the mutual inductance. There is thus a certain amount of coupling required for a certain amount of shunted resistance. To adjust the receiver the shunted resistance is set at some convenient value, say about 25,000 ohms, and the tickler coupling is then adjusted so that the set operates just on the verge of oscillation. Theoretically this procedure should do the trick, no matter on what wave-length the adjustment is made or under what conditions, but on account of the approximations mentioned before, several trials may be necessary.

If it is found that the amplification drops off at the longer wave-lengths, the setting of the resistance should be changed a little and the tickler coil readjusted. If this does not do the trick another adjustment should be tried—and so until the best setting is obtained. After two or three trials it will be found that the set can be operated

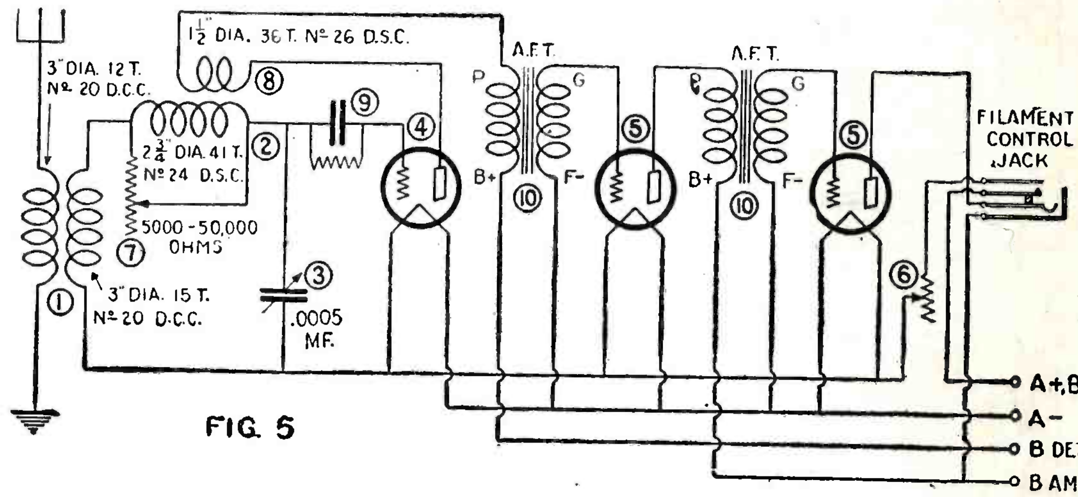
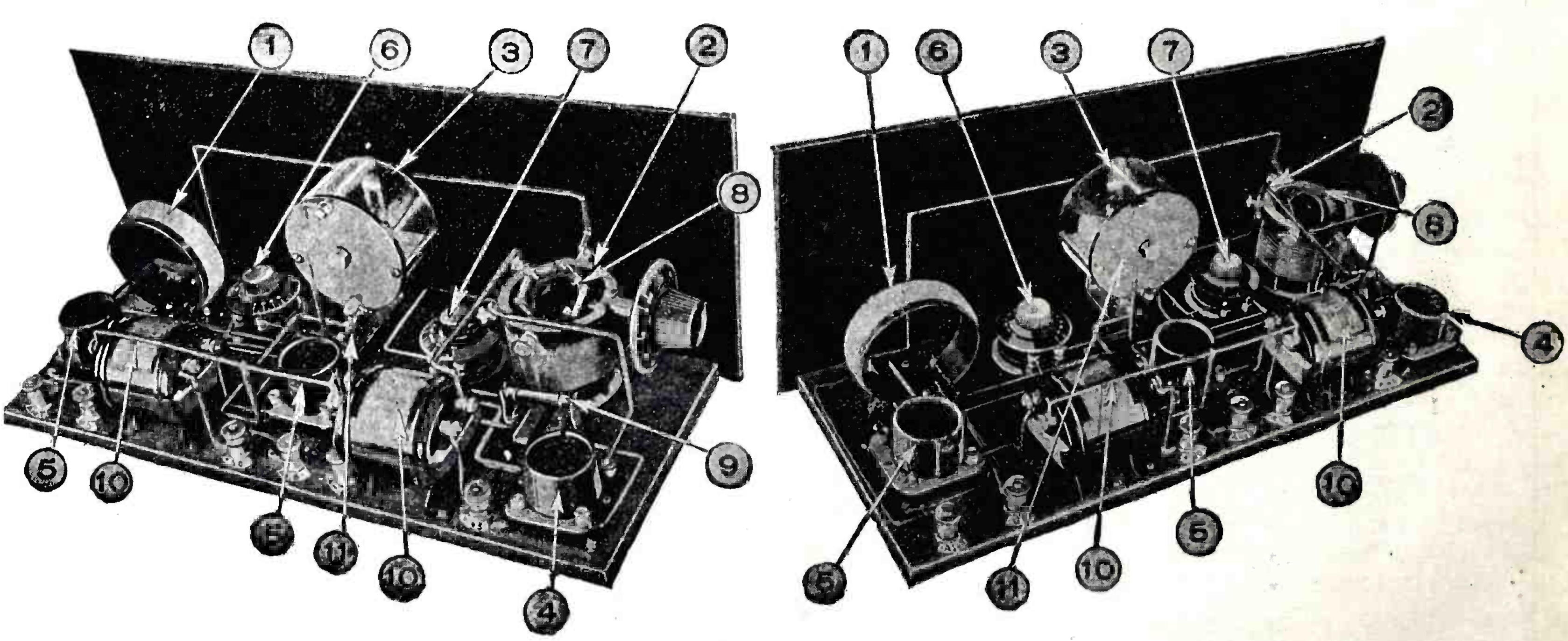


FIG. 5

1, Antenna and pick-up coils; 2, loading inductance; 3, variable air condenser; 4, detector tube; 5, amplifier tubes (201-A); 6, filament rheostat 6 (ohms); 7, shunted resistance (5,000 to 50,000 ohms); 8, tickler coil; 9, grid leak and condenser (.00025 mf. and 2 meg.); 10, A.F. transformers.



Two back views of the receiver. The numbers in these photographs correspond to those on the large layout diagram on page 25.

(*Continued on page* 35)

How to Construct the Hetro-Five

Building of Set and Making Coils Are Explained in Detail

"FIVE tubes, performing in a superheterodyne system and doing their work not only as well but somewhat better than does the same quintet in any other type of five-tube receiver—that is the radio accomplishment now possible for any fan. And, in addition, such a system will function on four tubes with plenty of volume for an ordinary sized room. Not only that, but all of the selectivity of the large superheterodyne is retained."

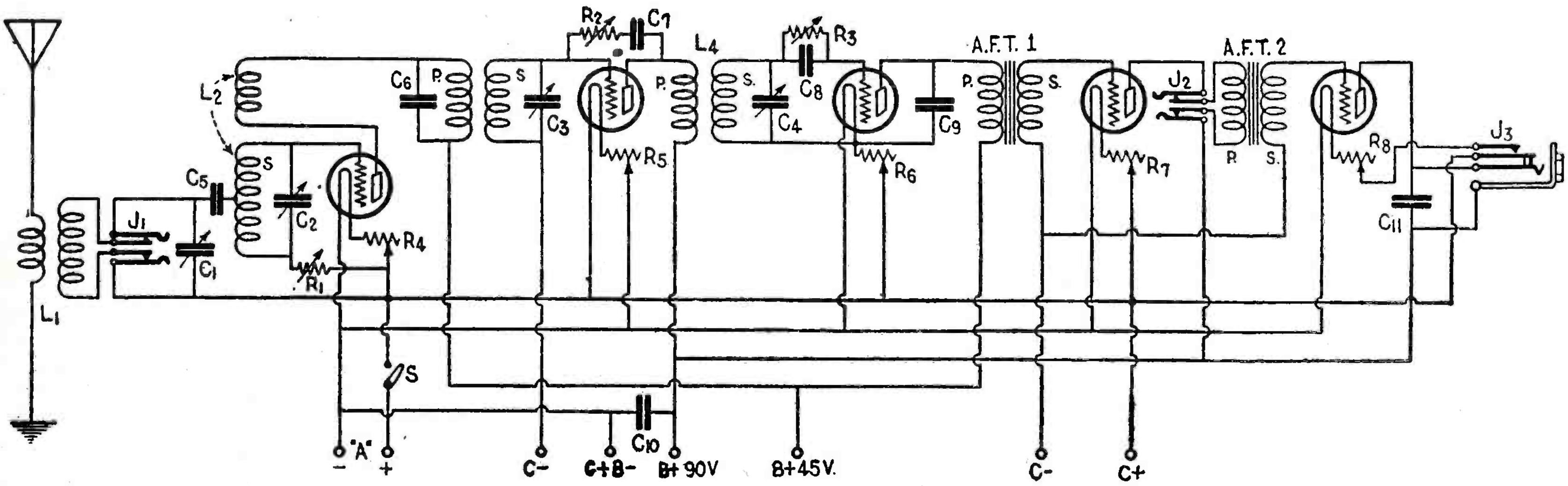
Thus the first of *C. E. Butterfield's* article reads in a recent issue of *The Chicago Evening Post.* Mr. Butterfield goes on to give a further description of his "Hetro Five" as follows:

course, all of this was not accomplished in a minute, and several months of experimentation were required before the set was evolved. Besides, numerous changes were necessary over the original Tropadyne, which contained seven tubes.

Numerous attempts have been made within the last year to design a practical superheterodyne functioning on fewer tubes than the old eight or nine-tube sets. Fitch and others lopped off a tube by successfully combining the oscillator and the frequency-changer tube. Another tube was cut out in the latest Armstrong superheterodyne, in which reflexing was used. Then along

which has no more tasks to perform than does the detector in an ordinary regenerative set. Also we adopt the Tropadyne oscillator in preference to other autodynes because it was believed to do the work better.

Another fact that is a credit to Fitch's oscillator is that the oscillation circuit is isolated from that of the antenna, making it impossible to radiate energy into the aerial, as do many of the superheterodynes now in existence. Of course, the same is true of the Pressley system, but we are not extolling its merits and are only interested in the set at hand. And the "Hetro Five" will not put oscillations



Illustrations by Courtesy of The Chicago Eve. Post

Complete diagram of Mr. Butterfield's Hetro Five. Standard parts are used in this circuit. Coil L3 can be seen between condensers C6 and C3 and is a long wave transformer as is L4.

In presenting for the first time the 'secrets" of the "Hetro Five," the writer also offers an improved inductance coil, which may be used in any type of radio receiver. The coil, which has been given the "title" of "Figure 8 low loss, high inductance," while offering somewhat of a task in its construction, provides not only high inductance, but has an extremely small external field, requires very little room and has the lowest possible "pick up." That is, the coil will not act as a small loop, as does an ordinary large solenoid, thus giving sharper tuning.

Attempts to Reduce Tubes

Analysis of the diagram of the "Hetro Five" immediately calls to mind the Tropadyne, designed by Clyde J. Fitch. In fact, the autodyne type of oscillator, such as he used, with tuned long-wave transformers, was adopted by the writer in his task of squeezing a superheterodyne into five tubes and still getting the necessary volume. Of

came McMurdo Silver, who, using the Pressley bridge type of oscillator—"detector"—also cut the superheterodyne to six tubes by sharpening up the long-wave amplifier and holding it to two tubes.

Now another tube has been cast aside and we have the "Hetro Five." It was done, too, with no reflexing which will give the fan plenty of trouble alone without hooking it into a superheterodyne system. In fact, several efforts have been made to design five-tube sets by reflexing the intermediate amplifiers. The writer does not wish to discourage any reflex fan or deride any reflex set, home made or otherwise, but he desires only to call attention to the difficulties that the fan sometimes encounters in building the reflex, let alone trying to add it to the superheterodyne.

Is Non-Radiating

So we forget the reflex idea, and give each tube only one job, except for the combined oscillator "detector,"

into the antenna to worry all of the neighbors, no matter what type of aerial is used.

After selecting the desired frequency-changer circuit, the big task came in building an intermediate amplifier that would amplify properly without corralling a small family of tubes. It was decided that the tube boiling down process must take place in the amplifier. That's easy, was the first thought. All of the amplifying tubes but one would be forgotten. Simple? Extremely so, but along with the missing tubes went nearly all of the amplification. So it was necessary to help along the lonely tube by providing an amplifier that would "perk" from the word "go." So again the Tropadyne was called upon. From it the hint of tuned long-wave transformers was thoroughly looked into. Immediately the amplifier stepped into action. Then was tried a "different" type of transformer. Tuned honey-comb coils were used. They worked like a top, until the set was tried under the eaves of a broadcasting station. Not so good. More trials and tribulations. A weeding-out process was put under way and transformer after transformer was literally looked into and then given a back seat.

Finally the Remler tuned stage transformer, which operates on a peak wavelength of 6,666 meters, or forty-five kilocycles, was given the job in the amplifier. Eureka! The days of grief were over. Recommendations which accompany each carton containing the Remler transformer were ignored. The engineers who designed that transformer did not know what the writer was up against. So instead of using only one of the Remler TS transformers, two were gathered in, one used as an input or "filter" transformer, and the other given the job of passing the signal onto the long wave detector.

The input transformer was tuned as sharp as possible. A .0005 fixed condenser was placed across the primary, with a .0005 variable across the secondary. Another .0005 variable was used across the secondary of the second transformer.

The reader probably wonders by this time if the writer is attempting to press-agent the Remler products. But he is only attempting to save a lot of grief for the fan who builds the "Hetro Five." Unless the builder desires to experiment and go over the same field already covered by the writer, he will do well to follow instructions as to the few particular instruments that are specified here and there. By the way, this Remler transformer is Type 610, so don't forget it. The Type 600 Remler will not function properly in the "Hetro Five."

Passing to the long-wave detector, an attempt was made to incorporate regeneration through a feed-back coil. But it didn't mean anything. It worked fairly well when honeycomb transformers were used, but it was found with the change in transformers that there was plenty of regeneration without adding this extra unit. So the ordinary straight audion detector was incorporated in this set.

Returning to the long-wave amplifier, it will be noted that no potentiometer is used. Tests showed that its use cut down the volume, although it did prevent oscillation. So the Farrand system of regeneration control was selected. It consists merely of a blocking condenser and a variable resistance, such as the Bradleyohm. Also an aid in building up the volume was the separate C battery incorporated in the amplifier circuit. Its value will range from 1½ to 3 volts.

The audio hook-up is standard, except that it was found that with the laboratory audio transformers the bypass condenser, C9, was not needed. However, it is best to try the set both with and without this condenser.

In constructing the "Hetro Five," the builder is advised to pick up the best material on the market. And he should, where such instruments are specified, buy those listed in the outline of parts. The other material in the set can be any good equipment.

PARTS FOR "HETRO FIVE"

L 1—Antenna coupler.
L 2—Oscillation coupler.
L 3 and 4—Long-wave transformers (Remler tuned stage transformers, type 610).
AFT 1 and 2—Audio-frequency transformers (laboratory type preferable).
C 1 and 2—.0005 variable condensers of any good make.
C 3 and 4—.0005 variable condensers (Rathmun preferable because of small space required).
C 5—.0005 fixed condenser.
C 6—.0005 fixed condenser.
C 7—.001 fixed condenser.
C 8—.00025 fixed condenser.
C 9—.006 fixed grid condenser.
C 9—.006 fixed condenser (optional).
C 10—One mfd. fixed condenser (B battery bypass).
C 11—.006 L. S. bypass (optional).
R 1—Bradleyohm, range 5,000 to 50,000 ohms.
R 2—Bradleyohm, range 25,000 to 250,000 ohms.
R 3—Grid leak (variable preferred—if fixed leak used 5 megs).
R 4, 5 and 6—Rheostats to fit tubes used.
R 7 and 8—Amperites to fit tubes used.
J 1—Double circuit jack for loop antenna (optional).
J 2—Double circuit phone jack.
J 3—Single circuit filament control jack.
S—Filament battery switch.
Two C batteries.
Panel—7 by 26.
Subpanel or baseboard—7 by 24.
One-half pound No. 22 D.S.C. wire.
Five sockets for 201-A type of tubes.
One dozen binding posts, wire, screws and other desired hardware.
Five 201-A tubes.
Note: If bakelite subpanel is used, subpanel brackets will be required.

No panel layout is given, nor is an outline included for the subpanel or baseboard, because the writer feels that the fan who will build this set is so far advanced in the radio art that a map of a panel is an unnecessary evil. Besides, mounting templates vary with the instruments purchased, and a panel and baseboard diagram is virtually useless unless the builder buys identical material, and what fan who does not have his own pet instruments?

As to Panels

In starting with the antenna circuit and continuing to the last jack, a number of hints will be given. In the first place, the recommended panel size is 7 x 26, although a panel two inches shorter may be used by slightly crowding the instruments. The baseboard should be two inches shorter than the panel, and the same is true if a subpanel is used.

Here let us say a word regarding subpanels. This set lends itself very readily to subpanel construction, due to the fact that the two variable condensers, which tune the long-wave amplifier, may be mounted in the rear of the set. Such is the case with the two Bradleyohms and the grid leak, as it is necessary to adjust these instruments only for the best reception and then forget them, unless one wishes to experiment.

In the writer's set a subpanel was used, it being mounted on brackets which were attached to the panel. The antenna and the oscillator condensers were mounted at the left-hand side of the panel with enough room between them to permit the placing of the oscillator tube. The loop jack was placed in the lower left-hand corner of the panel. At the rear of each condenser was placed its respective coil.

Also on the panel were put three rheostats, one each for the oscillator, the amplifier and the detector. Rheostats were used on these tubes because it was felt that they required closer filament adjustment than did the audio tubes, which were controlled through amperites. The filament switch was put at a convenient place, with two jacks at the lower right-hand corner.

The loop jack is optional, although it permits the use of a very small pick-up system for local and some distance use. The first audio jack was placed in the plate circuit of the first audio tube, providing plenty of volume for local stations and such distant transmitters as KDKA. The other audio jack was a filament-control type, this being used because of the adoption of amperites.

If a baseboard is used, the builder must provide some method of mounting the two long-wire condensers. One method that suggests itself would be small panels attached to the rear of the baseboard. The same is true of the Bradleyohms and the variable leak, although these may be put on the panel.

Where a subpanel is used, a number of hints are in order. In the first place, it conceals practically all of the wiring and provides a method for the mounting of the variable instruments whose adjustments do not require that they be placed on the panel. These include R1, which is put as close as possible to the oscillator tube; R2, placed near tube No. 2, and the grid leak for the second detector. R1 is a Bradleyohm with a range from 50,000 to 500,000 ohms; R2 is another Bradleyohm with a range of 25,000 to 250,000 ohms; R3 may be any good variable leak.

In addition, the subpanel provides an excellent place to mount the long-wave tuning condensers. Rathbun's .0005 were used in the writer's set because they required very little space and lent themselves readily to subpanel mounting. A small dial is recommended. The Remler transformers were mounted contrary to all rules and regulations. They were turned upside down and holes bored in the subpanel through which the binding posts on top protruded. These were fastened from the bottom, with soldering lugs under the nuts.

All of the fixed condensers may be mounted on the wiring if the proper type are purchased. Almost any type of sockets lend themselves to subpanel use, although some will be found that require considerable ingenuity to place properly. Audio transformers of almost every make are easily adapted to a subpanel.

Before starting construction the builder should lay out all of the instruments, both on the panel and baseboard or subpanel so that he will not crowd off a necessary unit. On the writer's set a voltmeter, with a switch so that the first three tubes could be cut in on its circuit, was incorporated, but this is only a refinement that complicates the construction.

The Inductances

While the writer has attempted to point out all of the intricacies of the "Hetro Five's" layout, he may have dropped some out, but he leaves those to the ingenuity of the builder.

Two coils, both of which should be home made, are needed. The antenna coil circuit may be any type suitable for a .0005 condenser. In the diagram it is L1. If the Figure 8 coil is used—and its construction will be explained later—the primary will require seven turns and the secondary thirty-seven turns. If an ordinary solenoid is used, the primary should be about nine turns, with forty-nine-turn secondary.

The oscillator coil (L2) is wound in two sections. The grid coil, using the Eight type, has thirty-nine turns, tapped exactly in the center, or at the end of 19½ turns. The plate coil, which is coupled to the grid coil, consists of sixteen turns. If the solenoids are used, the number of turns should be: Grid coil 47, tap 23½, plate coil 18. The plate coil is put on one-half inch from the grid winding.

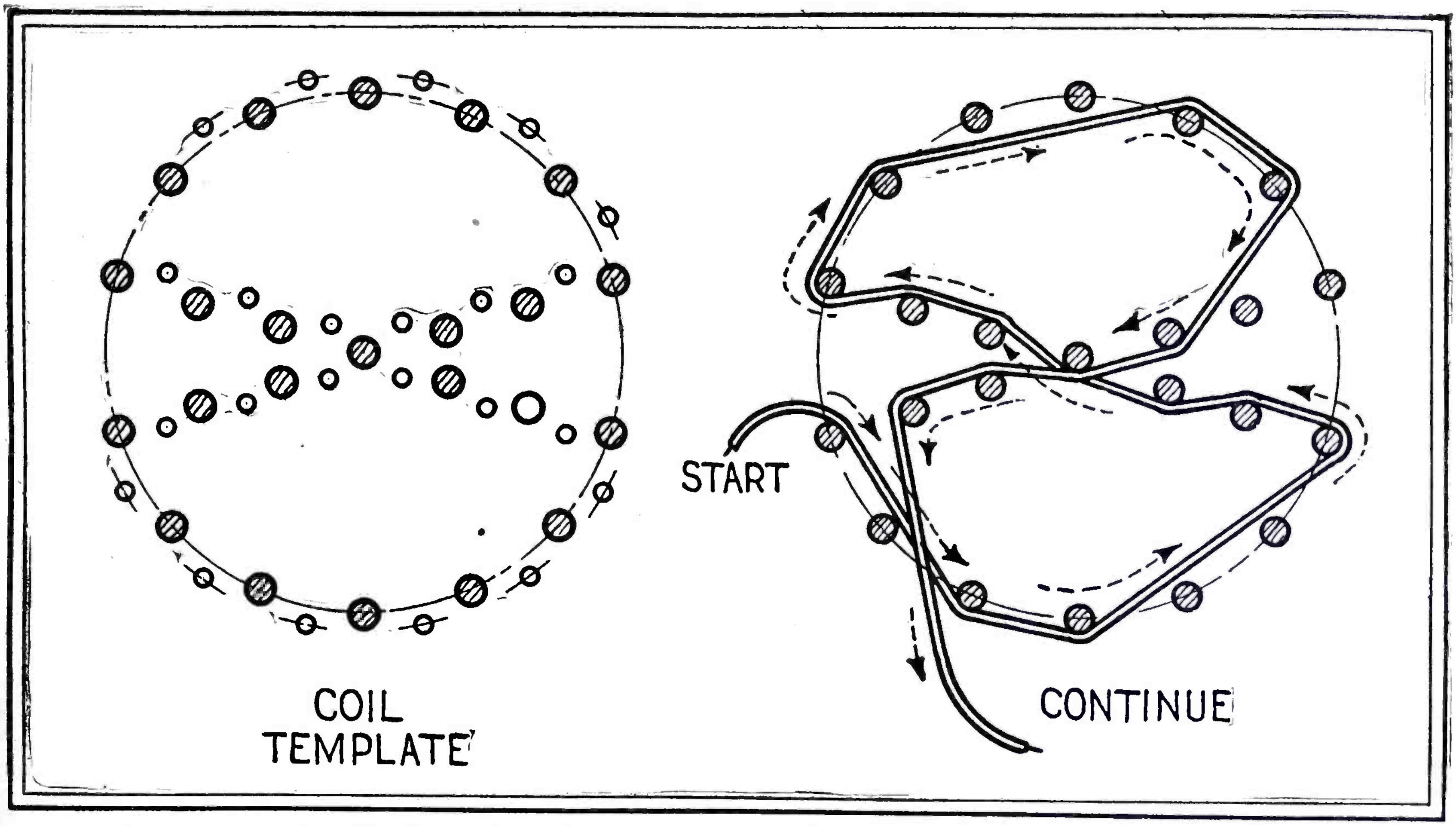
The connections on the oscillator coupler are standard. That is, the beginning of the grid coil goes to the grid of the tube and the end to the filament. The beginning of the plate coil is connected to the B battery and the end to plate of the tube. However, if a mistake is made and the connections placed wrong, all that is necessary is to reverse the connections on one of the coils. Wrong connections make themselves known by refusal of the first tube to oscillate, a condition that is evidenced by the lack of a signal.

The Eight coil may be mounted at the rear of the condenser with two bakelite strips. Provision should be made so that the coupling of the oscillator coil can be varied, although it may be permanently set about one-half inch from the grid coil.

In connection with the grid coil, the placing of the tap exactly in the center is important, as its location is instrumental in preventing oscillations from reaching the antenna.

Wiring Not Difficult

Wiring of the set is a comparatively simple matter. It is all straight away. All that is necessary is to follow the diagram closely. Grid returns are clearly indicated. Note should be taken of the fact that the wire leading from R1 should be connected between the tube and the rheostat. If this is not done, varying the resistance of R4 will have an effect on R1. All the fixed condensers listed are absolutely necessary except C9 and C11. C9 will be required on some audio transformers, while with others its use is unnecessary. C11 is a refinement that is not absolutely needed.



Twenty-four pegs are used in making the form from which to wind the figure eight coils. Care should be taken to have the pegs placed properly or otherwise the coil will not be satisfactory. Note should be taken of the fact that to obtain the Lorenz winding it is necessary to wind the wire over two pegs and under two. This makes every fifth turn follow the same path. The template should be drawn on paper and glued to a block of hard wood, and a bit slightly smaller than the pegs should be used to bore the twenty-four holes represented by the large dots. The diameter of the coil should be three and one-quarter inches. A 3-32 drill is used to bore the holes represented by the smaller dots, they to be used in sewing the coil.

Two C batteries are used, one in the long-wave amplifier circuit and the other in the audio. Another hint that should be called to attention is the placing of the oscillator and antenna coils. These should be mounted at right angles if solenoids are used. When using the Eights, the only care required is that the coils be at least two inches apart, whether at right angles or not.

Binding posts for the various batteries may be placed on the subpanel if one is used, or swung on a bakelite strip below the panel. When using a baseboard the posts may be placed on a bakelite strip raised about an inch above the board.

Making the Eight Coil

In the construction of the Eight coil, a block of hard wood 4 inches square and twenty-four wooden pegs, such as may be obtained from spoked spiderweb forms, are required. The template illustrated is drawn on paper. A bit —such as is used in panel drilling—

slightly smaller than the pegs is needed. Drill twenty-four holes in the block, one at each of the large dots. Now, with a 3/32 bit drill out the smaller dots. These holes are to be used during the sewing of the coil. The pegs are then driven into the large holes, which, by the way, should be drilled so that pegs slant outward slightly. However, the holes within the circle must be absolutely straight. The method of winding, which is the Lorentz system, is clearly illustrated. That is, the over two pegs and under two method is used. The only care required is that no pegs be skipped, for if this is done some of the turns will be placed side by side, defeating one of the benefits derived from the coil. Of course, the wire should be put on as tightly as possible.

The maker is advised to use wooden pegs and not metal, as the metal pegs tend to rub off the insulation on the wire, resulting in a shorted coil. The diameter of the template should be three and one-quarter inches. If it is desired to use solenoids, the diameter of the tubing should not be less than three inches nor more than three and one-half.

When the coil winding is completed, a needle and stout thread are used in holding it together. It will be noted that there are small apertures in the coil over each of the small holes in the block. Through these spaces in the coil the needle is pushed, so that it comes out the bottom of the block. Now the needle is pushed back through the same hole, but outside the coil. Moving to the next hole, the head of the needle is pushed into it, but outside the coil. Coming back, the needle is pushed up through the coil. The thread is tied at the top of the coil, and the sewing process is continued around the coil and across the center spaces.

With the outside sewing completed, the coil is slipped from the pegs. Care should be exercised in doing this so that the insulation on the wire is not scraped off nor the coil bent out of shape. After the coil is off the pegs the inside apertures are sewed, as were the outside. This is much easier, as the block is not now in the way.

If the proper care is taken, it will be noted that we have a coil that has no support except the wire itself, and the thread which holds it together. The thread should be the stoutest obtainable, as it is under quite a strain in the sewing. The wire best suitable is No. 22 double silk covered, or 22 double cotton.

A coil wound in this fashion will consist of two small solenoids whose magnetic fields are opposed. This gives a coil that may be placed fairly close to another in a set without causing unnecessary coupling. With its field so small, it will not pick up stray radio-frequency current, and it handles only that which enters through its lead wires. It contains all of the features of the Lorentz coil as well as the D coil, which, in a sense, are its parents, as well as having a number of its own.

Antenna Coupler

In making the antenna coupler the seven-turn primary is wound on the pegs first. Then is put on the thirty-seven-turn secondary. In making the oscillator coupler, the constructor must not overlook the halfway tap on the thirty-nine-turn grid coil; that is at the end of nineteen and one-half turns. The plate coil, as has been stated, has sixteen turns.

The fan may think that the number of turns given is too few for the condenser used. But the peculiar construction provides a higher inductance with a lower dieletic loss, giving a more efficient coil with less wire, and providing a wavelength range with a .0005 condenser from 550 meters down to above 150 meters.

With our set completed, our task is not yet finished, for we have a number of adjustments to take care of. The tuning of the set will not be described, as it operates like an ordinary super-heterodyne. That is, two places will be found on the oscillator condenser at which most stations can be brought in. Nearby stations, such as those within a half mile or so, may come in at more than two places, but these should give no trouble.

After testing the filament circuit to see that the tubes light and that the B battery has not been shorted onto the filament circuit, the aerial and ground are connected, and a station brought in. The set will probably be found to be oscillating violently and it is up to us to correct this evil with the adjustments provided back of the panel. In the first place, R2 is adjusted until oscillation stops. Then the oscillator dial should be turned to zero. As this point is neared a high-pitched whistle will probably be noted. Now R1 should be adjusted until the whistle disappears.

Learning how oscillation is controlled, we next proceed to perk up the long-wave amplifier. This is done by adjusting the two long-wave condensers. About 50 on the dials will give the most satisfactory volume. Other places may be tried, but the best amplification will be with the condenser plates halfway out.

Completion of this task should be followed by another process of adjustment with R1 and R2, so that our set is working at its best. Then the three panel rheostats are adjusted until a spot is found where good volume is coming through the loud speaker. Of course, care should be taken not to burn the tubes above their rated filament current.

It will be found that the set can be so adjusted that the detector rheostat will act as a volume or regeneration control. The detector tube, it will be noted, can be burned at a very low voltage without impairing volume. The same is true with the oscillator and R. F. tubes. Here it might be well to say that if the maximum is expected from the set 201-A tubes should be used throughout.

After the set has been adjusted to satisfaction, it will be noted that some stations, especially those near the receiver, will heterodyne the station which it is desired to pick up. But this occurs at only one of the two places that a station can be picked up on the oscillator dial, the fact that a station comes in at two places on this control being an advantage rather than a detriment.

What Set Will Do

Now a word as to what our "Hetro Five" will actually do. It not only will separate the Chicago locals, which is an accomplishment in itself, but it will reach into the outside air and bring 'em in on the loud speaker. While this is being put down, the writer's "Hetro" is bringing in WIBO on the loud speaker on four tubes, with WMBB, which is a scant half mile away, going full blast. And the antenna in use is exceptionally large. In addition, during the month of August—also with WMBB going—WPG at Atlantic City was copied on the loud speaker, using all of the tubes.

Of course, as with any set, the antenna system governs to a large extent the volume and selectivity. But with the "Hetro Five," lengthening the antenna gives a greater ratio of increase in volume over drop in selectivity than does almost any other type of five-tube set. However, if the fan desires good volume with plenty of selectivity, the recommended antenna length would be 75 feet. And if the greatest selectivity possible is desired, he can resort to a loop, which, while it will not bring in the distance that an outside aerial will pick up, will log enough DX under favorable conditions to thrill almost any fan.

If the builder has used care in his construction along with good parts, he should not encounter untold difficulties in making the five-tube family perform to the point where the "Hetro Five," using an outdoor antenna, will step along with any multi-tube super-heterodyne, using a loop aerial. Not only that, but it is in a class by itself when compared with a tuned radio-frequency set, using the same number of tubes.

Having thus unburdened in an effort to aid the humble fan in his pilgrimage along the path of better radio, the writer desires to wish you all the luck in the world, and if the "Hetro Five" doesn't hurdle all of the obstacles it should, it's just up to you to make it forget its bad habits.

How to Build the RX-1 Receiver

A Timely Adaption of Tuned Radio Frequency Amplification, Detector, Resistance Coupled and Transformer Coupled Audio Amplification

ONE of the most practical and efficient types of new four-tube receivers which has been offered to the radio fan for home construction is the RX-1 set. This outfit consists essentially of one stage of tuned radio frequency amplification coupled with a high impedance detector and two-stage audio frequency amplifier. The tuned radio frequency circuit and tuner are non-regenerative and the audio amplifier consists of a combination resistance and transformer coupled arrangement. Much interest has been shown in this set throughout the country, and now our Canadian brothers accord it welcome approval. The development of the RX-1 system and constructional details of the set recently appeared in the *Radio Informer* of Toronto, Canada, as follows: :

Since the discovery of the feed-back circuit for regenerative reception, every circuit developed has employed regeneration in one form or another, or else a circuit which normally oscillated, such as the neutrodyne, has been provided with neutralizing devices to stop oscillations and allow the circuit to work just under the oscillating point, leaving it in a regenerative condition.

Regeneration, unfortunately, is unstable. Therefore, any set which depends upon this factor for its efficiency will break into oscillation at the low waves if it is efficient on the high waves. In designing a tuned R. F. set it has been customary to cut down the primary turns on the R. F. transformers to prevent oscillations by using the minimum amount of inductance in the plate circuits. This is not effective. Oscillations are not stopped because tuning the secondary of an R. F. transformer has the effect of tuning the primary, which makes the circuit oscillation anyway. The real result accomplished is to make the R. F. transformer extremely inefficient, producing what amplification it does give by regeneration.

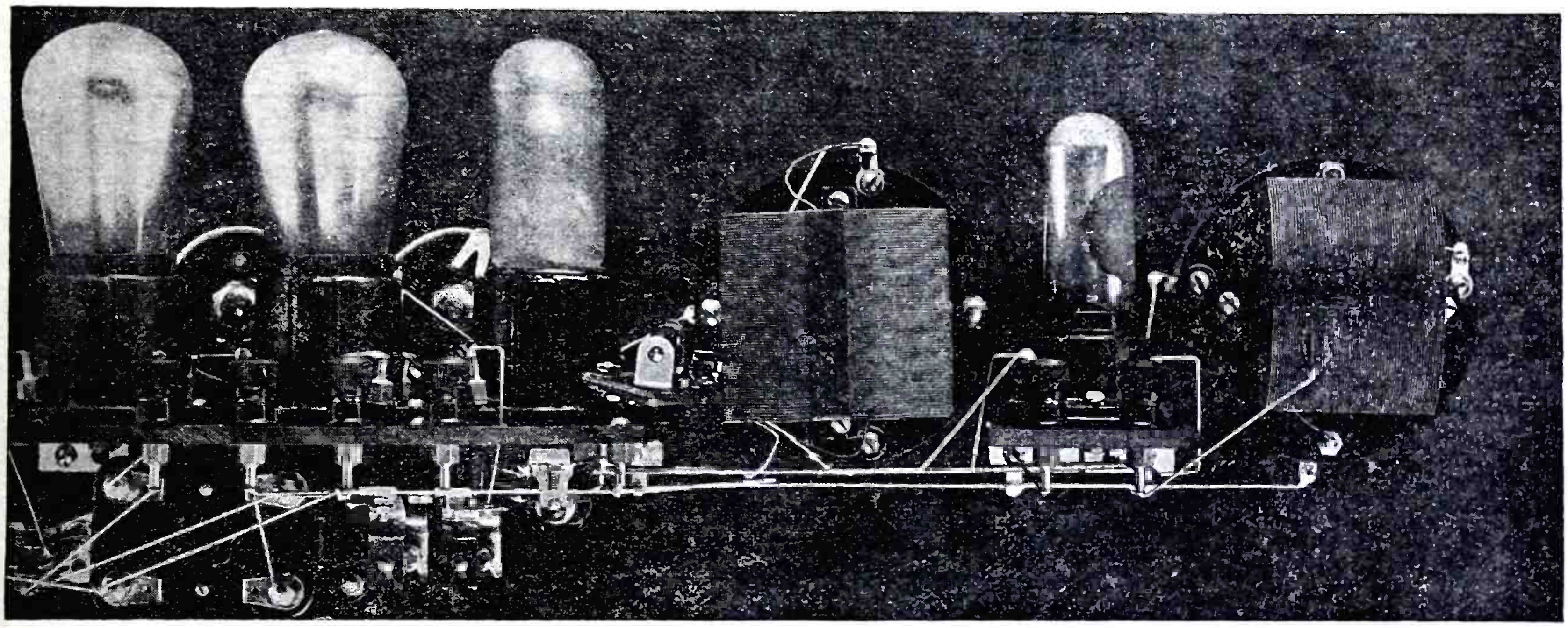
Realizing that regeneration, whatever the circuit to use it, whatever the device to control it, results in critical tuning, howling, poorer quality, and interference at other receiving stations, there has been developed a strictly non-regenerative receiver, a set which operates at exceedingly high efficiency, yet with a circuit so inherently sensitive that it is not necessary to even approach the unstable condition of oscillation to produce full efficiency.

It was in the development work on this set that the RX-1 principle was discovered. Briefly stated, it centres around the use of a high impedance detector tube, preferably one which acts as a rectifier rather than an amplifier, followed by a stage of resistance coupled amplification.

From the nucleus of the RX-1 principle distinctive features are incorporated, such as the long tube life, three or four times greater than in the past, by getting full volume with the tubes operating 20 per cent. below their normal filament voltage. B battery life is greatly extended because of the low current drain. All tuning, over the entire wave-length range, is done without adjusting any auxiliary controls such as a potentiometer, vernier, rheostat—nothing but the two condenser dials.

One of the controlling elements in set design is the expense. Consider any circuit. You can build it into a set which will cost perhaps forty dollars if you use cheap parts, or eighty dollars if you use the best throughout. That is not true with the B4. The parts for this model were chosen for efficiency, regardless of price. Yet the total cost of the parts comes to the astonishingly low amount of thirty-two dollars. It isn't necessary to compromise because of expense. If you spent more you couldn't make the set better.

In the tuning circuit there are Rathbun S. L. W. condensers and Eastern pickle-bottle coils. Since the RX-1 is not subject to radical change and improvement, an RX-1 set is good for several years of operation. For that reason, we want condensers protected from dust. Losses introduced from that source in an open condenser are far greater than those eliminated by the familiar low-loss design. More-



Illustrations by Courtesy of Radio Informer (Toronto, Canada)

Fig. 1. Scientific precision in every detail assures permanently satisfactory results from operation by the most inexperienced broadcast listener.

over, the design of the bearings on these condensers insures long service. The wave-length separation is much greater than with S. L. C. plates, and enough for good tuning.

Pickle-bottle coils are as nearly perfect, from the standpoint of low losses, as coils can be made in practical form. Because of their negligible capacity, they give, in combination with S. L. W. condensers, curves which are as near S. L. F. as spider web and woven coils do with S. L. F. condensers. In radio frequency resistance they are far superior to the various types of coils just mentioned.

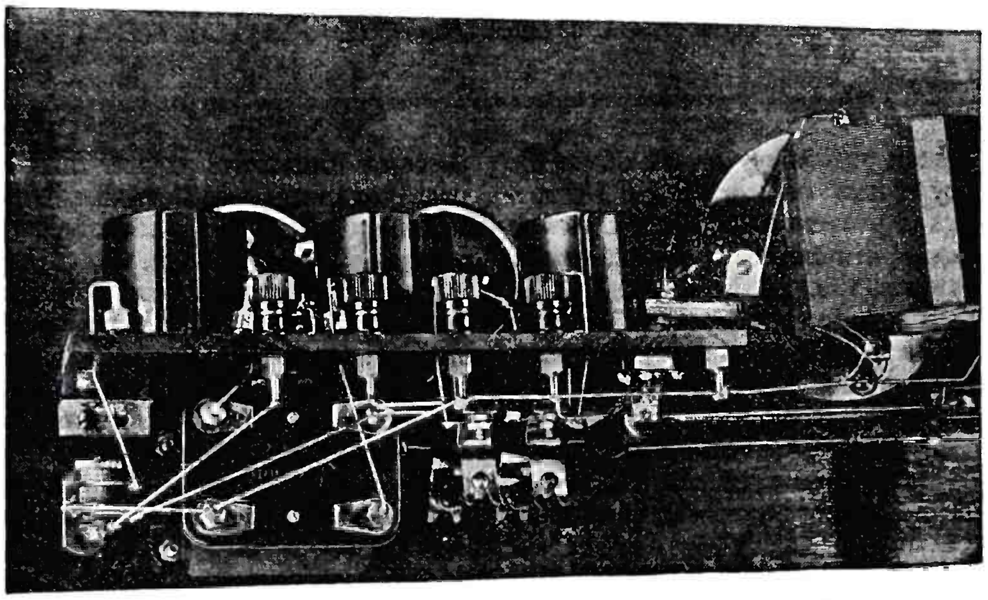


Fig. 2. Close-up view of the audio frequency amplifier, illustrating particularly the use of soldering terminals which make wiring simple.

You will notice that the Daven resisto-coupler is of the new design, with no fixed condenser showing. Here again is an improvement, for Daven has developed this coupler to give an impedance changing by only a few per cent. over the audio frequency range. Resistance coupling to the first A. F. amplifier was employed to produce maximum amplification from the D-21 Sodion, and at the same time it prevents the slightest bit of distortion.

Those who think that resistance coupling takes more from the B battery than transformer coupling will be surprised to find that only 22 volts are applied to the coupling resistance, and that the current is only 0.25 milliampere, or 0.0055 watt, while an ordinary detector with a transformer would take 45 volts at 6.0 milliampere, or 0.27 watt. This is 45 times as much energy as is drawn by the D-21 Sodion.

Again, you may be surprised to see that the transformer in the second A. F. stage has a low ratio. This does not mean that a low ratio transformer of another make would be preferable to the high ratio. This applied only to the Samson type. In order to get perfect reproduction from cone loud speakers, particularly the Western Electric, it was found essential to use a transformer having the lowest possible capacity in the secondary winding. Consequently, it was necessary to use the helical-wound Samson transformer. The effect of eliminating capacity will be noticed if a 0.0005 mfd. condenser is put across the secondary of the Samson. Because of the high volume delivered from the first stage, the 1-3 ratio gave better quality and nearly as much volume as the 1-6 type.

The other parts have been chosen with equal regard to their design and the convenience of using them. A 24-inch panel was used on the original model, but it was reduced to 18 ins. in the final design for the B4 model. However, this did not affect the operation in any way—a further indication of the entire absence of regeneration, which in other sets causes howling from inter-transformer coupling.

You will notice that the layouts for the front panel give the arrangement as it appears at the rear. This allows all parking to be done at the back. Dimensions are given where accurate limits must be maintained.

Two holes must be counterbored or deeply countersunk under the large tube panel. This is to allow the socket mounting nuts to come flush with the under side of the panel because the resisto-coupler fits directly beneath.

Be careful to press lightly and to turn the drill fast so as to keep the holes clean and free from chipping.

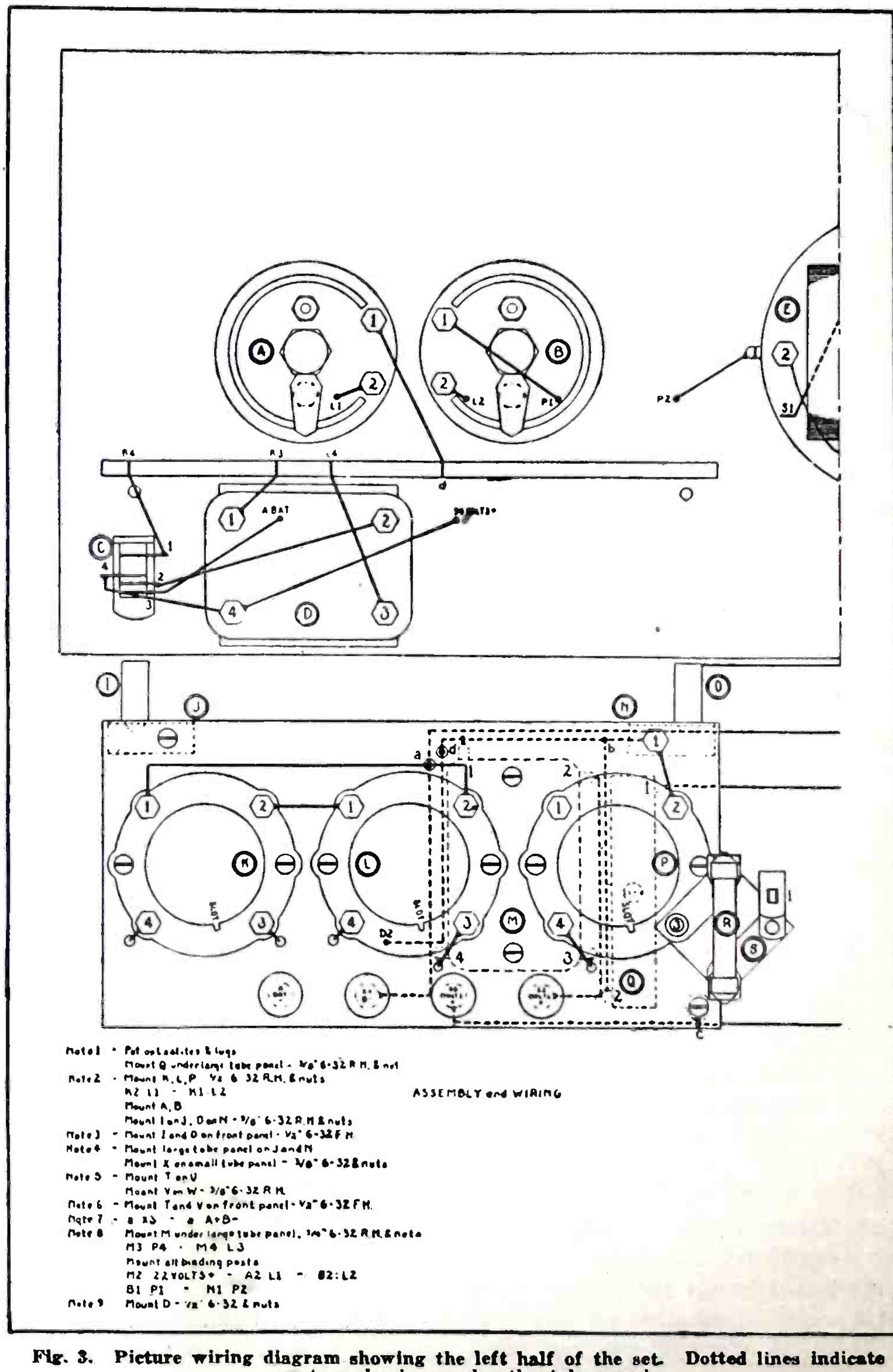


Fig. 3. Picture wiring diagram showing the left half of the set. Dotted lines indicate parts and wires under the tube panel.

You can purchase the set of panels drilled and engraved, if you wish, although the patterns do not show letters for engraving.

A set as fine as the RX-1 deserves the best possible workmanship. Use Wirit for the connections. Straighten it by stretching. Then cut it into 18-inch lengths. You will find it a pleasure to solder connections to the Lastites, for they are easy to use and what is very important, act as their

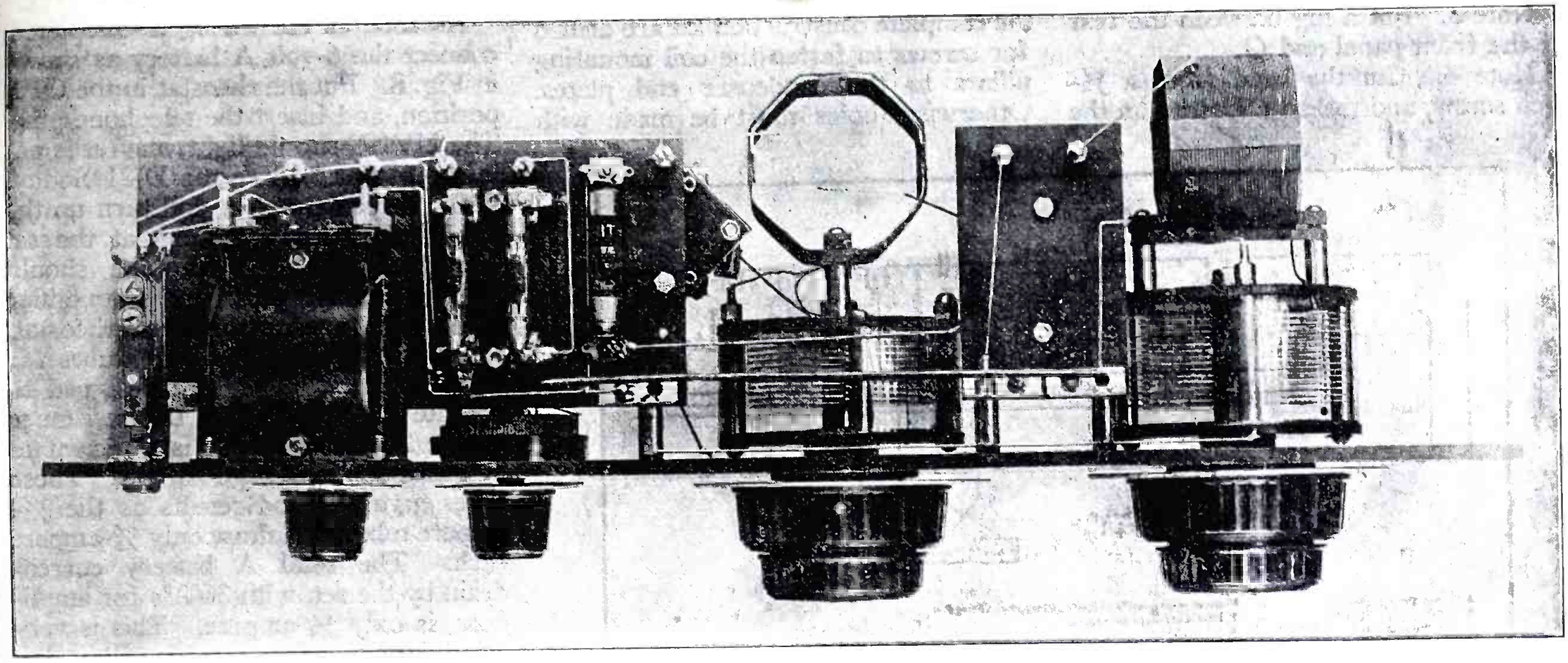


Fig. 5. Bottom view explains the wiring as it is shown in the picture wiring diagram. Notice how short the leads have been made.

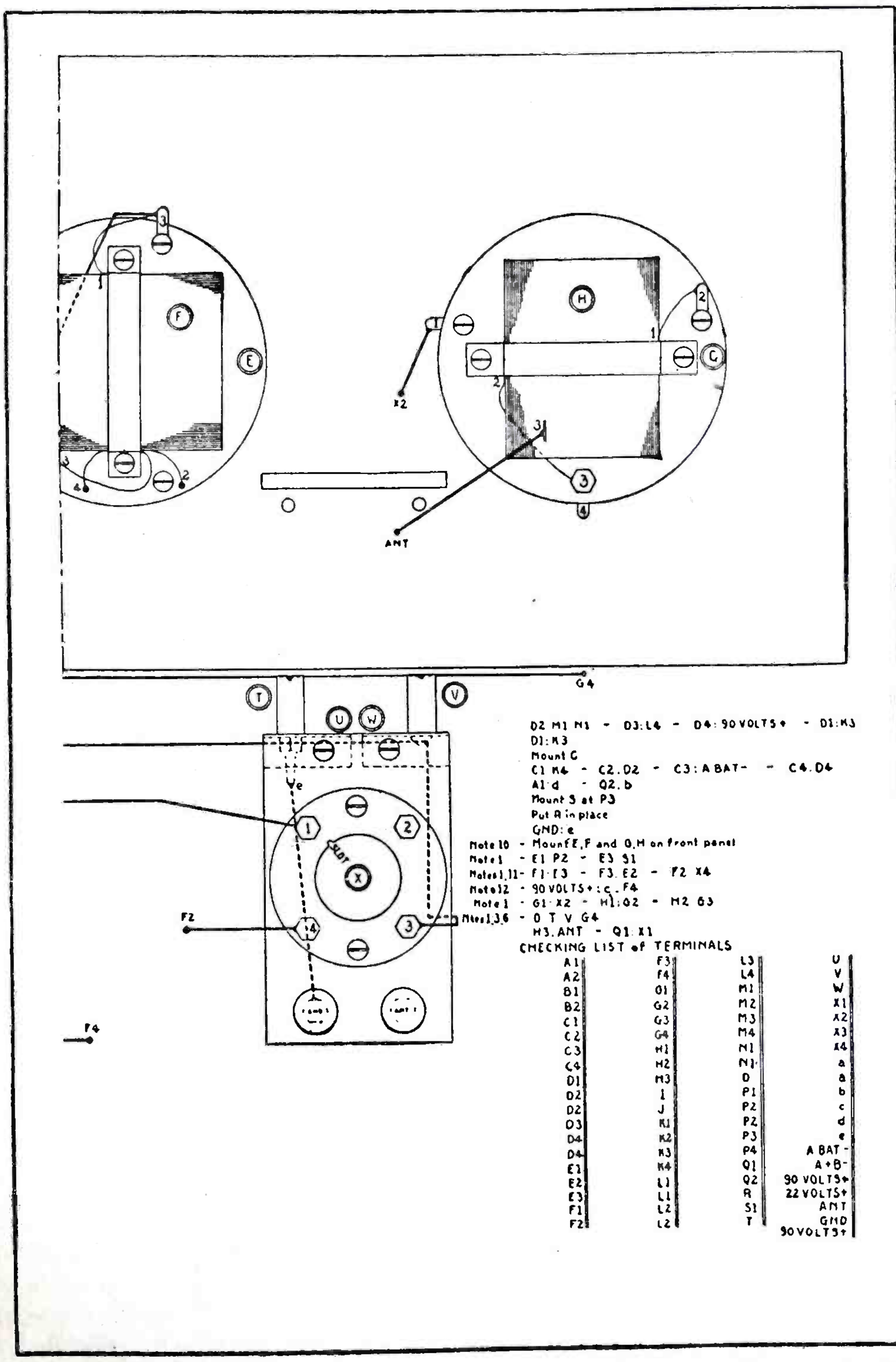


Fig. 4. Right-hand half of the set. The notes on the assembly steps refer to explanations given in the accompanying text.

own lock nuts, since the wires keep them from turning. If you use soldering paste, dip the wire 1/8 inch into the paste. Then put it in the Lastite and solder it. With rosin core solder, melt a little solder on the top of the Lastite, tin the wire, and then, holding the wire in place, apply the iron to the tip of the Lastite until the heat remelts the solder and allows the wire to slip into the hole.

Where two wires are shown going to one Lastite, put only the first one in the hole. On the other wire, make a little hook, and solder it to the first wire near the tip of the Lastite.

Following are the explanatory notes which accompany the assembly and wiring instructions in Figs. 4 and 5. In addition, there is a checking list in Fig. 5. When you make a connection, put a check beside the terminal number. If a terminal is listed twice, two wires go to it. When you have finished, if all the numbers are not checked, you have missed a wire. Small letters, such as a, b and c, indicate joints which are not made to instrument terminals.

Note 1. Lastites are indicated in the picture wiring diagrams by hexagons with the terminal numbers inside. They can be seen in Figs. 2, 3 and 7. If the screws are too long, put a nut on the screw, cut it off to the right length, and remove the nut. This cleans the thread. Notice the lugs E1, E3, G1, G2, G4. Lug E1, is at the front end, fastened to the pillar connecting with the variable plates, and E3 is at the rear, on the pillar holding the fixed plates. G1 is at the front on the pillar holding the fixed plates, G2 is at the rear, on the pillar holding the fixed plates, while G4 is similar to E1. E2 and G3 are Lastites on the screws from the pillars connecting with the variable plates.

Note 2. The adjacent mounting screws on L and P must be cut off so that they will be flush with the bottom of the panel, to allow the mounting of M.

Note 3. Put a lug between the rear of the front panel and O.

Note 4. Cut the head from a ½-inch screw, and thread a Lastite on the screw. Then put the screw through the panel and N. and secure the screw with another Lastite instead of a nut. This makes the top and bottom terminals N1.

Note 5. Cut the head off a ½-inch 6-32 screw, put a Lastite on the screw and use this to fasten T on U. This Lastite is terminal e.

Note 6. Put lugs between T and V and the front panel.

Note 7. Insulate this wire with tubing.

Note 8. Have the plate and grid terminals of the resisto-coupler at the rear of the tube panel. The wiring is put on exactly opposite to the terminal markings, but that is all right.

Note 9. Have the plate and B+ terminals at the bottom.

Note 10. Condensers supplied with the complete construction kit are drilled for screws to fasten the coil mounting pillars to the condenser end plates. Otherwise, holes must be made with a No. 18 drill. The holes are 2¼ inches apart on a line drawn through the center of the shaft, and parallel with the straight edges of the fixed plates of the condensers.

Note 11. F1 is a lead from the secondary, F3 is the other secondary lead, and F2 and F4 are leads from the fine-wire primary coil inside.

Note 12. Terminal c is a Lastite mounted beneath the panel, held by a ¼-inch 6-32 R. H. screw. This is to support the wire running to the lead F4.

Note 13. A clock-wise dial must be used with the Rathbun S. L. W. condensers. Have the 100 division mark coincide with the line on the panel when the plates are totally interleaved.

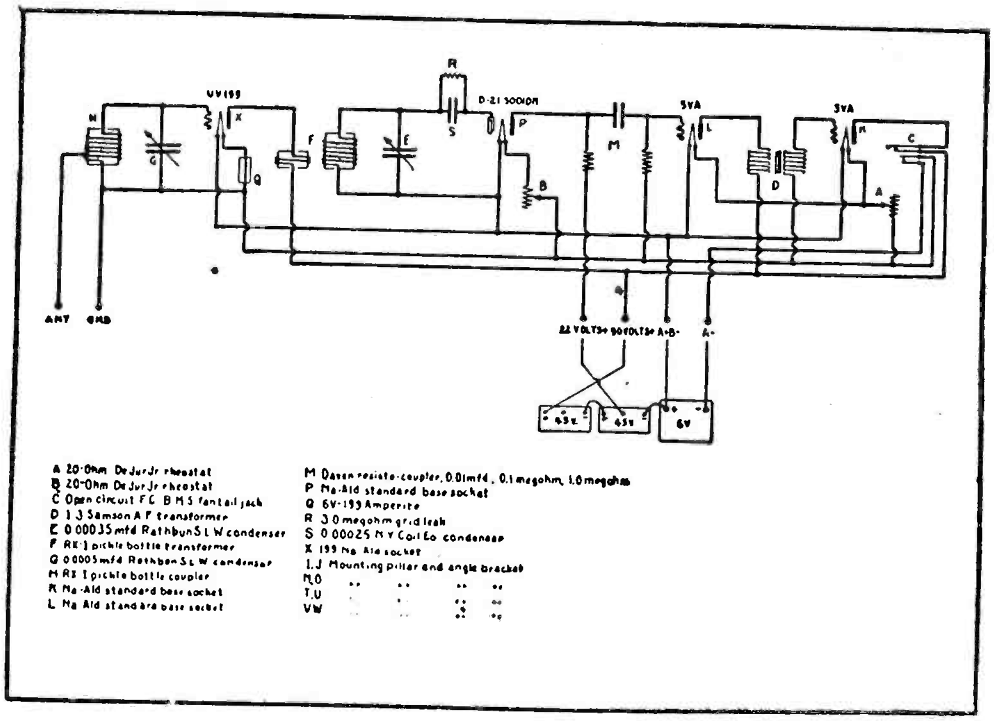


Fig. 6. Theoretical circuit of the RXI receiver.

Testing and Operating

As soon as the wiring is completed, connect the 6-volt A battery as shown in Fig. 8. Put the rheostat in the OFF position, and insert the telephone plug. The UV199 should light when it is put in the socket. Place the D-21 Sodion in the detector socket, and turn up the left-hand rheostat, looking at the set from the front. This tube should light. Finally, put in the amplifier tubes, and turn up the other rheostat.

We used Van Horne 3VA tubes for the amplifiers. They are designed to operate on 3 volts, but the resistance of the 20-ohm rheostat is sufficient to handle a 6-volt storage battery. These tubes give as good results as the ¼-ampere tubes, and draw only ⅛-ampere each. The total A battery current drain by the set, with 3VA's for amplifiers, is only ½ ampere. This is very small indeed when you consider that other sets require five ¼-ampere tubes to give as much volume, and draw 1¼ amperes, or more than twice as much current.

Connect the B batteries and antenna and ground. Do not use more than 22 volts on the Sodion. 90 volts is sufficient for the amplifiers. If you get the new Layerbilt B batteries, they will last almost indefinitely on this set.

The antenna can be a single wire about 100 feet long, including the lead-in, or you can use a small indoor antenna. In places where there is much interference, use an indoor antenna for DX. Have the ground lead as short as possible, run to a clean connection to a pipe which carries water at all times.

You ought to have a high resistance voltmeter for getting the correct voltages on the tubes. Measure the voltage at the socket terminals. For a 3-volt tube it should not be over 3 volts, or

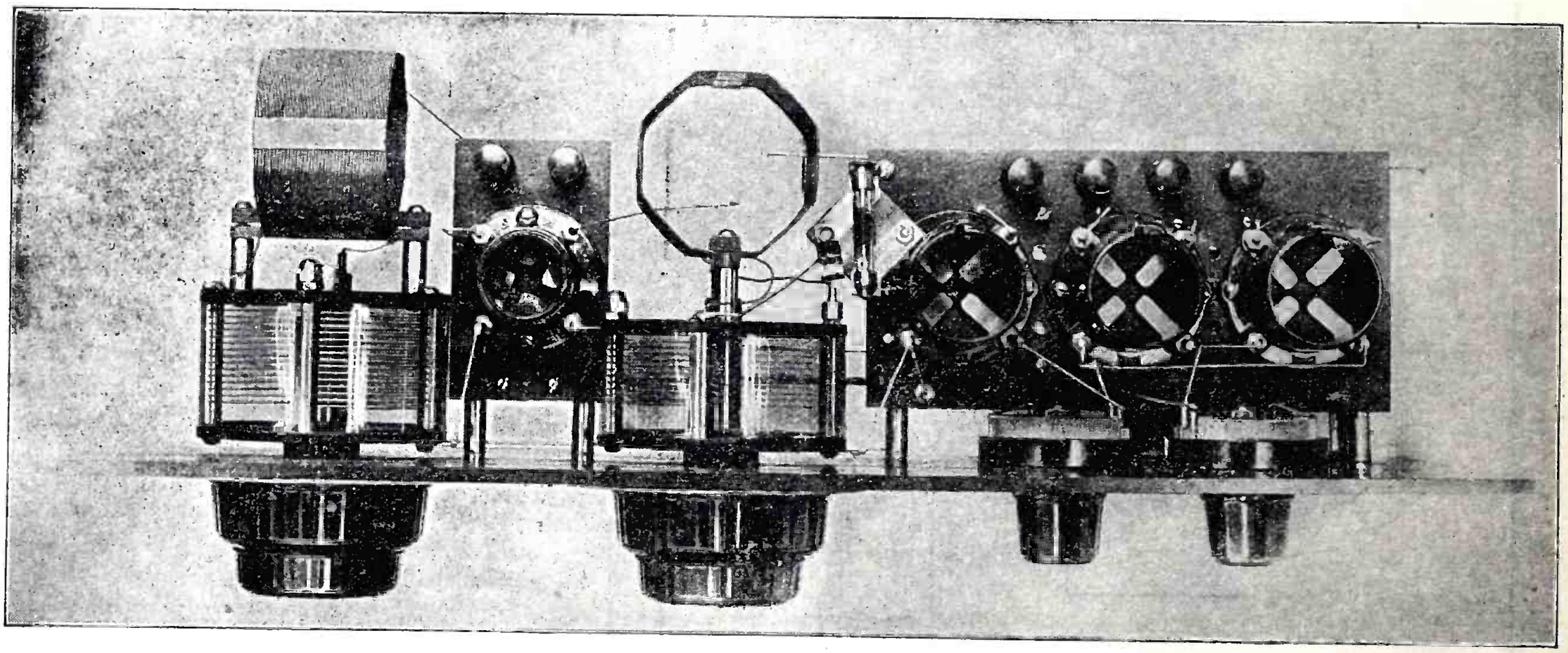


Fig. 7. Under-panel view showing layout and close-up of the coils.

5 volts for a 5-volt tube. Actually, you can get just as loud signals on the RX-1 with much less than the rated voltage, thus increasing the life of the tubes.

As for the tuning—it isn't necessary to tell you how amazingly different it is to tune an RX-1 than any other set you ever operated. You'll be sufficiently enthusiastic yourself when you have had the set going for five minutes.

Special RX-1 Data

For the benefit of those who want to wind their own coils, the following data is given on the number of turns and dimensions. The antenna coil has 58 turns of No. 22 D.S.C. wire wound on a hexagonal form 2¼ ins. across the flats. The antenna tap is brought at the 15th turn.

The RX-1 R.F. transformer has 70 turns of No. 22 D.S.C. wire wound on a hexagonal form 2¼ ins. across the flats. Inside this winding, at the end of the secondary coil, which is connected to the filament circuit, the primary is wound with 20 turns of No. 40 D.S.C. wire. The primary turns should be bunched together just as closely as possible. It is important to use No. 40 wire, for results are quite different with heavier wire.

A number of preserves and pickles are packed in bottles of this size. They make excellent forms because, after the coils are wound, the bottles can be broken out.

The extreme simplicity of the circuit leaves very little possibility for trouble. Some suggestions may, however, be helpful. Do not use an antenna series condenser. If the results seem unsatisfactory, try the 199 in another set to make sure it is O.K. If it burns with excessive brilliance, measure the voltage across the filament terminals on the socket using a high resistance voltmeter. Do not use a pocket voltmeter for that will not give accurate indication.

If the Sodion appears faulty, change the detector voltage. We have found, after testing a number of Sodion tubes, that they are exceedingly uniform, so that there should be no trouble from that source. Do not use nondescript resistance units in the resisto-coupler, or full amplification will not be obtained. If the transformer appears faulty, test the primary and secondary for open circuits, using a battery and telephones. If there are no breaks in the winding, the battery should cause a loud click in the phones. Test also between the primary and secondary. This should give no click at all or possibly a very slight sound, but much weaker than when the battery and phones are put across the primary and secondary.

When the jack is inserted and the tubes are lighted, remove one of the phone cord tips. This should make a strong click in the loud speaker. If it does not, there is an open in the plate circuit of the last tube.

Do not substitute inferior parts in place of those specified, as the cost of this outfit is so reasonable that it is not necessary and even the slightest alterations in the design are very liable to upset the different circuits and very greatly cut down the efficiency and performance of the set.

It is not always possible to make the schematic and picture wiring diagrams look alike. In case of doubt, therefore, follow the picture wiring diagram. Then your design and the results will be exactly like our original model. If the results aren't right, don't blame the drawings unless you have followed them in every detail.

A New Single-Control Regenerator

(*Continued from page 26*)

without whistling and without decrease in amplification on the upper wavelengths. The particular value of resistance required depends upon the way in which the coils are built. In the particular set described here, using 201A tubes, a .0005 mf. condenser and a standard coupler on the market, the best value for r was found to be 23,000 ohms.

The complete wiring diagram is shown in Fig. 5. Two stages of transformer amplification are added to the automatically controlled detector. The various dimensions are given on the diagram. The pick-up coil consists of 15 turns of No. 20 D.C.C. wire wound on a 3-inch tube. The primary winding, to be connected to the antenna and ground, is wound immediately on top of the secondary or pick-up coil, and consists of 12 turns of No. 20 D.C.C. wire. The loading inductance, across the terminals of which is connected the shunting resistance was originally the secondary winding of a standard three-circuit tuner. The primary winding has been removed, as it is not needed in this circuit. The winding has a mean diameter of 2¾ inches and has 41 turns of No. 24 D.S.C. wire on it. The tickler coil has 36 turns of No. 26 D.S.C. wire on it, having a mean diameter of 1½ inches. The tickler coil is located at the end of the main coil.

The resistance used for shunting the large inductance is a special one, having a range of from 10,000 to 100,000 ohms. A close-up view of it is shown on these pages. It consists of a strip of impregnated material around which is wound a wire upon which the slider makes contact. This wire is used merely for the purpose of making good contact with the impregnated material. After being wound around the strip, the wire is cut so that it does not short-circuit part of the strip.

The tuning condenser has a maximum capacity of .0005 mf. and should be used with a vernier or slow-motion dial. The slow-motion dial is required, because when tuning there is no whistle to give evidence of the presence of a station and, because of the selectivity of the receiver, the station is likely to be passed over.

The set should not be used on a very long antenna for ordinary broadcast reception for if it is, it may tune broadly. With a single-wire antenna about 50 feet long, the selectivity is very good.

The general arrangement of apparatus is shown in the photographs. The antenna coupling coil and pick-up coil, wound on the same tube, are at one end of the baseboard, and the loading inductance and tickler coil rotating within it, are at the other end of the base. Next to the latter is shown the variable high resistance, which is also shown in a separate photograph on these pages. The rheostat for controlling the filament current in the tubes is shown next to the antenna coupling coil.

There is a phenomenon in connection with this receiver which will surprise many of those who try it out, and that is that there is slightly greater tendency to oscillate on the longer wave-lengths than on the shorter. This, as everyone knows, is contrary to what happens in the usual set.

In the first place the resistance of the secondary loading coil was neglected, as well as its distributed capacity. The coil capacity causes the inductance to change with changes in wave-length or frequency, so that tuning will be slightly affected. This, at the same time, changes the resistance of the coil, due to the effects of the distributed capacity.

The most important thing which affects the operation of the set is the change of resistance of the condenser by means of which the set is tuned.

A Six-in-One Receiver

A Neutrodyne Type Set Incorporating a Novel Idea for Covering Multi-Ranges

THIS receiving set is really six sets in one. It can be operated with one, two, three, four or five tubes, and as a long or short wave receiver on any or all of the tubes. The limitation of wave-length range, common to most receivers built on the principle of the Neutrodyne, is overcome to a great extent in this instrument by a tapping arrangement, which allows equal volume on all wave-lengths.

L. A. Ringer, who designed the receiver, claims most satisfactory results have been obtained with this arrangement, and we are presenting it herewith to our readers for their approval. Mr. Ringer gives data for the construction of the set in *Science and Invention* magazine as follows:

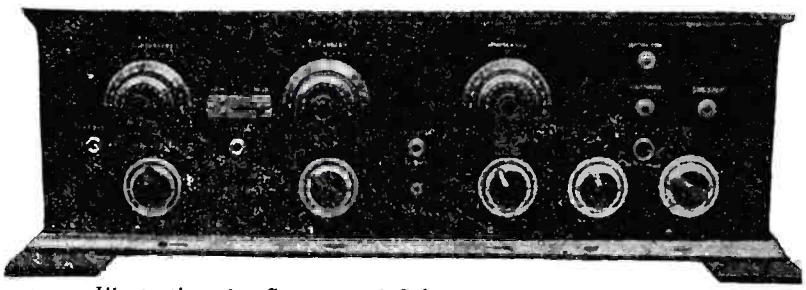
I attribute the success of this set to the coils which I have used. They are made in the following manner:

Drill fifteen radial holes in the edge of the flange of a wooden magnet wire spool (around the circumference of the flange, toward the center) with a No. 29 drill, at such distance apart that the space between them is equal. Some spools differ slightly in diameter, but the holes will usually be about 3/8 inch apart. Be sure to drill the holes in a true circle around the spool. Insert fourteen eight-penny nails in the holes and a wooden dowel, or preferably a piece of celluloid knitting needle, in the fifteenth hole. Do not drive nails or dowel into the spool, because they must be taken out again after the coil is wound. The coils are wound with No. 24 double silk-covered wire throughout.

To wind the coils, first wrap two turns of ordinary wrapping cord next to the spool, winding over one nail and under one. This is to prevent the coil from sticking after being completed. Coils L3, L5 and L7 start at the dowel. Wrap the wire around it once and twist to hold it in place. Then wind on 35 turns, winding over two nails and under two, and again twist around the dowel. This coil is wound to the right with preferably green covered wire. Then let the spool of wire you are using lay in your lap or on the bench without cutting the wire, until the primary coil is wound.

Before winding the primary, wind on four turns of ordinary wrapping cord, over one and under one. Red or blue will make good-looking coils when finished. Wind the primary coils, L2, L4 and L6, with No. 24 D.S.C. wire (white), winding over two and under two, as with the secondary, but to the *left* instead of the right. Wind on fifteen turns, then twist around the dowel and cut off, leaving about six inches of wire for leads. Four turns of red cord are then wound on as before.

Then take the spool of wire you started with, and, bridging the primary coil with a small loop, wind on 10 turns to the right, and make a loop for a tap, then wind on 15 turns, twist around the dowel and cut off. This will give you 60 turns on the secondary.



Illustrations by Courtesy of Science and Invention (New York)
A front view of this rather simple yet very efficient and flexible five-tube receiver is shown in the photograph above. Note the wave-length change switch that is located between the first and second dials. A plug and jack arrangement makes it possible to use from one to five tubes on any desired wave-length between 200 and 600 meters.

Cement the coils along the nails only. Do not cement at the dowel, or between the nails. Then withdraw the dowel until it just clears the spool at the inside of the coil. Then take out all the nails and slip the coil off the spool. Then push the dowel through the coil until it extends about 1/8 inch beyond the inside winding, and cement all leads to it. Use collodion for cementing.

You will then have a low-loss coil with the primary in the center of the secondary, the two coils being wound in opposite directions, and separated from each other by the wrapping cord. The dowel is the mounting.

When connecting the coils in the set, the inside winding is the long wave-length connection, and a tap is taken 30 turns from the inside winding, *after the condensers are balanced* (as described later) for the short wave-length connection. The tap near the outside of the coil is connected to the neutralizing condenser, leaving the outside connection for the grid. The primary lead nearest the inside of the coil is connected to the "B" battery, except on the first coil, which connects to the ground.

These coils are mounted, by means of the dowel, on a piece of hard rubber 14 inches long and 2 inches wide. Bore three holes 6 inches apart, the size of the dowel, and shellac the dowels into them, placing the coils at an angle of about 30 degrees from the line of rubber base (see photos). Put rubber supports one inch high under the rubber base, and screw to the base of set. It is advisable to drill six holes near each coil for No. 6 screws, for connections from coils to other parts of the instrument.

The condensers, 8, 9 and 10, are 19-plate condensers, *with verniers,* preferably of the same make. It is better to get 23-plate condensers and rebuild them to 19 plates, with 10 plates on the rotor and 9 plates in the stator, so that the end plates will be rotary. Selectivity and volume are added to the set by assembling them in this manner. After assembly the plates and washers should be soldered together, in both stator and rotor.

The dials will very seldom read the same, after the instrument is assembled. To remedy this, tune in a station around 500 meters, then remove wire from inside of secondary coils, one turn at a time, on those coils connected to condensers which read lowest, until the readings are same. After condensers are balanced, tap each coil 30 turns from the inside end of winding. This connection is for the short wave side of the switch, as shown in diagram.

The "A" battery is connected to the switch. It will be seen in the diagram that these condensers are switched to shunt either the long or short wave connection. Do not connect rotors to the grids.

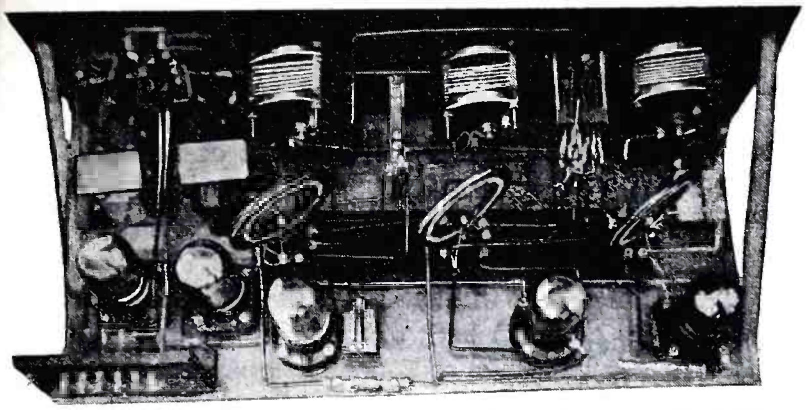
The 1 M.F. condenser by-passes both "A" and "B" batteries, and adds volume and clarity to the results.

Any standard tube will work in this set, but UV201-A tubes are recommended. Note well that each tube has its own rheostat. After you have used this set for a while, you will find great advantage in having the rheostats at hand for tuning.

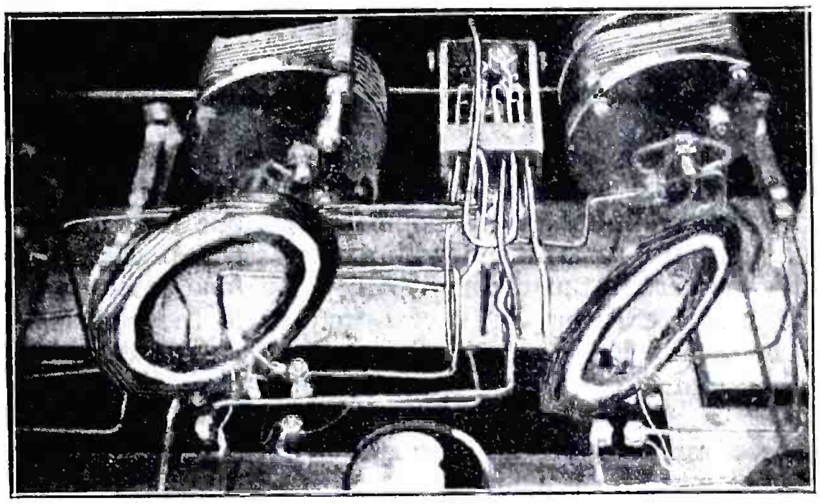
When less than five tubes are in use, the filaments are turned off in those not used. The rheostats all have 30 ohms resistance.

This receiver has several advantages. There is no necessity for using five tubes to bring in a station which is located only a few miles away. The plug, with the antenna and ground connected to it, is inserted in the detector aerial jack, and the station is received on three tubes with the loud speaker and one or two tubes with the phones as desired. Stations between 325 meters and 600 meters are received with the switch thrown to long, and between 200 and 325 with the switch thrown to short.

There is no difficulty tuning through local broadcasting with this receiver.

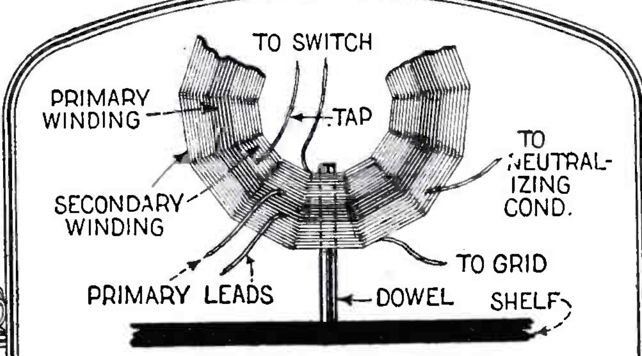


Reference to the photograph above will give the reader an excellent idea of the complete layout of this rather unique receiving set. Note the method of mounting the special coils used. Connections are brought out to a terminal block at the rear of the baseboard.

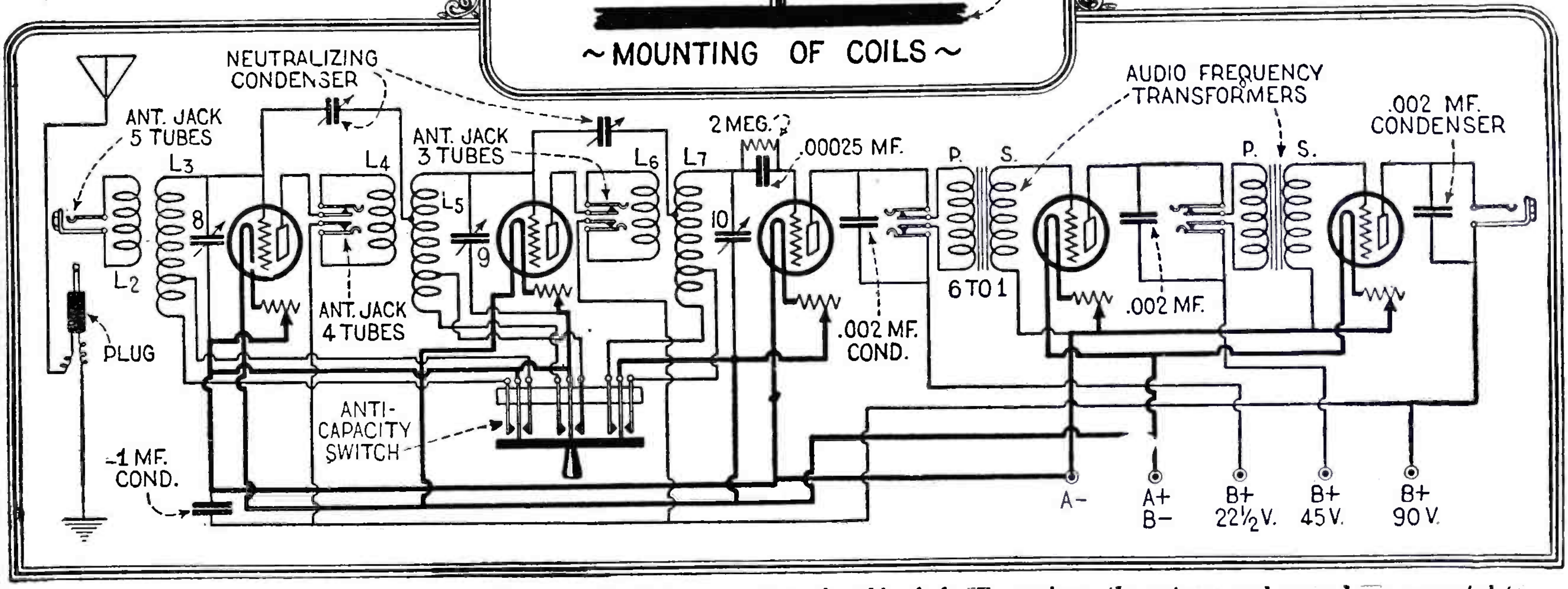


The close-up photograph above shows the details of the anti-capacity switch that is used for changing from the low to the high wave-length band. All of the connections for this switch are shown in the diagram directly below. You will probably have to get a four-pole double-throw switch of the type shown and use only three of the movable poles and six of the stationary contacts. You can easily determine this for yourself when you go to buy the instrument. Note the angles at which the coils are mounted. This helps in keeping the set quiet in operation.

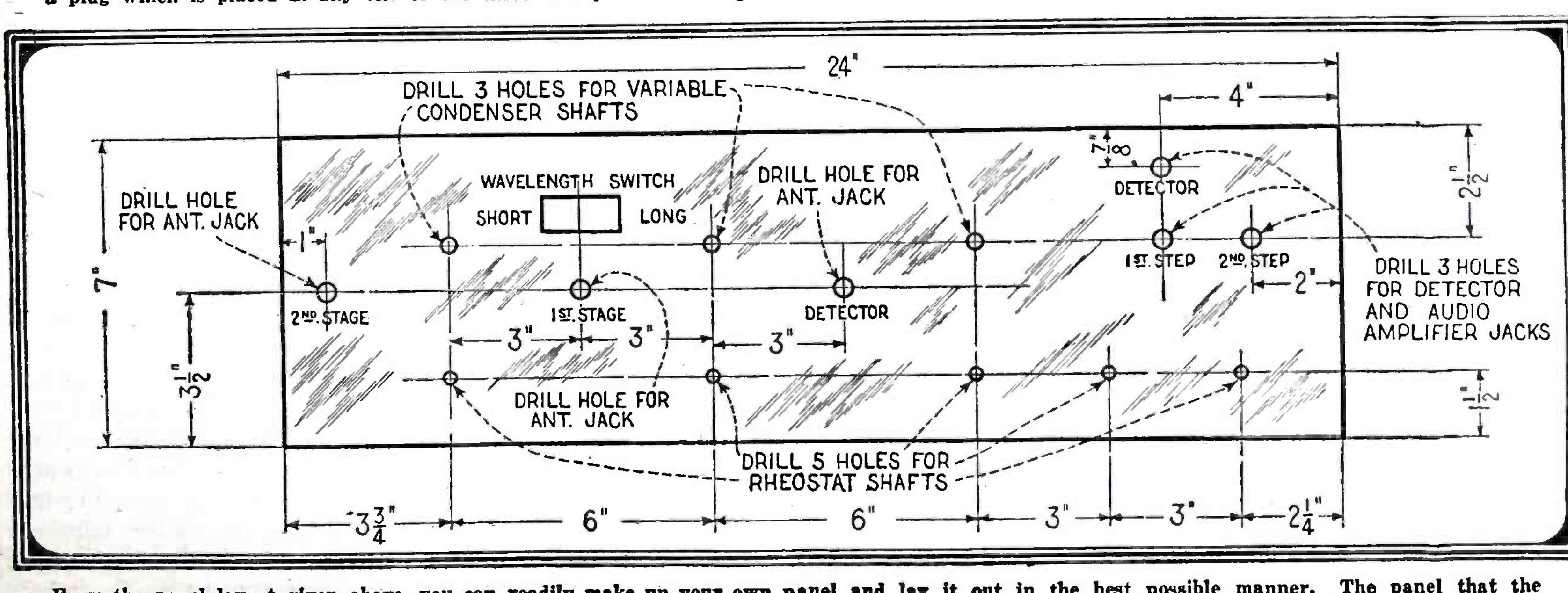
The illustration at the immediate right shows in detail the construction of the specially wound tuned radio frequency transformers that are employed in this multi-wave receiver. Note that the tap which goes to the change-over switch is not made until the receiver has been balanced so that the dial readings are all the same for a given wave-length. The directions for the locating of this tap are given in the text on opposite page. A second tap is made for the neutralizing condenser connection. Make this when winding the second half of the secondary coil.



~MOUNTING OF COILS~



The complete circuit diagram shown above illustrates all of the connections for this six-in-one receiver; the antenna and ground are connected to a plug which is placed in any one of the three first jacks according to the number of tubes that it is desired to use. Turn off tubes not in use.



From the panel layout given above, you can readily make up your own panel and lay it out in the best possible manner. The panel that the author used was 24 inches long by 7 inches wide. Any suitable insulating material may be used but fibre or substances that absorb moisture should be avoided.

The Four-Tube DX Special

A Practical Radio-Frequency Set for Reception of Distant Stations

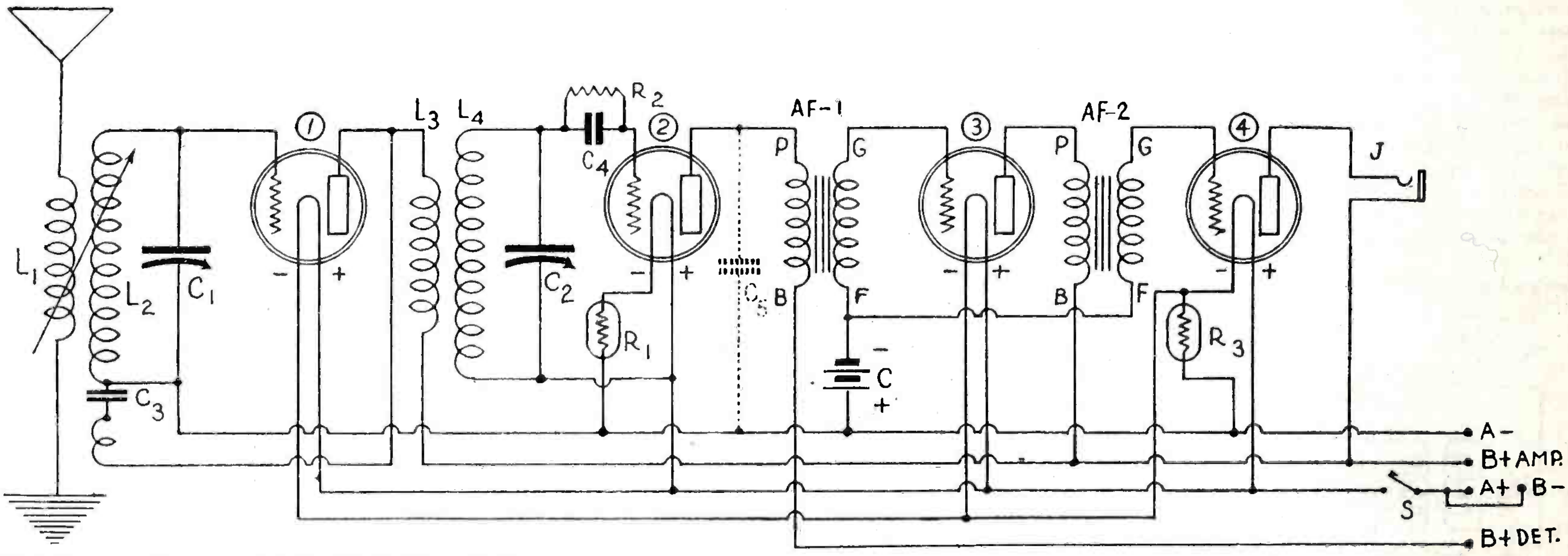
IT has been pointed out time and again that a radio receiver, under existing conditions of development of the art, must be arranged with a view to some certain outstanding quality if the utmost efficiency in that respect is to be obtained. In other words, a receiver that can be relied on to pull in the distant stations with regularity cannot be made to operate at maximum efficiency as far as quality is concerned. Similarly, or rather, conversely, if it is designed to give the last word—if there is any such—in the way of reproduction, it must of necessity be at the expense of some of its distance-getting ability. Accepting this rule as axiomatic, we may say that the quality of one set, if superior at the expense of sensitivity, cannot be approached in another where sensitivity has been made a prime condition.

Peculiarly enough, few attempts have been made to combine these two requisites in one receiver by the simple expedient of providing means for instantly removing the sensitivity and introducing the quality factor. True, there are any number of systems in use whereby a stage of radio frequency can be eliminated by means of a switch or control jack, but these seem to provide merely the customary long distance ability and a way of saving the extra tube when it is not needed for local reception. Writing in *Radio World*, New York, *Herbert E. Hayden* has met and conquered the situation in the following:

The compromise between tonal quality and distance reception is one not easy to achieve in all cases. Where one lives fairly close to local stations and uses a very selective receiver the tone quality will not be very good, due to the power of the transmitters and the drowning effect of the locals. They push their way in, so that the real problem may be to cut them out when desired. Nevertheless, they assure themselves of being satisfactorily received, so that the necessary side bands are accommodated in the set, instead of being chopped off, as is the case when a very selective receiver does not encounter such powerful transmitters of proximate location.

But not everybody lives near to many powerful locals. Such a condition exists only in a few large cities. Therefore it is gratifying to have a receiver that is splendid for the reception of distant stations, when one is after DX, but which receives stations, say 100 or 150 miles away without any sacrifice of quality. This is done by employing regeneration when it is needed and omitting it when it is not. No alteration of the wiring is necessary to achieve this goal. All one need to do is regulate the "B" battery voltage, particularly on the detector plate. As a rule, if 22½ volts are used here, not even free oscillations on the lower broadcast wave-lengths will be encountered. But by increasing this voltage to 45 or just a little more, the regeneration will be ample. It is controlled then by adjustment of the variable primary, L1.

The important part of the radio set, in this case, is in the radio-frequency stage. It is imperative to have a tube that is a ready oscillator. The output of this tube is delivered to two points: (1) back to the grid, through the fixed plate coil, not designated by letter in Fig. 1, and then across the fixed condenser, C3, to the low potential end of the secondary, L2; (2) to the primary, L3, of the interstage coupler, so that the energy is passed on to the second tube for detection.



Illustrations by Courtesy of Radio World (New York)

Fig. 1. The wiring diagram of the A-A receiver, which is convertible in a moment from a DX set to a strictly quality receiver. Thus it may be made as selective as needs require. The antenna coil is variable and may be used for regeneration control.

Feedback Features

Whether there is any feedback depends much on the plate voltage on the detector and, to a lesser extent, on the amplifier plate voltage, and on the C3 capacity.

All three amplifier tubes—one radio and two audio—are connected to the same B plus lead, normally 90, but for louder signals this voltage may be increased, and the grid bias on the audio tubes made greater. For 90 volts on the plates of the two audio tubes 3½ negative grid volts will usually be found all right, while 4½ to 6 may be used if the voltage is increased to 135 (three 45-volt "B" batteries in series).

Without regeneration, you still have a sensitive receiver, one that is bound to pick up some distant stations, and still without any of those common muffling effects due to the elimination of side bands of the audio frequency supplement of the carrier wave.

The Hookup Novelty

The set uses standard coils. For instance, the one in the antenna circuit is a regulation 3-circuit tuning coil, while the other is a radio-frequency transformer of the tuned type. The novelty surrounding the use of the 3-circuit tuner lies in the connections of the rotary coil, L1, and the small fixed coil (not designated). Normally, the rotary coil is used, in other sets, as a tickler to supply inductively fed-back plate current. This is the most common way of using regeneration. But in Fig. 1 the rotary coil, instead of being in the plate circuit, is put in the antenna circuit and used both to regulate the antenna input and to control regeneration because of varying the effective resistance of the antenna upon the tuned secondary. This is a very easy way of handling regeneration, and no dial is necessary, a knob serving the purpose excellently. Even when the set is put in a regenerative state, L1, the rotary coil, may be put in a given position so as to avoid self-oscillation even on the lower broadcast waves. Thus the set, in two ways, may be operated as a neutrodyne would be.

The coil that in the 3-circuit tuner hookup is conventionally the aperiodic primary is here put in the plate circuit of the R. F. tube, to help build up the natural period, so that regeneration will be assured. The result is not achieved, however, unless C3 is sufficiently high enough in capacity. As it is a series condenser, it will reduce the natural period of the plate circuit unless it is of higher value than the reactance in the plate circuit, made up, in this case, of the inductance of the fixed coupling coil in the plate circuit, the capacity of the plate electrode of the tube, and the resistance in those two components.

This small coil connected to C3 is called fixed because it is left in one position, although if it is of the adjustable variety, its position may be varied until best results are obtained, and then the coil is locked at that angle. However, there is nothing critical about this particular coil, and unless the set is fiercely oscillating, it matters little what position the coil occupies. This is because it is used for its inherent self-inductive value, no reliance being placed on the chance mutual inductive coupling that may result between it and L2. The 3-circuit coil used in the set shown in the photographs was the Aero antenna coupler, while the interstage transformer was the Aero wave trap unit. These have an inductance rendering them available for tuning with .0005 mfd. straight-line frequency condensers. The Amsco allocating type was used and the circuit called the A-A, for the Amsco and Aero instruments.

LIST OF PARTS

- 1 aero antenna coupler, L1L2.
- 1 aero wave trap unit, L3L4.
- 2 .0005 mfd. Amsco allocating straight-line frequency condensers, C1, C2.
- 1 Daven Leakandenser, R2, C4.
- 7 engraved G-K spring cap binding posts.
- 2 Fynur dials.
- 1 knob for ¼" shaft.
- 1 .0005 mfd. Hilco fixed condenser, C3.
- 1 .001 mfd. Hilco fixed condenser, C5.
- 4 standard sockets.
- 1 7x21" Radion panel.
- 1 7x19" baseboard.
- 2 Ambassador Low-Boy A.F. transformers, AF1, AF2.
- 1 ¾-amp. Daven ballast, R3.
- 1 1-A Amperite, R1.
- 1 Yaxley filament-control jack (or 1 "A" battery switch and single-circuit jack, J).
- 2 Eureka dial pointers.

Accessories: Two 45-volt "B" batteries, one 4½-volt "C" battery, one jack plug, one speaker, one storage "A" battery, aerial wire, lead-in wire, ground clamp, lightning arrestor, four tubes.

Tuning to Step

The two condensers will tune approximately in step. If there is any divergence, readjust the dial that gives the lower reading, to make it conform for some midway station with the reading on the other dial for that same station. This will mean a station of about 360 meters wave-length. For instance, if the reading is 45 for the left-hand dial and 50 for the right-hand one, then leave the right-hand dial alone and adjust the other so that it reads 50 also for the same station. The synchrony at one point may not be preserved all the way through, but the divergence will be slight.

The idea of simplicity was carried out, so far as possible, in the entire A-A set. No rheostats were used. A ¾-ampere ballast was employed to regulate the filament heating of all three amplifier tubes. This was a Daven product. The detector tube filament voltage was cut down to the required amount by using the 1-A Amperite. The set employed 6-volt storage battery tubes. The 201A, 301A or DV5 may be used throughout or interchangeably, but remember that the detector plate voltage may have to be changed for best results if you change tubes.

Another item of simplicity is the use of the Daven Leakandenser, a combination grid condenser and a grid leak (2 meg.).

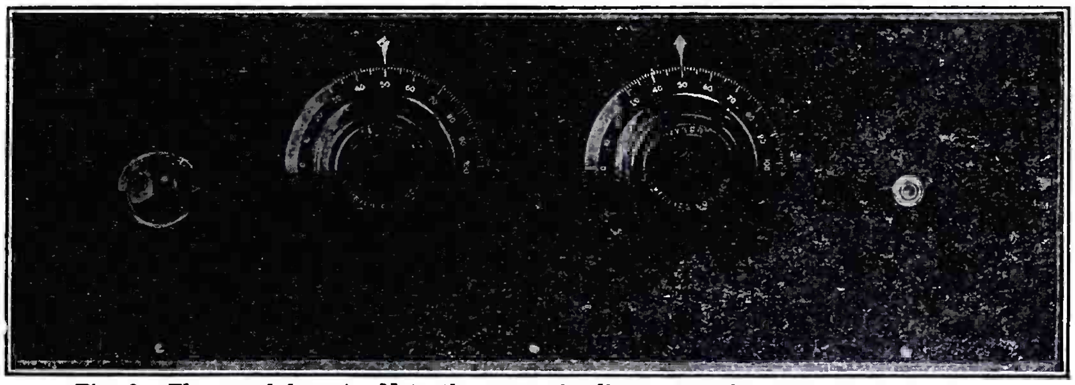


Fig. 2. The panel layout. Note the utter simplicity. Vernier dials are necessary.

Fig. 3. The rear view of the A-A. The flexible "C" battery leads should be brought out between the third and fourth tubes (at left). Note particularly how L3L4 is mounted on the backs of the two SLF condensers.

The constructor may use an "A" battery switch to turn the set on and off as a unit, as shown in Fig. 1, or may use instead, a filament control jack. The diagram shows a switch, the A minus lead being interrupted therefor, but the photographs reveal a filament-control jack. With a switch there is, of course, that extra item on the panel, not shown in the photographs, while with the FCJ it is necessary to remove the speaker plug when the set is not in operation.

Panel Data

The set is constructed on a panel, 7x21", with the variable condenser shafts well spaced apart, to allow sufficient room for unrestricted operation of the Amsco allocating straight-line frequency condensers. You may follow the same layout as shown on the

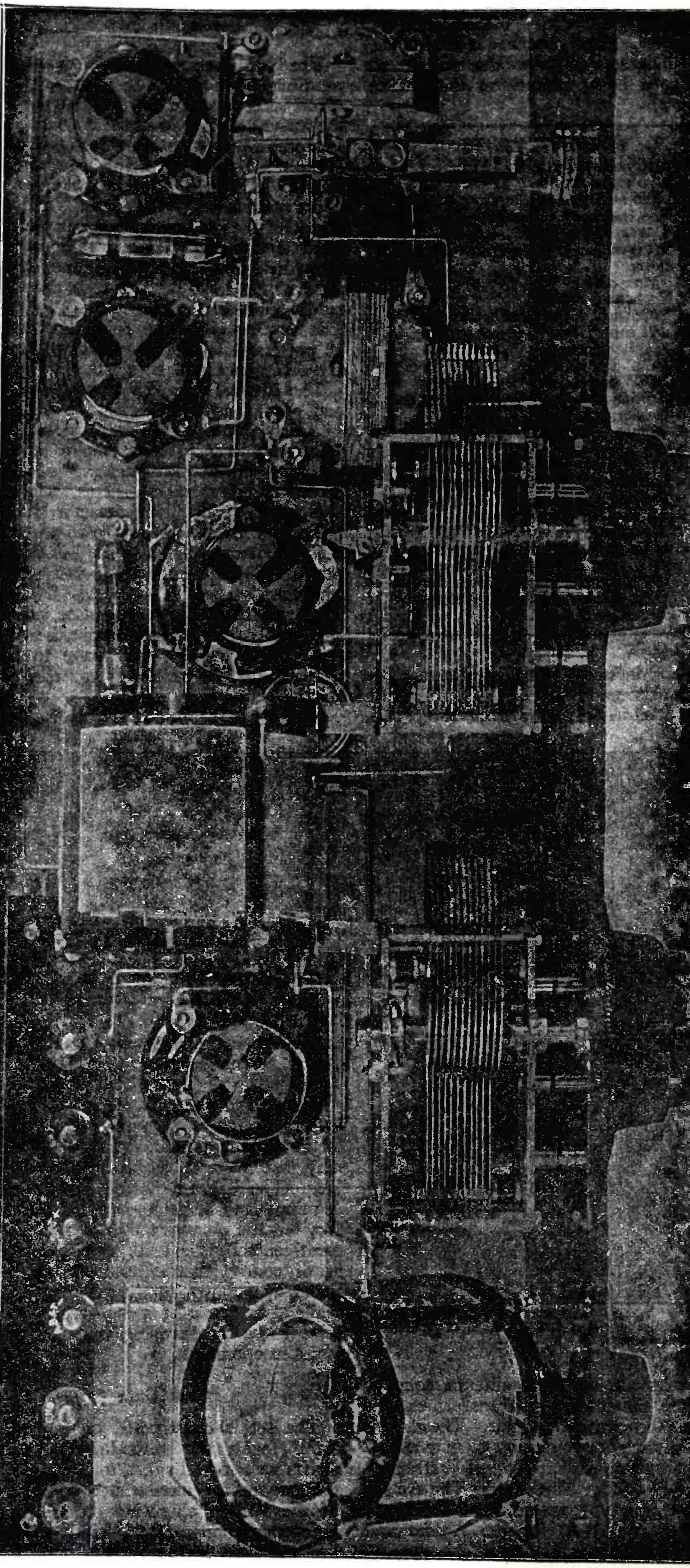


Fig. 4. Top view of the receiver showing the location of all parts on panel and baseboard and plainly revealing the wiring. One fixed condenser is obscured by the coil at the left of the illustration.

panel, or may change it slightly to meet any particular choice of your own, but it is well to play safe and use the panel arrangement as revealed in the photographs. The dimensions will be all right if you measure them in the photograph of the panel view and multiply by 5.

The baseboard is 7x20" and most of the parts are laid out thereon. The full-length picture, more than half the original size, plainly exposes the location of the board-mounted parts. Note the manner in which the interstage coupler is mounted on the backs of the two variable condensers.

"C" Battery Wiring

The "C" battery leads are not shown photographically as they would have obscured part of the pictures. Flexible wire is used. There are two leads, each 6" long. The wire must be insulated. At both ends of each lead scrape off a little insulation. Connect one end of one of the flexible leads to A minus. If a FCJ is used, this may be done at the jack. One end of the other lead is soldered to the F posts of the two audio transformers. Identify the lead from the A minus as C plus and the other as C minus and connect to "C" battery accordingly.

Binding Posts

The binding posts have a secure grip and may be used for either plain wire, in which case the wire tip is passed through the hole in the binding post shaft and the sprung knob is released upon it, or if lugs are used, lift the knob, insert the lug and let go. These posts are G-K Spring Caps.

Precautions

See that the variable primary L1 is nearer the A minus connection, which goes to the rotor plates of C1. The C3 connection, therefore, also is made at the L2 terminal nearest the primary. If a home-made 3-circuit coil is used, you should put the rotor shaft just above the secondary, which would force the plate coil at bottom, next to the end of the primary. The end of the plate coil goes on C3. In the Aero coils, made by the Aero Products Co., the small windings are inside the large ones.

The Coils

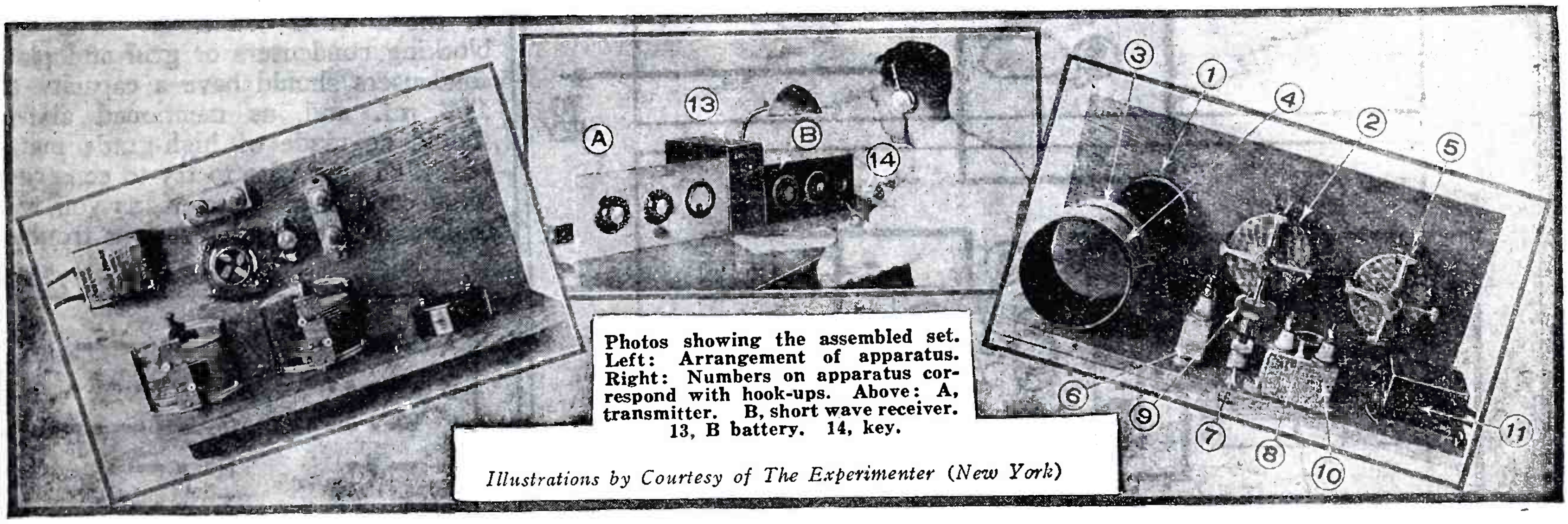
The correct inductance will be the result if one uses a 3¼" outside diameter, 4½" high, and winds 60 turns of No. 22 double cotton covered wire for the secondary, L2. Leave ¼" space, wind 8 turns for the plate coil. The rotary coil is wound on a form 2¼" outside diameter. The same kind of

(*Continued on page* 50)

A Low Power Transmitting Set

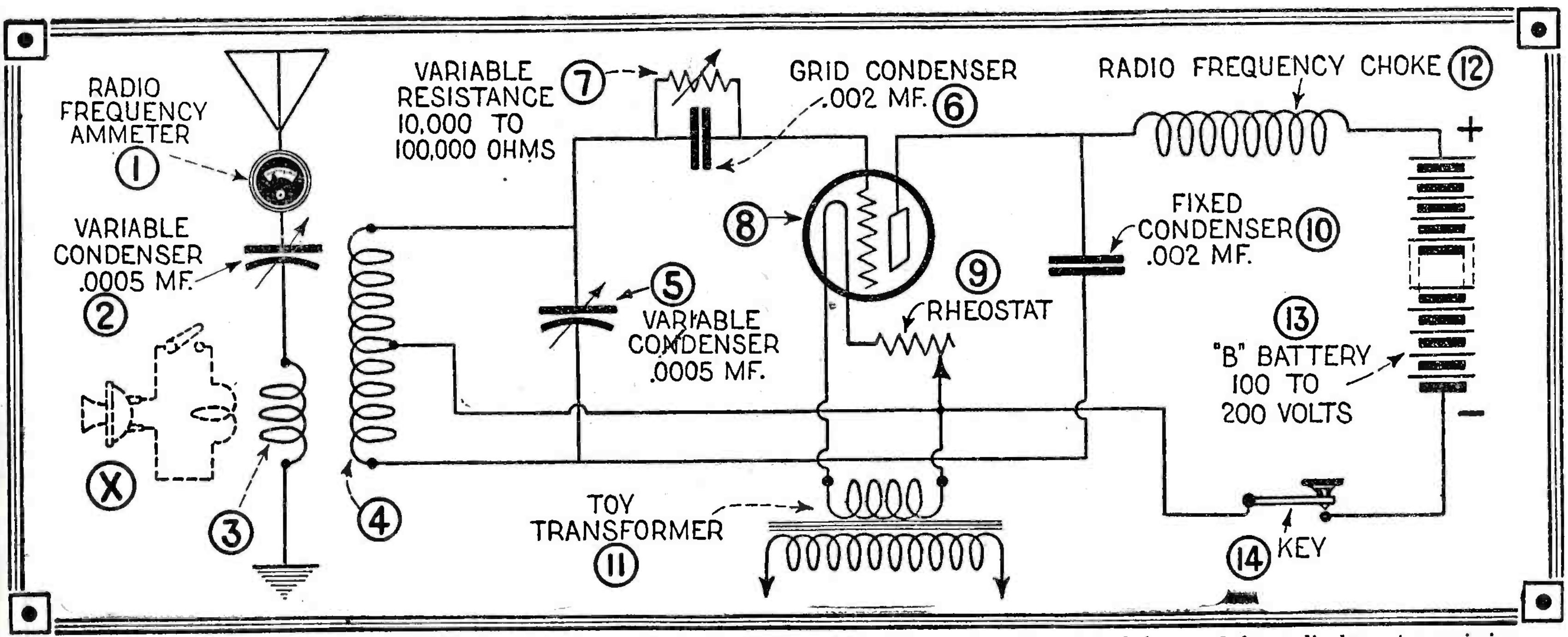
Directions for Building a Complete Low Power C. W. and Phone Outfit

SO many of our readers have expressed interest in the subject of radio transmission, both in code and by phone, that we have decided to present some detailed information on the subject, which, if carefully followed, will enable the reader to obtain very good results in transmission. In the following article from *Science and Invention* magazine, *A. P. Peck* gives data on the construction of a very simple transmitter, using a high voltage "B" battery for supplying the plate potential.



Photos showing the assembled set. Left: Arrangement of apparatus. Right: Numbers on apparatus correspond with hook-ups. Above: A, transmitter. B, short wave receiver. 13, B battery. 14, key.

Illustrations by Courtesy of The Experimenter (New York)



A schematic circuit of this simple transmitter is given above. The key must be closed when the set is being used for radiophone transmission. The radio frequency choke, 12, consists of 250 turns of No. 28 or No. 30 S. C. C. wire, wound on an insulating tube 2 inches in diameter. This coil is not shown in the photographs above. The rheostat is of a standard carbon disc compression type.

License Required

Before attempting any transmission whatsoever, the reader must remember that this work cannot be done without a government permit which takes the form of two licenses. One of these licenses is for the station and the other is for the operator. The first of these can be obtained as soon as the station is put into actual operation and as soon as the wave-length has been set at which the station is to be operated. The license for the operator, however, must be obtained first. You need not even have a transmitting station in order to get an operator's license, but you must have an operator's license before you can get a station license. The operator's license is comparatively simple to obtain, and the only thing that will hold you back at all is the code speed test which you must pass. In order to operate an amateur station, one must be able to receive at a speed of at least ten words per minute in the International Morse Code. In order to attain this speed, constant practice for a period of one or two months is quite necessary. A copy of the code is given on the next page. Equip yourself with a key, buzzer and battery connected in series so that when the key is pressed the buzzer will operate. Practice the code with this arrangement and also if possible listen in on some of the amateur transmission that is always going on. Try to copy some of the code that you hear, and after some practice you will be able to do so.

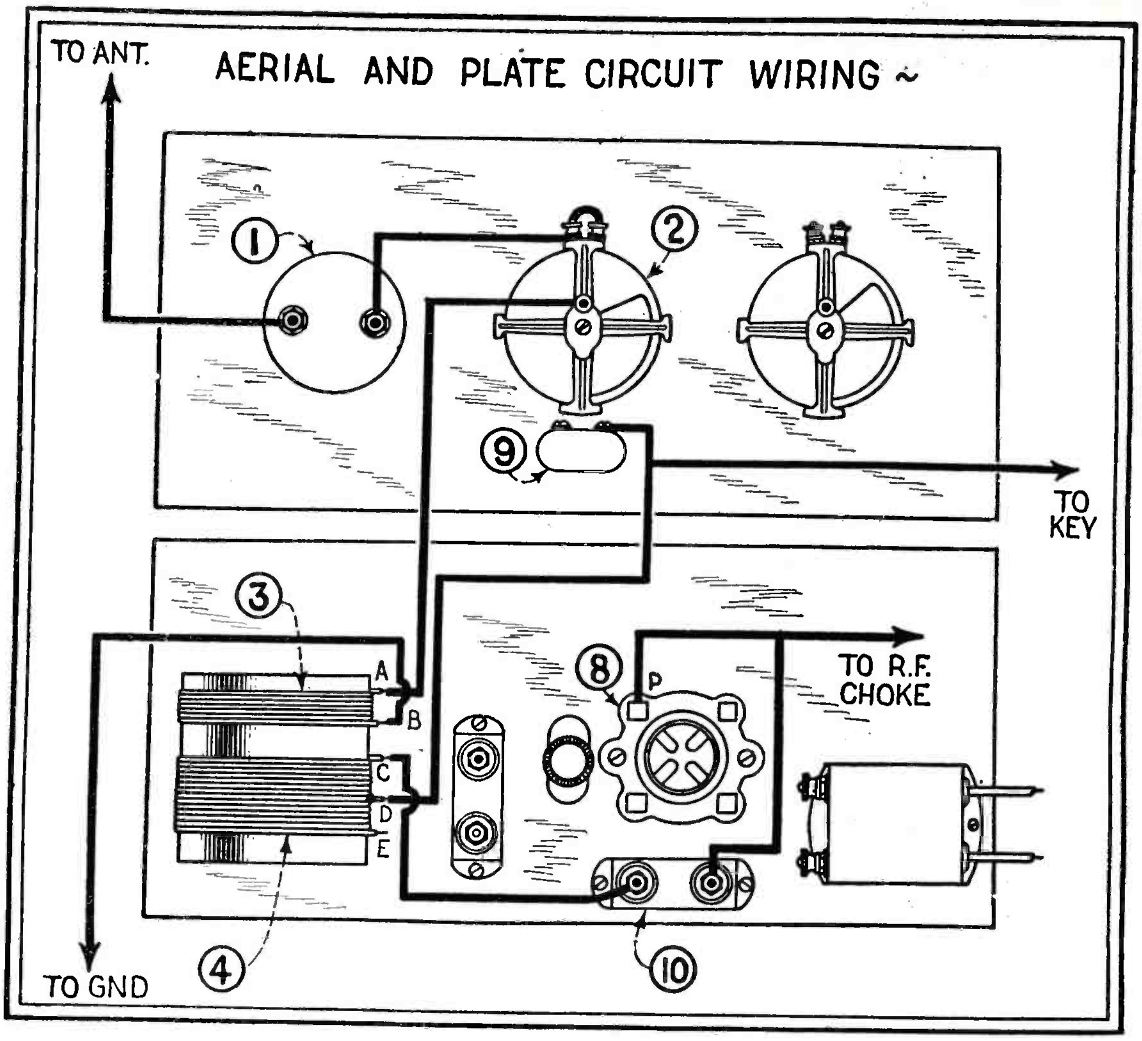
In any event, you will have to equip yourself with a good short-wave receiver before you can do any actual work in amateur circles, and therefore we would suggest reference to the article on this subject appearing in the October, 1925, issue of RADIO RE-

VIEW. After you have acquainted yourself sufficiently with the code and put it into practice, you should proceed to the nearest Custom House or Radio Inspector's office and take your examination for a first-grade amateur operator's license. If, however, you live too far from this point to make the trip, you can obtain a second-grade amateur operator's license by applying by mail to the Radio Inspector. He will furnish you with blanks which must be filled out and returned, whereupon your license will be issued. This, however, is good for only one year and within that time you must appear for a personal examination.

"B" Battery as Plate Supply

In the type of transmitter that we have illustrated on this and the succeeding page a storage "B" battery is used as the plate supply. Dry "B" batteries could, of course, be used, but the drain on them would be so great that the operation of the set would not be at all economical. With a storage "B" battery which can be charged frequently, operation will be more reliable. If you use a set of this nature for three or four hours every night, the "B" battery should be charged at least every other day or possibly every day.

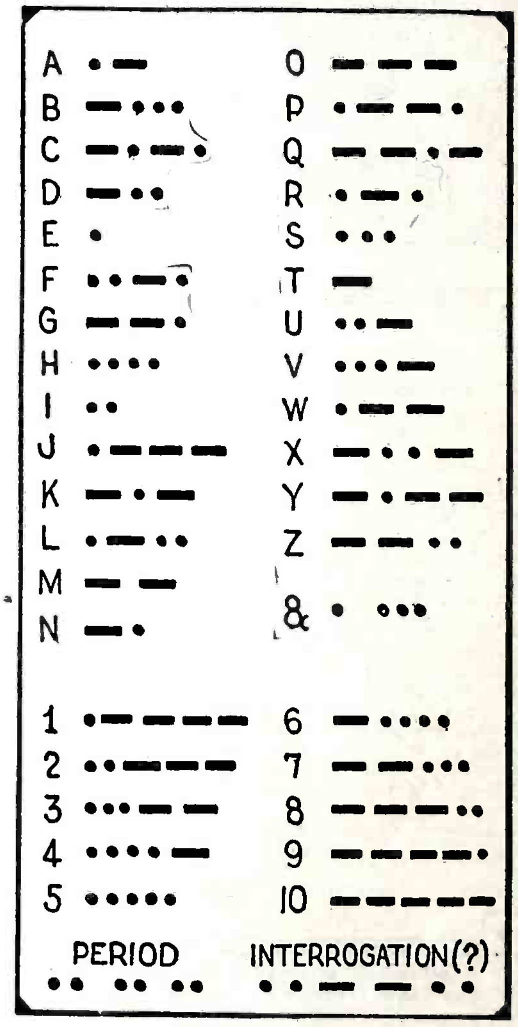
Do not think that just because higher power is not used in this set that it will do no good work. In fact, many United States amateurs have made contact with European amateurs using only a UV-201A tube with a potential on the order of 150 volts applied to the plate. This, of course, is rather exceptional work, but with a set of the type described you can easily depend upon transmission over a radius of 100 miles and even more with C. W., as continuous wave code transmission is known, or over a distance of 5 or 6 miles on phone. The set is rather inexpensive to build.



Above is shown the first progressive wiring diagram in which the aerial and plate circuit wiring is shown in detail. The grid leak is mounted on the baseboard rather than on the panel so as to reduce the length of the grid leads. Once it is adjusted for best results, it need not be changed until the tube itself is replaced by another. However, a change in the grid leak adjustment will sometimes be found beneficial when shifting from one certain wave to another in a different band. Details of coils are given on the next page.

Even though high voltage is not used, there are certain of the instruments which should be purchased with the idea in mind that some time you will want to increase the power of your set. You will undoubtedly want to do this as soon as you have been on the air for a few days and have been deeply bitten by the transmitting bug. Therefore, when you buy meters, obtain good ones inasmuch as poor meters are an unwise investment. The same rule applies to variable and fixed condensers. In the set illustrated here, the two fixed condensers shown can be used in any type of amateur transmitter with powers up to 100 watts or even more. Obviously, they are far over size for the type of transmitter under discussion, but you might as well get them now and then you will have good condensers that can be used in other sets. The same applies to the variable condensers—get good ones at first and you cannot go wrong. The writer is using two of the type shown in this set in connection with another amateur transmitter in which a 50-watt transmitting tube is incorporated. These variable condensers stand up very well even under high plate voltage, and only one of them has arced over and that only happened once when the transmitter was not properly adjusted.

The two tuning condensers, one of which tunes the oscillating circuit and the other of which tunes the antenna circuit, should have a capacity of .0005 mf. For 80-meter work, use only half of the antenna condenser. The two blocking condensers or grid and plate condensers should have a capacity of .002 mf. and, as mentioned above, should be made of high-grade material. It is not wise to try to construct these condensers yourself, as you will undoubtedly encounter serious trouble.



Above is given a chart of the code that you must learn in order to send and receive radio messages with this C. W. transmitter. You must be able to pass a speed test in order to get your transmitting license. The requirements are ten words per minute, five letters to the word.

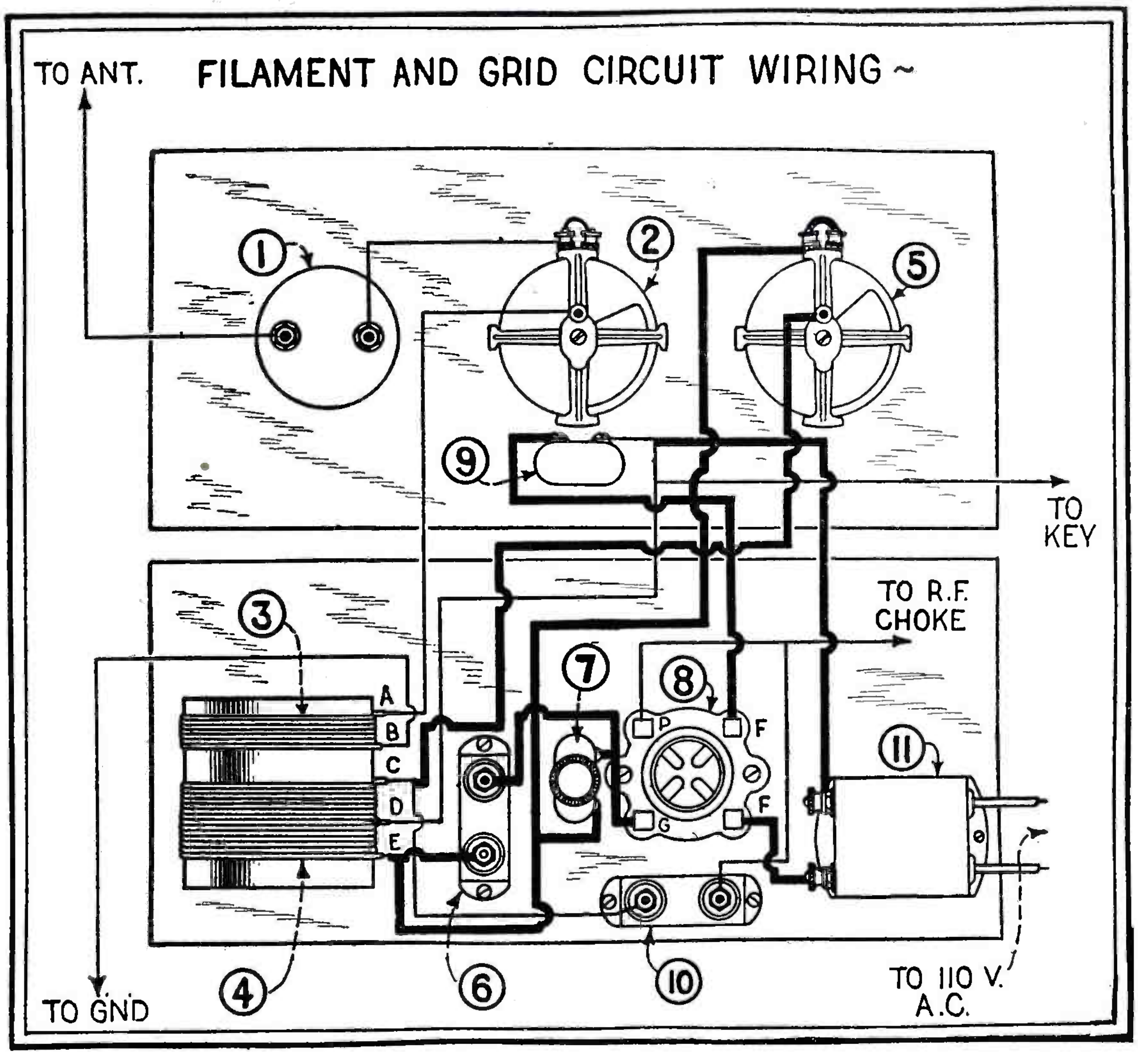
Of course, if you wish to use only low power and are sure that you will never want to build a higher powered set, small receiving condensers of the mica insulated type can be used for these blocking condensers, and will give satisfactory results.

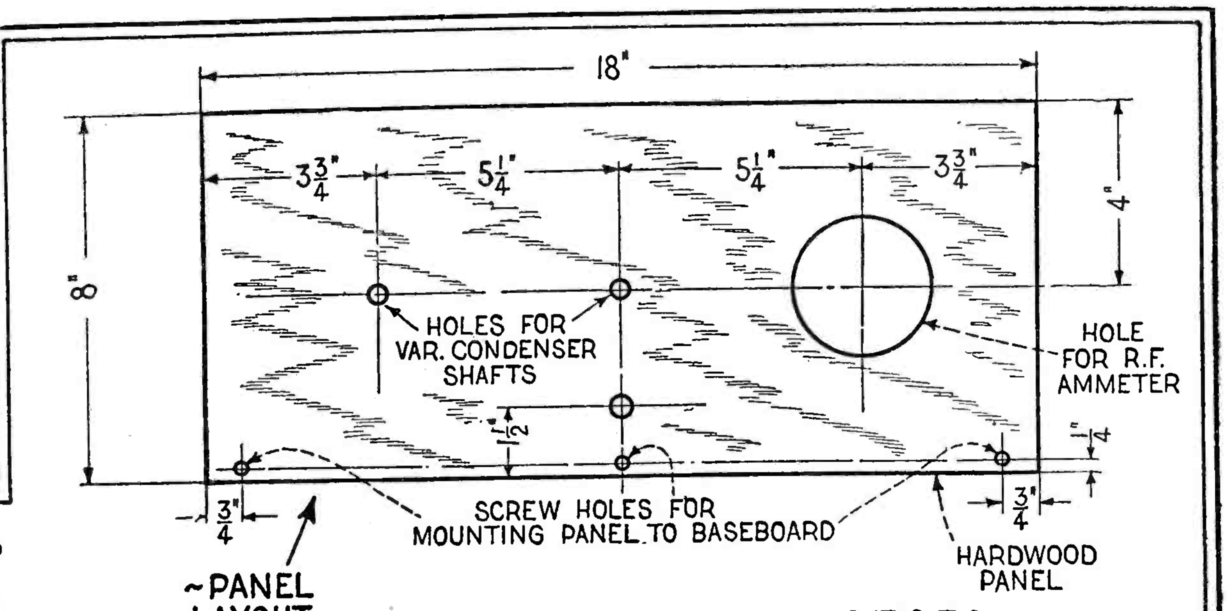
The grid leak should by all means be variable, as by the proper adjustment of this instrument much greater efficiency and a better transmitted tone can be obtained. A carbon disc resistance of the type illustrated with a maximum resistance of 100,000 ohms will be found quite satisfactory.

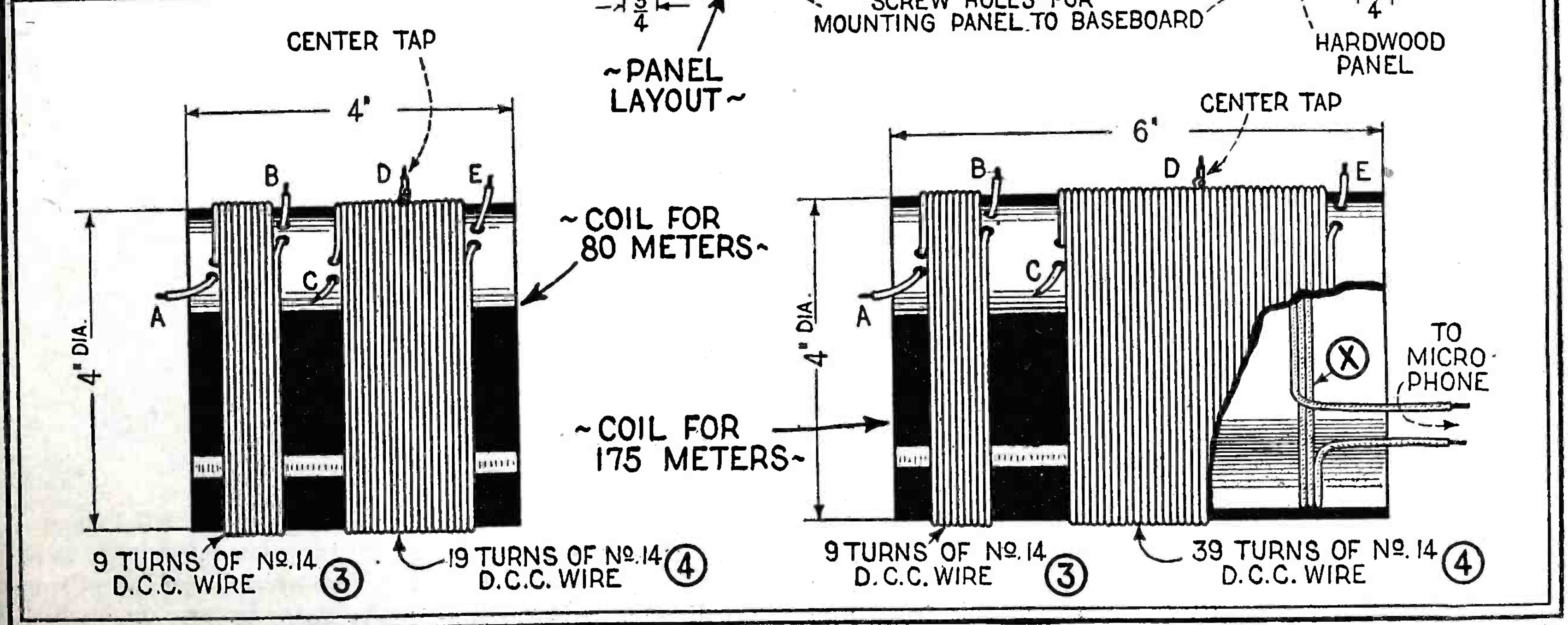
Undoubtedly you will want to try working on both of the two upper wave-length bands that are in use today, namely, those centering around 80 and 175 meters. To be more exact, these bands cover from 75 to 85 meters and from 150 to 200 meters. C. W. transmission can be used over both of these bands and phone transmission can be used between 170 and 180 meters. The inductances for both bands are to be wound on 4-inch diameter insulating tubes. Well-paraffined cardboard will be found quite satisfactory.

For the 80-meter band, wind the oscillator or primary coil with 19 turns of No. 14 D.C.C. wire, soldering a lug or tap at the center turn. The antenna inductance should have from 6 to 10 turns and must be determined definitely by experimenting. Use enough turns to have a good pick-up from the oscillating circuit, but do not use so many that they will stop the primary circuit from oscillating.

For the 150- to 200-meter band, use the same diameter tubing and wind 39 turns for the primary or oscillator coil. Tap at the 20th turn. The secondary or antenna coil can be approximately the same size as that used for the 80-meter tuner. In connection with this 150- to 200-meter inductance, you will want to incorporate some sort of modulating system so that you can use radiophone transmission between 170 and 180 meters. The simplest and easiest way to accomplish this is by using an absorption circuit. This consists of two turns of wire shunted by a microphone as shown in dotted lines in the







The second and last of the progressive diagrams for this simple transmitter is given above at right. The filament and grid circuit wiring is shown, completing the assembly. It is wise to include a switch in the 110-volt leads so that the "A" circuit can be easily opened.

Directly at the right the details are given for laying out the panel. The writer used hard wood, but of course any good insulating material may be employed.

The details of coils to be used with this transmitter are given below. The smaller coil is for use on the 75- to 85-meter band, while the larger one is to be used on the 150- to 200-meter band. An absorption microphone coil is included in this assembly, but phone transmission may only be used between 170 and 180 meters.

schematic circuit of the transmitter. Place a switch in series with the microphone, so that this circuit can be opened when you are using C. W. transmission on the upper band of wave-lengths. The two turns of the absorption circuit are placed inside the supporting tube and are wound so as to be held there by friction. Their position in relation to the primary should be varied until the best operating point is found. This can be determined while working with some nearby station or by listening in on your own receiver to your transmitted wave.

Meters

In the set illustrated we have only shown one meter, an antenna radio-frequency ammeter. This instrument shows you when your antenna circuit is in resonance with the oscillating circuit. Do not depend too much upon the amount of current shown by this meter and do not think that just because you get a high antenna reading you are getting out further. This does not always follow, and only a few hours of experimenting and trying out different settings of your variable condensers will determine just where the best point is for operation. However, the antenna meter is useful for tuning to resonance and therefore should be included. If you want to make a set somewhat more elaborate, incorporate a filament voltmeter and a plate milliammeter. You will need these instruments anyway when you build a larger set and come to use A.C. or motor generator power supply. It is best to buy three meters; one for the antenna, one for the filament and one for the plate. Then you will be fully equipped for future experimental work. The ratings of these instruments for general use up to 50 watts power should be as follows: Antenna ammeter, 0 to 2. Filament voltmeter, 0 to 15. Plate milliammeter, 0 to 200. If you get good instruments such as the antenna ammeter illustrated, they will give good readings even at the lowest parts of their scales, which points, by the way, will be used with a set of the type illustrated.

Vacuum Tubes

This set has been designed to operate with a UV-201A tube. Properly constructed and operated, it will give excellent results. The filament step-down transformer should be of a type that will supply at least one-quarter of an ampere to the tube. The one used in the writer's set had three voltage taps on the secondary; one for 6, one for 12 and one for 18 volts. This is not necessary in a set of this type and the transformer was used only because it happened to be the only one on hand at the time.

The antenna for use on both 80 and 175 meters should be about 60 feet long over all and at least 30 feet high. The lead-in and antenna should both be extremely well insulated. Exercise great care here, as any expense incurred in buying good insulators will amply repay you in results obtained.

A transmitter can be used with a ground connection in just the same manner as a ground is used on a receiving set. However, a perfect ground is hard to obtain and a poor ground used in connection with a transmitter will be a decided drawback. Therefore, the average amateur station uses what is known as a counterpoise. This usually consists of an exact counterpart of the antenna, stretched about 8 feet above the ground. It may run directly under the antenna, but this is not necessary. It can run in practically any convenient direction, although more often than not the easiest place to erect the counterpoise is in parallel with the antenna. The counterpoise and its lead to the set should be well insulated and a wise precaution is to provide two lightning switches for your entire antenna system. One is used to connect the aerial to the ground and the other to connect the counterpoise to the ground. The most important of these, of course, is the aerial grounding system, and many amateurs do not bother to use a lightning switch on a counterpoise.

Notes on Battery Eliminators

RADIO fans are acquainted with the fact that there is a vast difference between the kind of current delivered by a storage battery and that obtained from the house mains of the electric light company. The storage battery delivers smooth, direct current flowing in one direction, while that obtained from most service companies is alternating. That is, first it flows in one direction and then reverses to the other. Such current is not suitable for the radio receiving sets, although it is ideal for lighting purposes.

Therefore, when considering the construction of a "B" battery eliminator, it is a wise plan to decide what method of converting the current to its proper form for supplying the plate potential of a radio receiver will be best suited for the purpose.

In order to employ the alternating current as supplied by electric companies it is necessary to change it so that it is similar to battery current. Converting alternating current to direct current is termed "rectification." This operation prevents the current from flowing in both directions.

There are numerous types or methods of rectifying alternating current to direct. However, there are two which are better adapted for obtaining a current for supplying the plate potential of receiving tubes. The first is by means of an ordinary vacuum tube with two elements, namely, plate and filament. It is also possible to employ ordinary vacuum tubes. The presence of the extra element (grid) has no effect on the rectification qualities of the tube. The other method is probably the most economical and is known as the electrolytic or chemical rectifier.

Next in order, the method of rectification should be considered. There are essentially two circuits which may be employed. The first is rectifying half the cycle. For this method it is only necessary to use one vacuum tube or one jar of an electrolytic rectifier, whichever the case may be. The second is known as the full-wave principle. This requires the use of two tubes or two or more jars.

A half-wave rectifier acts as a check valve, simply allowing only half the cycle to flow. This method leaves a pause between each cycle equal to half of the time required to complete one cycle. If the current is 60 cycle, which most of the current supplied by power companies is, there will be sixty pulsations to every second. If the full-wave means of rectification is employed it is obvious that instead of sixty interruptions a second there would be 120 pulsations to the second. When the problem of filtering is encountered this latter method would naturally be simpler to filter. For such a circuit a filter having eight microfarads connected across the rectifier high voltage with a fifty henry choke inserted in the positive lead would be sufficient. Incidentally, for the choke coil it is possible to use the secondary of an ordinary audio-frequency amplifying transformer.—*N. Y. Herald Tribune.*

Some Valuable Battery Tips

Methods of Connecting Batteries and Their Places of Installation Is Important

BATTERY connections are frequently the cause of many radio troubles, which include lack of volume, broadness in tuning, noisy and interrupted reception and in some cases absolute failure to work. Daily the questions asked of this magazine by mail from our readers indicate a lack of understanding of the importance of using the proper gauge and length of wire for connecting the batteries, which leads to the troubles enumerated.

In the following, several valuable suggestions are offered which were recently presented in the *New York Evening World.*

The requirements for battery connections are simple but exacting and no set will function at its best if they are disregarded. Many manufacturers, realizing the abuses heaped on otherwise perfectly good sets because of improper wiring of batteries, now incorporate in the set a cable of the necessary number of wires for A, B and C battery connections of the proper gauge and length.

For the benefit of the fan not favored in this way it should be remembered that the requirements of the "A" battery circuit are such that a heavy wire, imposing the least possible resistance to the flow of current, must be used. In all cases for filament lighting purposes the wire should be as short as possible—not exceeding four feet on each leg. Copper wire should always be used in preference to any other type. For the sets now on the market operating anything up to six tubes, where the flow of current does not exceed two amperes, 16 B & S gauge copper wires can be used. It may either be of the solid or stranded type but it must be covered with insulating material, except, of course, where it is connected to the battery and set. The stranded wire is preferable because of its flexibility and ease of handling—the solid wire having a tendency to break at the terminals.

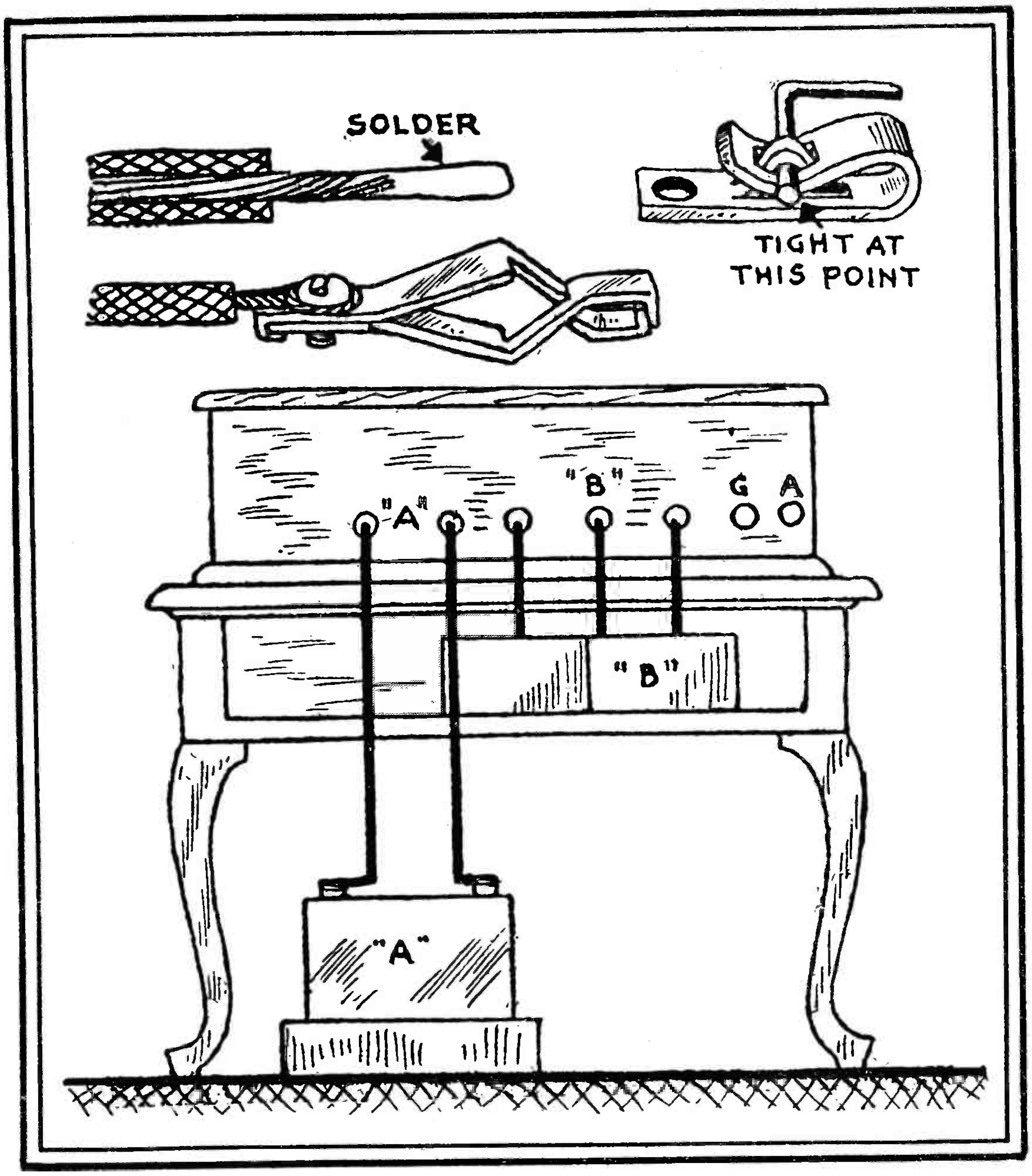
The contact ends should be scraped clean, twisted together and a drop of solder sweated in to bind the strands. To the battery ends of the wires when a storage battery is used a pair of heavy battery clips can be connected to facilitate disconnecting when the battery is removed for recharging. In passing it is important to note in this connection a perfect contact can only be assured when the battery terminals as well as the connecting wires are free from corrosion and dirt. The positive terminal will be found to corrode very quickly and will need cleaning frequently to keep it free from the white encrustation, which, if permitted to accumulate, will break the contact between terminal and wire and ultimately destroy the metals.

Where dry cells are used the straight soldered ends without battery clips are preferable for connections under the binding posts. The element of corrosion in this connection is negligible.

A fine wire should never be used for an A battery connection because it imposes a resistance in the circuit that does not permit the proper amount of current to flow to the tubes. It holds the current back so that the rheostats have to be turned on full to allow the tubes to light and prevent any adjustment of the governing rheostats. Sometimes where an excess of fine wire is used, by having the battery in some other room of the house, or in the cellar, sufficient current cannot be passed through to light the tubes.

The connections, no matter what type battery used, should be mechanically as well as electrically perfect. A loose connection will impart a noise level to the receiver that makes static sound quiet in comparison. The connections must be secure on the set as well as the battery.

The shortness of connections cannot be over-emphasized, both for A and B batteries. Long, straying wires broaden the tuning of the receiver. Not infrequently a set is made so broad that it is almost impossible to



Illustrations by Courtesy of N. Y. Eve. World

Showing how to make connections to battery clips and to the batteries of the set.

separate one station from another, due to the pickup of these over long battery leads.

The requirements of the B battery connections differ somewhat from the A leads, but only in the matter of gauge. Inasmuch as the plate takes voltage rather than current (as in the case of the filament or A battery circuit), the carrying capacity of the wire is not so important and can be of smaller gauge. Eighteen gauge copper wire, flexible and covered, will be found ideal. Smaller wire down to 24 can be used without introducing any losses, and, in other respects the treatment is identically the same as the A battery leads. The battery ends of the wire need not be equipped with clips—the soldered ends will be more practical for use with the terminals with which all B batteries are equipped.

The battery connections on the B terminals need special attention because of tendency of certain type clips to make loose contacts, giving rise to a continual cracking noise when the set is jarred. A person walking across the floor will make the receiver sound like a Fourth of July celebration.

Weak "B" Batteries Cause Trouble

"B" batteries not infrequently give rise to peculiar troubles that are particularly annoying and hard to locate in the receiving set. The troubles are evidenced in a series of characteristic sounds and noises that range from a Fourth of July celebration to absolute quiet. The "B" battery is usually the last thing in a set that gets any attention and then only when it is through functioning. Its comparative long life relegates it to obscurity in the minds of the fans, from which it is rescued only after everything but the binding post has been changed in chasing troubles that develop as the batteries start to run down.

The first sign of "B" battery trouble is usually evidenced in a falling off of signal strength after the batteries have been in use for a considerable period. This is followed in a short time by a slight crackling noise that occurs intermittently and is often mistaken for static. As the batteries run down, the crackling noises increase in intensity and frequency until they develop a steady splutter that resembles a miniature bunch of firecrackers, endlessly doing their "stuff."

The combination of the failure of signal intensity due to the run-down condition and the high noise level developed preclude the possibility of bringing in any broadcast matter.

The "B" battery is the most faithful part of the set, but once it starts going there is nothing to do but replace it.

The care and handling of "B" batteries of the dry cell type are very simple.

To begin with, the capacity of the batteries in amperes is very low and in most batteries does not exceed 5 or 6. The duty they perform is efficiently done by this low capacity. The majority of sets do not draw more than twenty-five milliamperes an hour, giving the high potential battery a long period of usefulness despite regular use of five or six hours a day.

Never test a "B" battery with an ammeter to get a line on its condition. The ammeter is a direct short across the battery and will drain it as quickly as shorting it from positive to negative with a piece of heavy copper wire. Voltmeter tests are the only ones that should be made and these at not too frequent intervals. The average voltmeter draws about 15 or 20 milliamperes at a reading. Ordinarily it will not be found necessary to take a reading until after the batteries have been in use at least three months. Then a test once every two weeks until the cut-off point is reached should be made. The cut-off point is reached when the voltage of a 22½-volt unit reaches 17½ volts and the 45-volt unit reaches 35 volts. From this point on the battery rapidly falls off, and should be discarded at the first sign of noise.

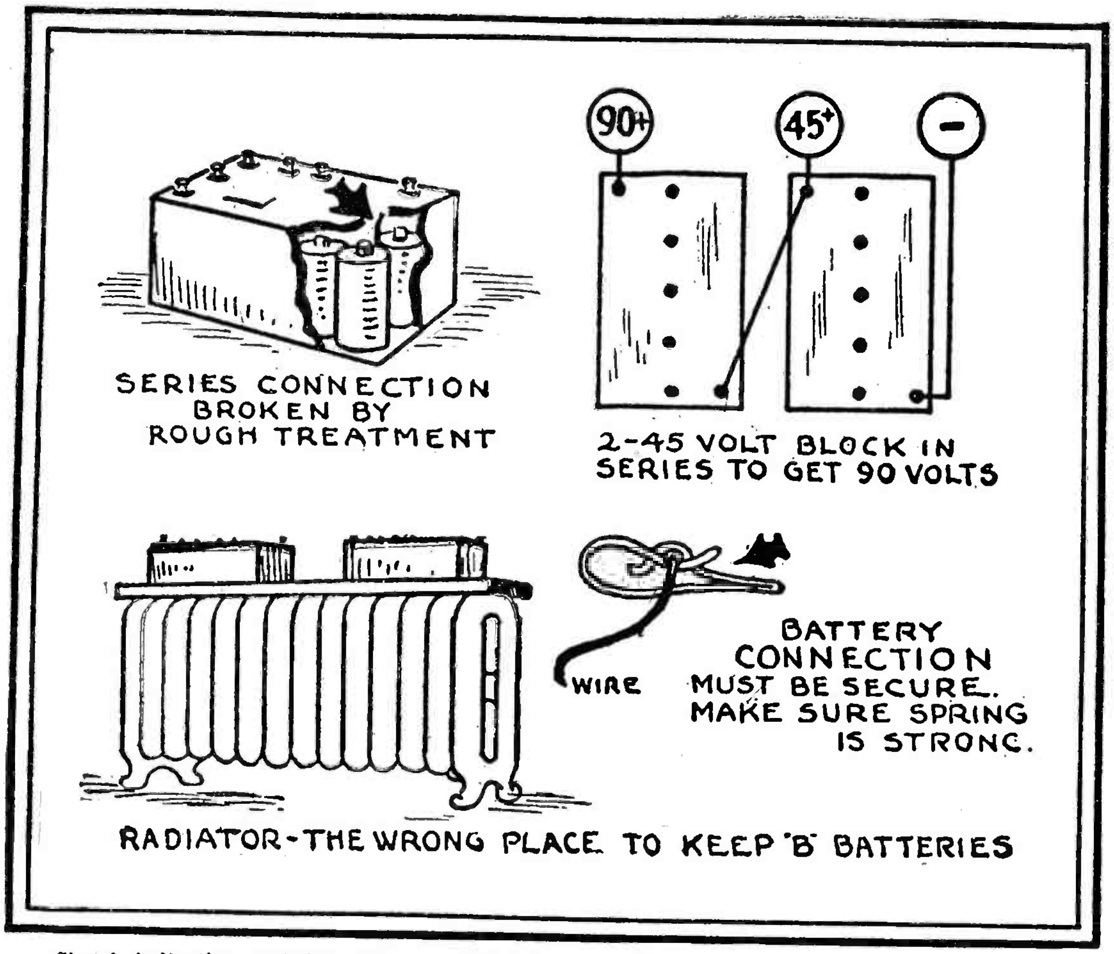
Batteries, through defective workmanship and rough handling, are internally damaged and develop open circuits. A voltmeter test will immediately show this defect by giving no deflection of the meter.

Tests when the batteries are bought are always necessary to insure against starting with a defective unit.

Where rechargeable batteries are used, either the Edison cell or lead cell type, they should be checked and charged at regular intervals so as to keep them in good condition.

In placing "B" batteries be sure that they are not directly over a radiator or other heating apparatus. The heat will cause the chemicals to gas and swell the battery to half again its size and ruin it within a very short time.

"B" batteries should always be purchased as fresh as possible. Never purchase a "B" battery that is more than one month old. The more reliable dealers stamp the batteries so that no mistake can be made as to their age.



Sketch indicating probable cause for "B" battery trouble and method of connecting batteries.

Separate Positive and Negative Wires

One thing that simplifies the wiring of the set to a great extent is to have all sockets in a line, so that it is possible to put lugs on the filament binding posts and run a single wire through all of them.

You may think that the positive and negative wires will come too close together, but this can be overcome by bending one lug up and the other down on the same socket.

Procure as large a lug as possible, with a hole at both ends, and after putting it on terminal, twist with a pair of pliers so that the wire can be run through the little hole at the end of the lug.

The grid and plate leads should be separated as much as possible and kept away from the other leads. The filament and the "B" battery leads can be run quite close to each other, providing they are all well insulated. Quite a number of sets are now wired up with rubber-covered flexible wire, and all the leads, excepting the plate and grid wires are run together in a cable.

A Unique Impedance-Coupled Set

Carborundum Crystal Detector Insures Stable Operation

THE radio fan with a little more than the ordinary operating knowledge of radio principles has perhaps been educated to think of regeneration merely as a system for increasing volume, sensitivity and selectivity. If he has gone a little deeper into the technical phases of the subject, he possibly regards it as being a system for re-introducing a part of the current present in the plate circuit into the grid circuit; in effect, obtaining a measurable reduction in resistance of that part of the circuit. For the inquisitive enthusiast, the article by *J. E. Anderson* in the *New York Herald Tribune* radio magazine will afford a few interesting sidelights on this important function of radio receivers, and this detail being incidental describes a more or less radical type of receiver with tone values the paramount issue. The article, which follows, is well worth reading.

One stage of tuned radio-frequency amplification, one stage of choke coil coupled, regenerative radio-frequency amplification, a crystal detector and two stages of transformer coupled audio-frequency amplification are the main elements that make up the present receiver. There is nothing especially unique about that, is there? But wait.

When the diagram of the receiver, which is published herewith, was shown to a radio fan long since passed the novice stage, he remarked that everything in the receiver was done backward. Well, not everything is done backward, for most of the circuit is strictly orthodox, but there is one thing which is done in the reverse order, and it is this fact which makes the receiver unique. This fact is the manner in which regeneration is obtained in the second tube. As will be observed, the tuned circuit L-3, C-3 of this stage is placed in the plate circuit of the tube, and the tickler coil L-4 connected in series with the grid lead of the tube is placed in inductive relation with the tuned coil L-3. In this manner a voltage is induced in the coil L-4, and this is added to the input voltage across the resistance R. If this added voltage is sufficient, regeneration will be obtained, provided, of course, it is in the right phase.

The tuned coil L-3 was placed in the plate circuit for several reasons. In the first place, it was desired to use a crystal for detecting the signals so that advantage could be taken of the greater quietness and economy of operation obtainable with this device. It was also found that the signals could be increased tremendously by connecting the crystal directly across the plate coil and tuning it instead of connecting the crystal across a tuned secondary. No tube noises go into the crystal because the audio-frequency difference of potential across L-3 is entirely negligible, and there is no danger of injuring the crystal by heavy direct current, because the D.C. difference of potential across L-3 is even less than the audio-frequency alternating current potential difference. Hence, neither tube noises nor direct current of appreciable magnitudes will go into the crystal detector circuit. These statements are made in answer to objections raised on these points. The fact that the crystal detector circuit is connected to the positive side of the plate battery does not mean that the plate battery voltage is in the crystal circuit.

Since the grid coil L-4 is not tuned, it requires closer coupling between L-3 and L-4 to obtain regeneration than when the grid coil is tuned and when the tickler is in the plate circuit. For this reason it will be necessary to use a high inductance in L-4 in order to obtain satisfactory regeneration. As it is desirable to have a compact coil for a tickler, L-4 should preferably be wound with fine wire. The writer used 100 turns of No. 36 double cotton-covered wire wound on a diameter of 2 inches. Other coils of different modes of winding and different sizes of wire were also tried with good results, but in every case the inductance had to be large before regeneration was satisfactory.

Since the crystal circuit is connected across the tuned circuit L-3, C-3 and takes considerable energy from it, the latter is naturally very broad and non-selective. In order to increase the selectivity of the arrangement L-3 should be wound with fairly heavy wire, and the low loss method of constructing it may be employed. Two or three taps should also be provided on it so that the crystal circuit may be connected across only a portion of L-3 when greater selectivity is required.

The regeneration does not increase the selectivity to the same extent in this case as it does in the ordinary circuit. The reason for this is that the grid coil is aperiodic and responds equally to currents of all frequencies which are surging in L-3, C-3. That is, the side bands are intensified by regeneration almost to the extent as the carrier frequency. This may be a dis-

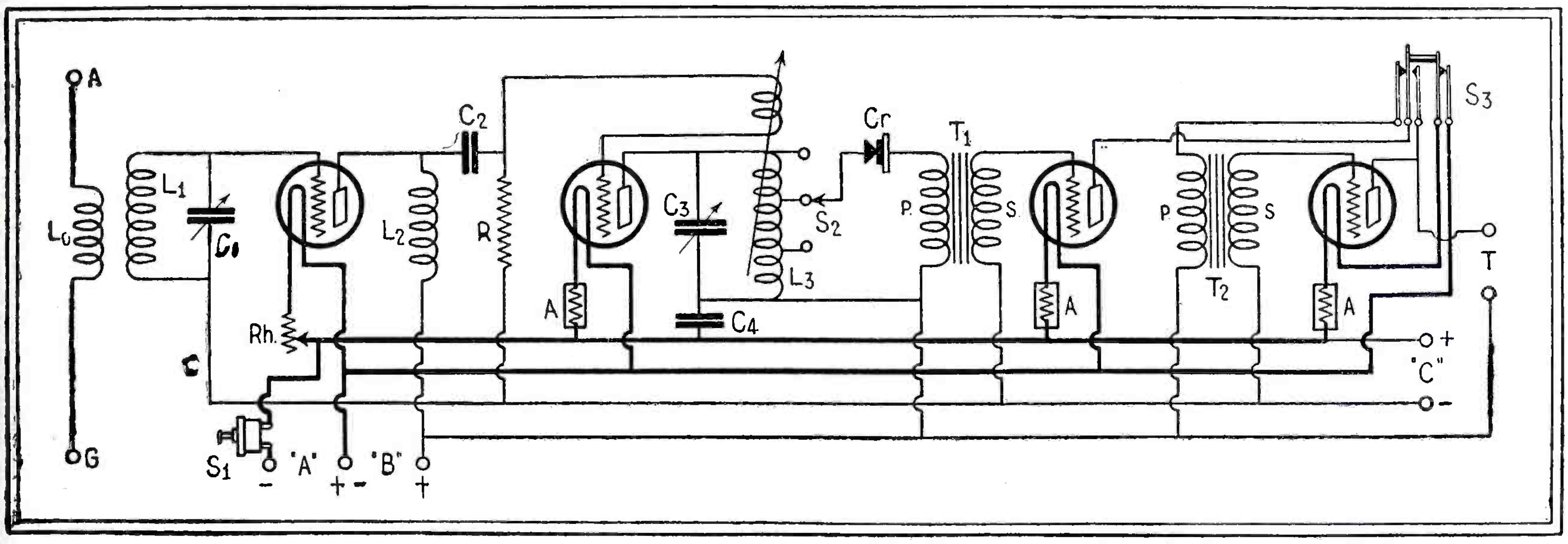


Illustration by courtesy of N. Y. Herald Tribune

The wiring diagram of the impedance-coupled set described by J. E. Anderson in the N. Y. Herald Tribune.

advantage where ultra selectivity is required, but from the point of view of quality of reproduction it is a decided advantage. The set reproduces faithfully, but, of course, the quality is dependent on the performance of the audio-frequency transformers. If the choice of these has been lucky or well advised, the set will make pleasant listening.

The antenna coil L-0 and the first tuning coil L-1 may be the two windings of an ordinary radio-frequency tuning unit, which may be purchased in any radio store. The coupling between the two windings should be loose, so that the selectivity of the set will not be impaired. If made at home, the primary L-0 may consist of ten turns and the secondary L-1 of forty-three turns, wound on a length of composition tubing 3 inches in diameter with about No. 20 double silk-covered wire. There should be at least a quarter of an inch separating the two windings. The two tuning condensers C-1 and C-3 should each be of .0005 microfarad capacity, and they should be of the best construction. The coil L-3 may be similar to L-1 as to number of turns, size of wire and diameter.

Construction of Choke Coil

Coil L-2 is a choke coil for radio frequencies. This should have the largest practical value possible. One of the larger sizes of duo-lateral coils may be used to advantage, provided one is not used which has so large a distributed capacity that it will act as a by-pass condenser for the shorter waves in the broadcast band. The coil used by the writer in the set that he constructed was of different construction. It consisted of 750 turns of No. 40 enameled wire wound on a wooden dowel 1 inch in diameter. This had a calculated inductance of about five millihenries, and, therefore, it had an impedance of about 17,000 ohms of 550 kilocycles. This is of the same order of magnitude as the plate resistance of a 201-A tube, and, therefore, this type of tube will amplify the signals about four times. A larger value of L-2 would have been desirable, as then the amplification would have been greater. The use of a choke coil here is preferable to the use of a resistance, because there is not so much power loss in the coil as in the resistance, and the effective plate voltage on the tube becomes greater for a given value of the plate battery voltage.

The coupling condenser C-2 may be one of .001 microfarad capacity. The resistance R should not be greater than one megohm. A half megohm should prove sufficient. The by-pass condenser C-4 should be one of large capacity. It is used mainly for the purpose of bringing the rotor plates of condenser C-3 as nearly to ground potential as possible, and thereby reducing hand capacity effects. Any value between .005 microfarad and 1 microfarad may be used.

LIST OF PARTS

1 radio-frequency tuning coil with two windings.
1 radio-frequency tuning coil with one winding and taps.
1 tickler coil, as described.
1 radio-frequency choke coil, five millihenries or greater.
2 audio-frequency transformers.
2 tuning condensers, .0005 mfd.
3 automatic filament resistances.
1 six or ten ohm rheostat.
1 coupling condenser, .001 mfd.
1 by-pass condenser, .005 mfd. or greater.
1 grid leak, 5 to 1 megohm.
1 crystal detector, fixed carborundum.
4 standard sockets and four tubes.
1 filament switch.
1 double pole, double throw jack switch.
9 binding posts.
2 condenser dials and one tickler knob.
1 panel, 7 x 21 inches, and one baseboard, 7 x 20 inches.
1 cabinet to match.

The crystal detector Cr is one of the new type carborundum crystals. These are sensitive and rugged and will stand up under heavy loads. They are also of the fixed type, so that the cat whisker nuisance is eliminated.

Simplicity of operation was one of the main considerations in building the set. Thus, there are only two main tuning controls in it, the two tuning condensers. Then there is the tickler control for varying the sensitivity of the circuit. The inductance switch S and the taps on the second tuning coil are not brought out on the panel. A short, flexible lead running from the crystal terminates in a small connector clip, which may be connected to any one of the taps located on the tuning coil. As a means of simplifying the filament circuits, self-regulating rheostats (A) are used throughout in place of adjustable rheostats. This is feasible, since all the tubes operate as amplifiers.

Also for the sake of simplicity, jacks have been eliminated. There are only four binding posts on the panel; two, A and G, for the input and two, T, for the output. The latter two serve for the customary jacks. As a means for throwing the loud speaker from the last to the preceding tube, in case the volume warrants such change, the switch S-3 has been provided. This automatically controls the filament circuit of the last tube, so that it is only lighted when the loud speaker is in the output circuit of that tube. The switch is of the type which closes two and opens one contact. S-1 is the filament switch for turning on and off the current. The three battery binding posts should be placed at the rear of the cabinet. The two binding posts provided for the C battery may be placed in the most convenient position in the set.

This set has not been tried with dry cell tubes, but no doubt it will work with these as long as the volume is kept down to moderate intensity. Since the first tube is operated as a voltage amplifier by virtue of the impedance coupling, better results should be obtained if a high MU tube is used in this stage. If, however, a high MU tube is used, it is of great importance that the impedance of L-2 be high, because a tube of this type has a plate resistance in the neighborhood of 40,000 ohms, and if the impedance of L-2 is much less than this, no advantage is gained by the high MU.

Since the tubes in this cabinet are all working as amplifiers, all the grid return leads should be connected to the negative C battery terminal, and the C battery should be given a value consistent with the plate voltage employed. The plate voltage should preferably be 67.5 or more. All the tubes are more efficient when high plate voltages are used, and this is particularly true of the first.

Headphones Need Attention

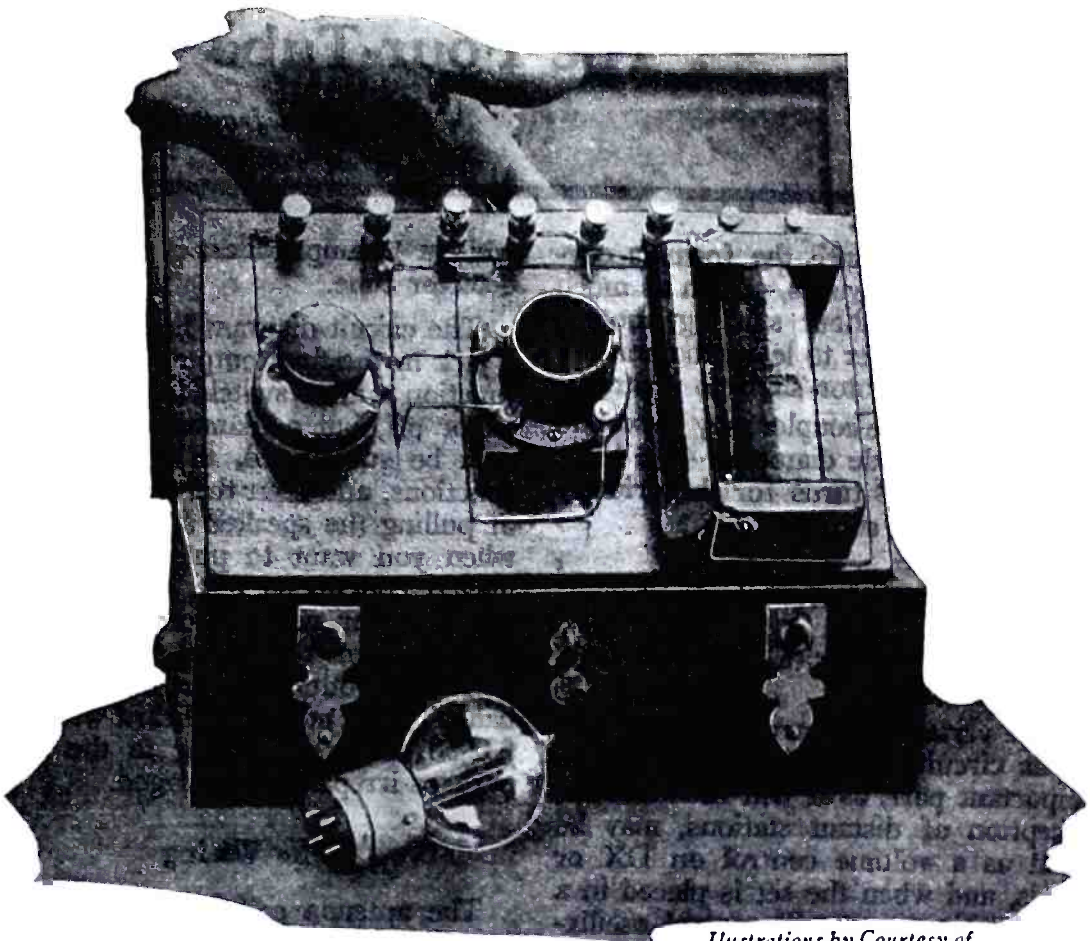
Headphones that have been in service for a year or more should be inspected by removing the cap and diaphragm. The mounting screws holding the horseshoe magnet in place should be tightened. Remove any dirt or particles of steel that may be collecting on pole pieces. The diaphragm should be inspected to ascertain if it has become bent, and, if so, it should be replaced with a new one. The screws holding the telephone cord tips should be tightened, but not removed, and reversed, as this will disturb the polarity of the unit, affecting signals. If the diaphragm has become weakened and touches the pole pieces, it should be turned over on its reverse side, which will correct the trouble.—*The Columbus Dispatch, Columbus, Ohio.*

A Novel Audio-Frequency Amplifier

Single Stage Impedance Coupled Amplifier Built in a Novelty Candy Box

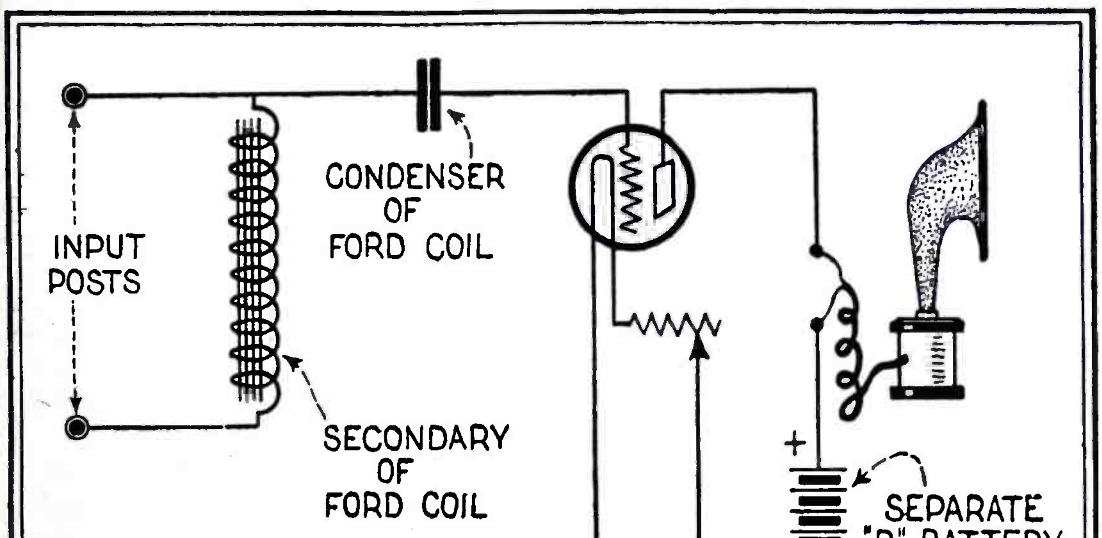
AN audio-frequency amplifier, that can be used to give a third stage of amplification with a minimum of distortion and noise, may be constructed from a few simple parts as described by *R. L. Young* in *Science and Invention* and presented herewith. The writer chose a novel cabinet for housing this unit. It consists of a miniature cedar chest that was formerly used as a novelty packing box for candy. Of course, the parts illustrated can be adapted to mounting in any type of cabinet that the reader may desire, with no difference in results. Mr. Young gives the constructional data for the unit as follows:

The essential parts of this instrument, aside from the usual binding posts and tube, are a socket, a Ford coil and a rheostat. After you obtain the Ford coil, and it is a wise idea to use a new one rather than a second-hand one, because often the latter are burned out before they are discarded, remove the casing and melt out the wax so that the condenser and the coils can be easily worked on. Preserve both of these carefully, as they are to be used in the set. Remove all the connections, being sure to leave sufficient wire on the ends of the secondary coil to allow for future connections and also preserve the connections to the condenser. The next step is to distribute the instruments on a suitable baseboard and the arrangement shown in the photograph is to be recommended. Wire them up according to the diagram given, using only the two secondary coil connections. The primary is disregarded but left in place together with the core.

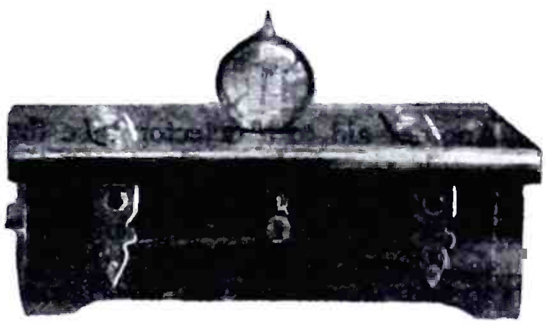


Illustrations by Courtesy of Science & Invention (New York)

The interior layout of this novel third stage audio-frequency amplifier is shown above. Notice the extreme simplicity of the wiring and the arrangement of the binding posts. The latter system allows all of the leads to the amplifier to be brought out through the back of the cabinet, thus eliminating unsightly wires in front of the unit.



The circuit diagram for this third stage amplifier is shown directly above. This amplifier is of the impedance coupled type and in order for it to operate correctly, the same "A" battery must be used on the filament of the amplifier tube, as is used on the other tubes. The grid condenser is very necessary to prevent the high voltage from reaching the grid.



The completed assembly with the cover closed and the tube in position. The cabinet used makes a most effective ornament for any radio receiving set.

In connecting this unit to your present receiving set, connect the two input binding posts to the output binding posts of the amplifier of this set. Connect the "A" battery leads of the amplifier to the regular "A" battery, so that the same source of current heats the filament of all the tubes. The "B" battery should be a separate unit, but it may be the common one that is used on the other tubes, if great economy must be practiced. If, however, the best results and the clearest reproduction are desired, use the separate "B" battery.

The writer uses this amplifier with either a VT-2 or 216A power tube. With 120 volts of separate "B" battery applied to the plate, wonderful results are obtained. It is possible, however, to use a UV-201A, with the normal "B" battery voltage applied to it. In this case volume will be sacrificed.

After you have connected the amplifier to your set, it is possible that it may not work on first trial. In such case, reverse the wires to the input binding posts and if the directions given above have been followed and the connections are made correctly, the amplifier will work perfectly.

The Four-Tube DX Special

(*Continued from page 40*)

wire is wound until the form is covered. In other words, get on as much as you can, without starting another layer. Remember to leave room at the center for the rotor shaft to protrude.

The interstage coupler may be wound on a 3¼" outside diameter, 4½" high, and comprise 8 turns for the primary and 63 for the secondary.

The Filament Jack

To wire the set with a filament jack, omit the switch.

The variable primary, L1, in the antenna circuit of the A-A set plays an important part, as it will facilitate the reception of distant stations, may be used as a volume control on DX or locals, and when the set is placed in a regenerative state will control oscillations in a most satisfactory manner. The volume will be found excellent, in fact it is necessary to have a speaker that will stand tremendous volume, otherwise detuning will be necessary to prevent the speaker from being overloaded.

The regenerative condition is certain if the detector B lead is placed at about 45 volts, while no regeneration need normally be expected if this is put at 22½ volts. If no regeneration is obtained at 45 volts probably the tube being used as detector is slow to oscillate, in which case use 67½ volts or thereabouts.

Another aid to a detector tube that responds sluggishly to the temptation to regeneration is the use of a by-pass condenser, shown as C5 in a dotted line in the diagram. This should be .001 or .002, but should not be incorporated unless found necessary.

Remarkable DX-Getter

When the set is working right it will be found to be a remarkable DX-getter. Moreover, it is a simple set to operate, this end being aided by the omission of rheostats. Note that the three amplifier tubes, one R. F. and two A. F., are controlled as to filament heating by a ¾-ampere ballast resistor, while a ¼-amp. ballast is used for the detector tube.

The circuit diagram herewith shows a jack in the final output, used in conjunction with a switch to turn the set on or off, but a filament-control jack may be substituted, to combine both functions, and then there is no danger of pulling the speaker across the floor when you want to put some experimental hookup on test, and decide to remove your pet set for a while. It often happens that the speaker connection is forgotten, the set is lifted, and bang! That noise you heard was your $32.50 speaker crashing to the floor, perhaps irreparably damaged.

The Wiring

The antenna coil is at bottom, the coupler being mounted that way. Hence connect aerial to the lower terminal of L1, ground to the other terminal thereof. The terminal of the secondary nearer the primary goes to the rotor plates of C1 and to A minus. This A minus lead connects to one side of the ¾-amp. resistor, R3, the other side of which goes to F minus of the three amplifier sockets, 1, 3 and 4. The other ballast, R1, is connected, one side to minus A, the other side to F minus of the detector socket. The A plus lead goes to one side of the switch S, the other side of which connects to the F plus post on all four sockets. A plus and B minus are joined. The stator plates of C1 go to the remaining unconnected terminal of L2 and to grid of tube 1. The plate of this tube is linked with the lower terminal of the aperiodic winding which otherwise would be the antenna coil in a 3-circuit tuner. The other side of this coil goes to one side of C3, the .0005 mfd. fixed condenser, the other side of which condenser connects to the terminal of L2 that went to rotary plates of C1. The plate lead of tube 1 also connects to one terminal of the primary L3 of the interstage coupler, the end of which goes to B plus amplifier voltage, say 90. The terminal that goes to B plus should be the end of the winding, and the terminal of L4 that goes to the rotor plates of C2, should be the one nearer L3. This lead to rotor plates continues to A plus, while the other end of L3 is joined to the stator of C2 and to one side of the grid leak-condenser combination, the other side of which combination goes to the grid of the detector socket.

Plate Connection

The plate of the detector tube is connected to P or P1 of the first audio transformer, the B or P2 terminal to B plus detector, say 22½. G of this transformer, otherwise S1, goes to grid of socket 3, while F of this transformer and of the other audio transformer is connected to a common lead, a flexible wire, later joined to C minus. To the A minus lead connect a flexible wire so that it will easily reach the C battery, this being the lead for C plus.

Plate of tube 3 goes to P of AF2, the B post of which goes to B plus amplifier. G goes to grid of the last tube. The F of AF2 has been taken care of. The plate of the last tube goes to one side of the single-circuit jack, the other side of which goes to B plus amplifier.

The jack and switch wiring presupposes the omission of a filament-control jack. If such a jack is used, omit the switch and connect the A plus to one of the two upper prongs of the jack, the other of these two to the common F plus lead to all four sockets. Then the lower part of the jack is wired like the single-circuit jack. Be careful to connect the A plus to one of the two prongs insulated by a piece of hard rubber, fiber or Bakelite.

In conclusion it might be well to advise the constructor to take uttermost care in wiring as one of the principal causes of trouble is a poorly or improperly wired set. It is suggested to use round bus-bar as this kind of wire can be more easily handled and makes a neat looking job.

A little special care taken in tuning will show that this set is a remarkable distance getter.

A Home-Made Tuned Radio Frequency Set

This Five-Tube Receiver Can Be Built at Home with the Aid of a Few Tools

WHEN greater distances, better selectivity and more volume of signal is wanted, amplification of the "radio frequency" type is necessary. This always precedes the detector and strengthens the faint impulses which are too weak to affect the detector as they first come in on the antenna. A receiving set involving two tubes operated as radio frequency or R. F. amplifiers, one as a detector and two others as audio frequency amplifiers forms the modern high class equipment.

Such an outfit which can be built at home with the aid of a few common tools is described by *Brainard Foote* in a booklet issued by the *American Hard Rubber Co.,* New York. Mr. foote explains the working of the set as follows:

Three variable condensers are used to accomplish the tuning of this tuned radio frequency set. One rheostat controls the brilliancy of the two R. F. amplifier tubes and the detector, while another one adjusts the filaments of the audio amplifiers. A jack is provided for headphone connection when the audio amplifiers are turned off and not used. A second jack permits connection of the loud speaker to the audio amplifier.

The tube sockets are laid in a row on a baseboard to which the panel is attached; behind each socket the corresponding transformer is placed. The R. F. transformers consist of two coils wound on a length of Radion tubing, one of them being tuned by a variable condenser. The audio transformers are of the customary iron core type. Since there is extra space between the panel and the audio transformers, the two rheostats are placed there. The binding posts are located at the rear, following the best practice, supported by a Radion binding post panel.

A novel method of suiting the receiver to varying antenna conditions is provided in the form of adjustable coupling between the antenna and the first tuned transformer. To control oscillation and cut out "howling," the coils are mounted adjustably on brass brackets, whereby the position of zero coupling between the adjacent coils may be attained.

For excellence of appearance, Radion Mahoganite should be selected for the panel material, together with Radion Mahoganite dials and knobs to match. The variable condensers should be of good construction, preferably with Radion end plates or supporting strips for best insulation conditions. Referring to the diagram, coils X, Y and Z are the R. F. transformers; C-1, C-2 and C-3 the three tuning condensers; C-4 the grid condenser, r the grid leak and C-5 the phone condenser. R-1 is the low resistance rheostat, 6 to 10 ohms and R-2 the higher resistance rheostat, 15 to 20 ohms.

PARTS NEEDED

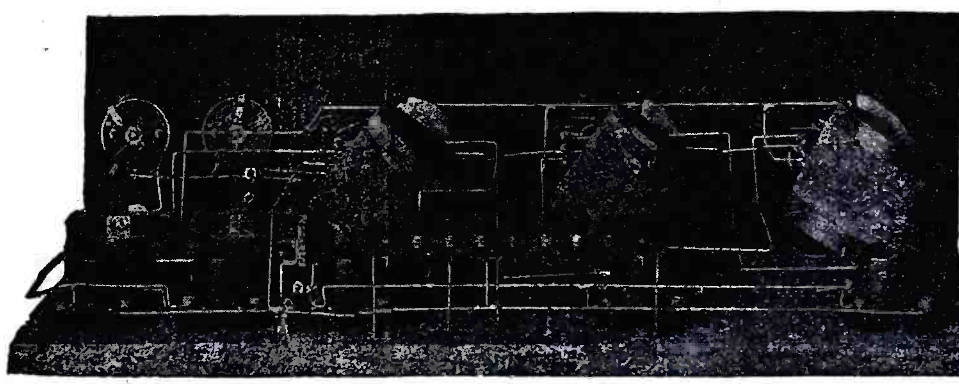
- 5 Radion sockets
- 3 .0005 mfds. (23 plate) variable condensers
- 1 Radion binding post panel
- 1 rheostat of about 6 to 10 ohms resistance
- 1 rheostat of about 15 to 20 ohms resistance
- 1 .002 phone condenser
- 1 .00025 grid condenser
- 3 lengths Radion tubing, 3 inches by 3 inches
- 1 2-meghom grid leak and mounting
- 7 binding posts
- 1 Radion panel, 7 inches by 24 inches
- 1 baseboard about 10 inches by 24 inches
- 12 lengths bus wire for connections
- 1 single circuit jack
- 1 double circuit jack
- 3 Radion dials, 4 inches diameter
- 2 Radion rheostat dials
- 2 audio frequency transformers
- ½ lb. No. 20 double covered wire

The shaft centers for the variable condensers are located on the center line of the panel, placed at approximately 3, 9 and 15 inches from the left-hand side. Rheostat shafts are placed slightly above the center line and at about 1½ and 4¼ inches from the right-hand side, respectively. Jack holes are drilled about 1½ inches above the bottom of the panel and directly beneath the rheostats. Screws to hold the panel to the baseboard are placed on a line one-half the width of the baseboard up from the bottom, and about 7 of them are symmetrically spaced along this line.

Holes for mounting screws are located by means of drilling templates furnished with the instruments. A neat indicator mark is illustrated. This is made by first making a conical depression about ¼ inch above the top center of the dials with a fairly large drill. Then a vertical scratch is made downward from this depression with the edge of a narrow screw-driver guided by a T-square or right angle. White paste sold for the purpose is rubbed across the scratches to fill and excess white wiped from the panel with a cloth. The screw heads may be of nickel plate for good appearance, or they may be countersunk a bit more than usual and covered with glazing compound, as in the photo.

Mounting the Parts

When the panel is firmly screwed to the baseboard, the sockets may be mounted. The photo tells where these are put—all in a row and about 7½ inches in back of the panel. The single circuit jack goes nearest the edge, with the higher resistance rheostat above it. The audio transformers may be mounted at this juncture also, and may be placed quite close to each other, with their primary binding posts in the right-hand direction, looking from the rear. Brackets for the coil supports may now be made of heavy brass strap ¼ inch in width. They are bent "U" shape, each one from a length of strap 5¾ inches long. The horizontal portion of each is 2¾ inches in length and is held to the baseboard



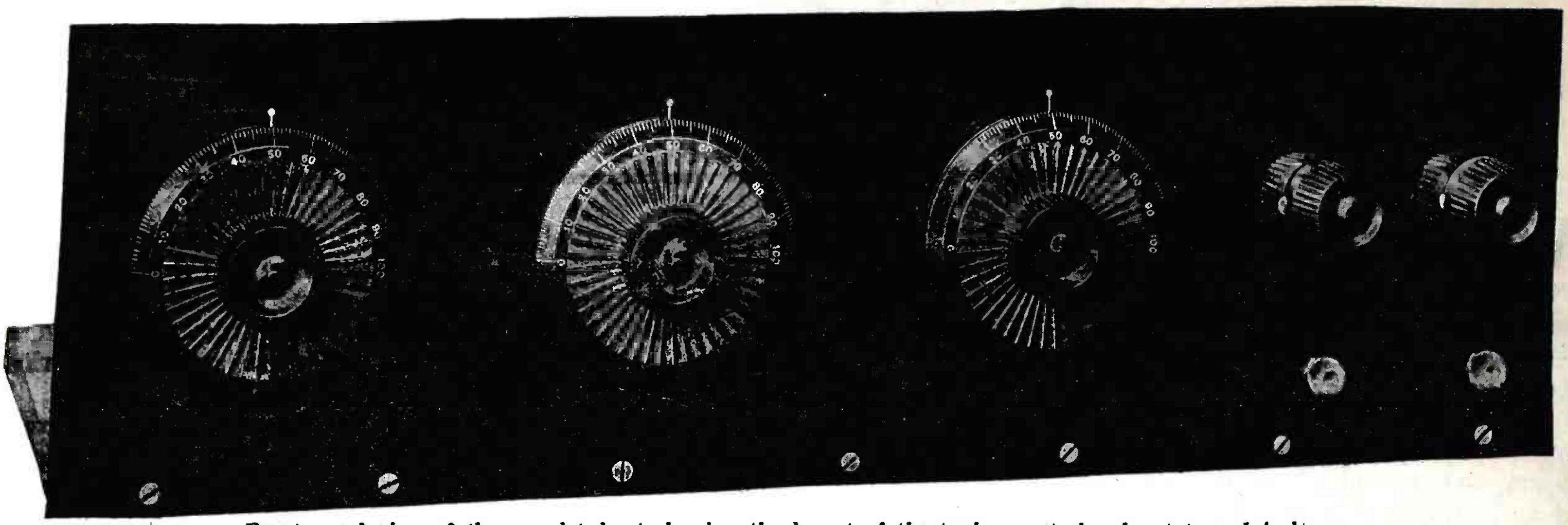
Illustrations by Courtesy of American Hard Rubber Co. (N. Y.)

Rear of Tuned Radio Frequency Receiving Set showing wiring and location of parts including transformer coils.

by two small wood screws. These supports are located one inch to the left of the condensers, so that the coils, when mounted, will fall right in back of them.

To permit of permanent and rigid connection to the coils, three little connector blocks are cut from a small Radion panel, about ⅝ inch in width and 1½ inches long. Four holes are drilled in each one and three of them countersunk on one side for a flathead 6-32 machine screw ½ inch in length. These are fastened to one of the mounting screws at the rear of the variable condensers, as per illustration.

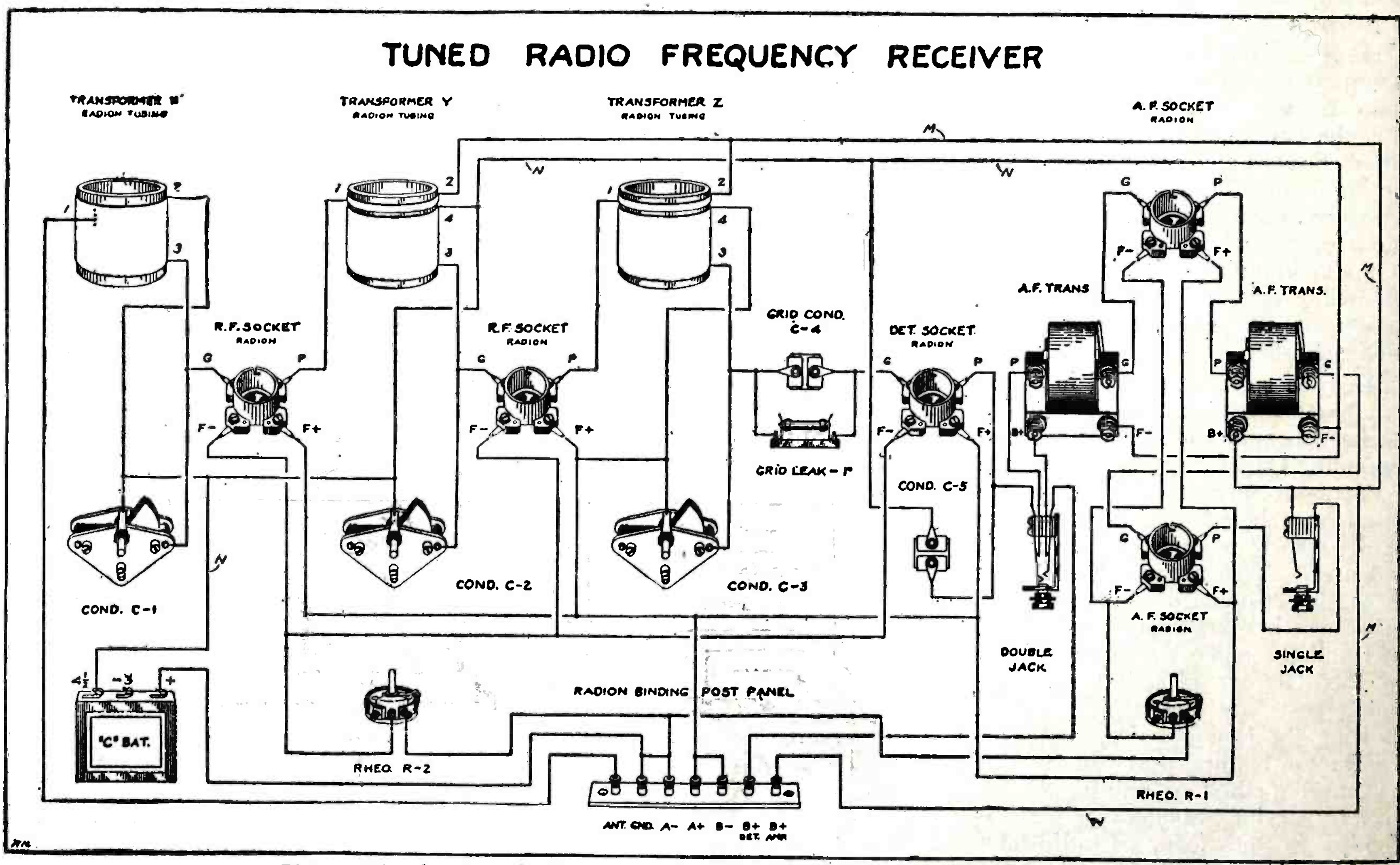
The Radion binding post panel, with binding posts attached, may be mounted next. Two long wood screws or else two brackets cut from strap brass serve for this. In case the wood screw method is adopted, two bushings about 2 inches long each may be cut from a 4 inch length of fiber or brass tubing.



Front panel view of the completed set showing the layout of the tuning controls, rheostats and jacks.

The wiring may now be undertaken, allowing space for the coils as in the rear view photograph. The coils may have to be moved somewhat, so no bus wiring should come near enough to cause possibility of trouble. The filament posts of the two R. F. tubes' sockets and those of the detector are connected in parallel. The plus posts of the audio sockets are connected together and also to the plus connector of the other three sockets. A lead from the plus filament binding post, A plus B minus, is joined to this positive connector. The negative A battery lead is brought to a jumper joining one binding post of each rheostat for distribution thence to the two groups of sockets.

The antenna lead is connected to the uppermost machine screw on the little connector block to the extreme right, looking from the rear. The middle machine screws of the two connector blocks of the second tube and the detector are connected together and to the amplifier B battery plus post through connector M. Connector N is the grid return lead from all four of the amplifier tubes and is brought to the negative C battery. The lowest machine screws of the first two connector blocks are used for connector N, that of the detector being connected to the A battery plus wire instead.



Picture wiring diagram. Carefully note all the connections before attempting to wire the set.

(*Continued on page* 66)

Proper Graduations for Dials

Various Methods of Graduating Dials to Simplify Tuning

IN this article *Mr. C. A. Briggs* offers some valuable suggestions as to proper dial graduations and shows the relative advantages and disadvantages of several different forms. The article appeared in *Q S T* and is well worth reading.

The decimal method of ruling used on most dials now manufactured is the best arrangement, and when proportioned properly is far superior to the method of progressive binary subdivision common on most measuring rules. In nicely designed graduations with a suitable indicator it is easy to read or estimate to the nearest tenth of a division, without eye strain, and this can be done quickly. The naked eye in small graduations and without strain is sensitive to differences as small as two one-thousandths of an inch.

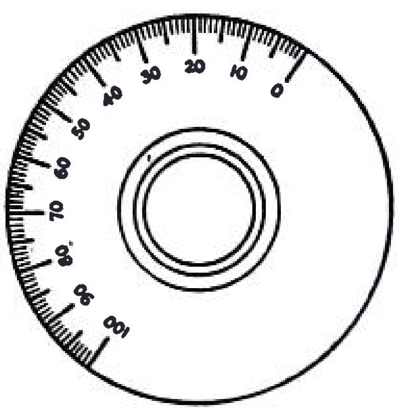
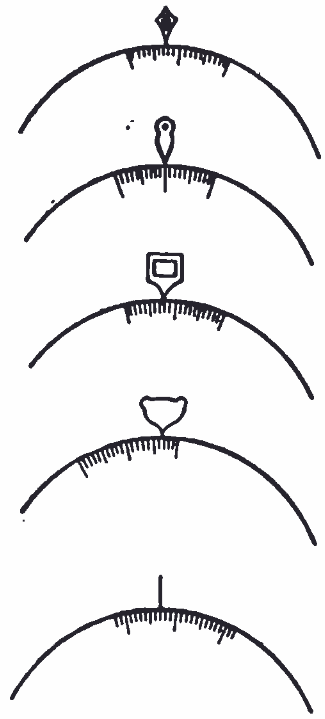


Fig. 1. The graduations on most dials are too long and the lines are too broad.

However, the graduations on most dials are too long. See Fig. 1. They delay and confuse the eye, which is required to run up and down the marks to study and identify the particular space; and the lines are mostly too broad, which unnecessarily interferes with fractional estimates. All this puts an unconscious burden on reading and makes persons tend to avoid it.

In addition to these undesirable things the index used for reading the setting is often a complicated or complicating scheme that appeals through its novelty, but is of questionable merit. The best kind of an index is a simple straight line of substantially the same character as the dial graduations; Fig. 2—this should come as near to the graduations as possible, preferably being in the same plane with them. Parallax—that is, conditions where the reading changes with the position of the eye—should be avoided.

Cross rulings are highly objectionable. See Fig. 3. They are hard on the eyes. All eyes are astigmatic to some extent, and suitable tests show that it is not possible to focus at the same time on the vertical and horiontal rulings of two intersecting lines. There is a struggle of the eye to focus on both which produces eye strain. Strange as it may seem, the most "finished-looking" ruling is often one in which graduations are boxed in by cross boundary rulings.



Illustrations by Courtesy of QST (Hartford, Conn.)

Fig. 2. The best index is a straight line.

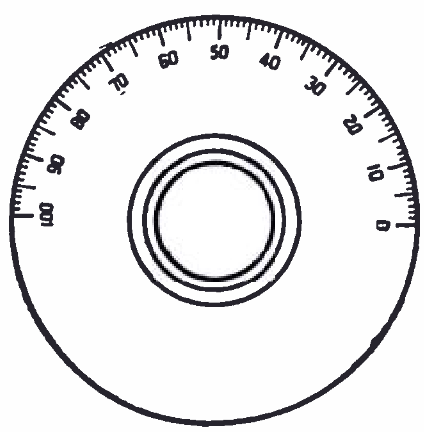


Fig. 4. The author's idea of proper graduations for dials.

For the same reasons it is not desirable to have a sharp contrast between the dial edge and the background beyond.

It seems strange that so often the people with poor eyes pick out the poorest kind of graduation, and are attracted by some complicated scheme that is novel, at least to them, and therefore is assumed to have merit or indicate progress, when the contrary is true. The writer's eyes are unusually good, but he has seen persons with defective vision strain at something he would not tolerate.

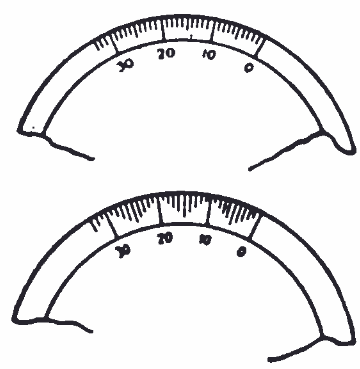


Fig. 3. Finished looking—but bad for the eyes.

A word about looking may be in order here. The readings should be looked at easily. Do not squint at the linese in an effort to resolve them into microscopic detail.

It has been found by tests that more accurate results are obtained when the readings are made promptly and without straining, than where the observer is over-anxious and studies and worries in making his decision. In practicing reading allow yourself just one second for determining the tenth of a subdivision, and finally get so you make the complete reading in this time easily, casually as it were, but accurately.

Specifications for Graduations

The following represent the ideas of the writer for proper graduations:

1. The decimal system of graduating should be used.

2. The length of the ordinary lines should be from 1½ to 2 times the distance between the centers of adjacent lines.

3. The fifth, fifteenth, twenty-fifth, etc., lines should be longer than the ordinary line, a good value being longer by the space between the ordinary marks.

(*Continued on page* 61)

The "X" Wire for Neutrodynes

Simple Method Aids in Making this Type of Tuned Radio Frequency Set More Stable

PERHAPS one of the greatest difficulties in making home-built neutrodyne receivers has been neutralization. In the accompanying article *Don C. Wallace,* winner of the 1923 Hoover Cup for the best amateur radio station in the country, gives the details of a simple expedient that should help many who have found it hard to make a neutrodyne live up to its name. Mr. Wallace describes the "X" wire in *The Christian Science Monitor,* Boston, Mass., as follows:

Prof. L. A. Hazeltine recently announced a new aid to the man who builds his own neutrodyne set. Frequently difficulty is experienced in the complete neutralization of this type of receiving set and while many have succeeded in neutralizing their sets satisfactorily, a great many still remain unneutralized. To cope with these cases the "X" wire idea has been developed, and while very simple both as to installation and as to use, has proved to be very effective during the time which has passed since its first announcement.

The "X" wire has been recommended in many cases where the set would not quite stop oscillating when an attempt at neutralization was made The "X" wire method is seldom used by any who are thoroughly familiar with neutralization, but the method is particularly advantageous to the one building a set, or to the one who has a set which has a tendency to spill over. It is connected at one end only, is at very near ground potential, the potential difference because of the 8- or 10-turn coil to which it is connected adds materially to its effectiveness.

It perhaps could be called an absorption affair. Shielding would undoubtedly do the same thing, but shielding is difficult, and where a set is already built the "X" wire may be just the additional stabilizing device necessary to clear up the set. It is at least very easily installed, has proved extremely beneficial in every case which has come to the attention of the writer, and thus saves the rearranging and possibly the rebuilding of the set without impairing its efficiency whatsoever. The presence of the wire at slightly above ground potential in the near vicinity of the coils probably has some of the effect of the Rice system of neutralization, wherein the neutralizing condenser is connected to a separate coil of its own, not tuned with the usual tuning condenser.

There are two ways of connecting the first neutroformer on a set of this character. Sometimes this is called an air core transformer, and it consists of two windings, a primary of a very few turns, say a number somewhere between four and 10, and a secondary winding of from 40 to 60 turns. The primary may be connected either as the antenna inductance or connected at the tap-off, say 15 turns from the grid connection. This latter connection is shown at "A" in the diagram. If the primary inductance is connected as a primary inductance in the antenna circuit, the antenna would be connected at point "B."

The "X" wire is merely a piece of buss wire connected at point "B," this wire extending through the set, preferably under the neutroformers or possibly supported by the brackets used to support this type of coil. It need be but a foot or so long and extend to the detector tube. Various locations of this wire may be tried out but usually it will be found most effective as indicated here. In a set which will not neutralize readily otherwise, this new arrangement solves a long-felt need for something to do the business. Oftentimes it improves the tuning of a standard neutrodyne set, and of course makes the neutralization more definite and easily done.

A few suggestions for the correct neutralization of a set would probably come in handy. It may either be done on a radiocasting station, or a wavemeter actuated by a buzzer. The wavemeter is, of course, preferable as it enables the neutralization to be carried out on several different waves to make sure the set is neutralized for all waves. Neutralization is merely adjusting the small condensers C1 and C2 so the radio frequency tubes 1 and 2 do not oscillate.

Let us suppose we are going to neutralize our set on KFKX. This or any other loud station may be used, but it is better to use one several miles away if it can be heard loudly enough for the test. After the station (KFKX) has been tuned in, take out tube number two, insert a piece of paper over one of the filament prongs and reinsert the tube. Then adjust C-2 with the aid of a small stick until the incoming signal is at a minimum. Take out tube No. 2, take out the piece of paper, re-insert the tube. Then repeat the whole process with tube No. 1. We suggest the use of a stick about a foot or two long in making adjustments of this nature, as by placing the hand down into the set, body capacities are brought into the field and more difficulties arise.

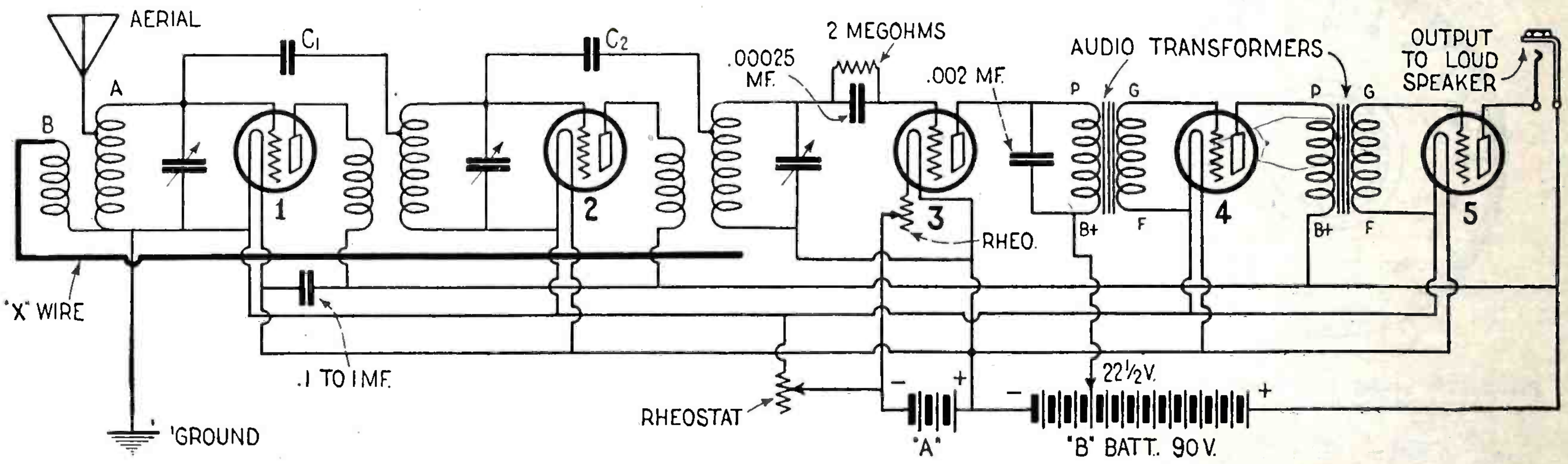


Illustration by Courtesy of The Christian Science Monitor (Boston, Mass.)

Wring diagram of Neutrodyne receiver showing how the "X" wire is installed in the immediate radio frequency portion of the circuit.

The L-C Circuit

A Tuned R. F. Receiver Using a New Combination of Auto-Transformer Inductance and Feedback Capacity

THE popularity of receivers employing radio frequency amplification with regeneration is evident from the number of such sets that have been constructed. The receiver to be described herein is similar in principle to the Browning-Drake, in that it has one stage of radio frequency amplification, regenerative detector, and two stages of audio frequency amplification, but regeneration is obtained by means of capacitive feedback instead of by means of a tickler coil, and the radio frequency transformer represents a departure. In order that the set may appeal to the largest possible number, the controls and parts have been reduced to an absolute minimum, as may readily be seen by a glance at the illustration of the panel layout.

In this introduction to his article appearing *Radio,* San Francisco, Cal., *G. M. Best* very modestly disclaims originality in the basic idea of the circuit. A study of the circuit, however, reveals the fact that some revolutionary changes have been made in one or two respects. Suffice it to say that the arrangement seems feasible, it represents a simple radio frequency, regenerative detector and audio amplifier system, with no multiplicity of controls and a particularly efficacious method of handling the regeneration in the detector tube. In the last analysis, we have seen so many excellent circuits evolved by this author that we are almost inclined to accept this without other proof than his own recommendation.

Before describing the procedure necessary for building the set, a brief discussion of the circuit will clear up any mysteries about the theory of operation. In Fig. 1 is a schematic wiring diagram showing all the actual connections. The two radio frequency coils consist of an antenna tuned circuit, and a radio frequency transformer. The antenna tuned circuit has an aperiodic primary and tuned secondary wound in the form of a continuous single layer coil, the ground tap being taken out at a selected point for any desired degree of coupling between the primary and secondary. The secondary coil is tuned by a variable condenser of .00035 mfd. (17 plate).

LIST OF PARTS

- 2 Variable condensers—.00035 mfd.
- 2 Vernier dials for above.
- 4 Cushioned vacuum tube sockets.
- 2 Audio frequency transformers.
- 2 Single closed circuit jacks.
- 1 Single open circuit jack.
- 1 Grid condenser .00025 mfd. with grid leak mtg.
- 1 Mica condenser .0005 mfd.
- 1 Mica condenser .006 mfd.
- 1 By-pass condenser 1 mfd.
- 1 Midget condenser, max. capacity .00005 mfd.
- 1 Neutralizing condenser, .000025 mfd. max.
- 4 Automatic filament cartridges, 25 ampere size.
- 1 Filament switch.
- 1 Binding post strip—7 posts.
- 2 Sections 3 in. bakelite tubing—5 in. long.
- 1 lb. No. 20 bare or double cotton covered wire.
- 1 1-megohm grid leak with mtg.
- 1 Panel 7x22x3/16 in.
- 1 "C" battery, 4½ volts.
- 1 Baseboard 8x22x½ in.
- 25 ft. Bus bar wire and like amount of spaghetti.
- 4 UV-201-A or C-301-A vacuum tubes.

The output of the radio frequency amplifier tube is fed through the primary of the radio frequency transformer to the secondary coil and into the detector tube. The transformer consists of three equal windings placed close together to form a continuous single layer coil, and is really an auto-transformer, as the primary is made to do double duty. The primary is made a part of the secondary circuit by means of a 1 mfd. condenser, which connects the "B" battery end of the primary to the filament end of the secondary. This condenser, having an extremely low resistance to radio frequencies, presents practically a short circuit and thus permits the secondary tuning condenser, which is of .00035 mfd., to tune the entire primary and secondary windings to the particular frequency desired.

A tap is taken out at the center of the secondary winding for connection to a neutralizing condenser, where neutralization is found necessary. The plate circuit of the detector tube feeds energy to the grid circuit through a variable condenser having a maximum capacity of .00005 mfd., and through the primary of the radio frequency transformer. The audio frequency component in the detector plate circuit passes through the primary winding of the first audio frequency transformer, and thence to the two stage audio amplifier, which is equipped with high quality transformers, so that the set will properly operate a cone type loud speaker.

The 1 mfd. condenser used in connection with the radio frequency transformer also acts as a bypass across the 45 volt "B" battery circuit, and obvi-

Illustrations by courtesy of Radio (San Francisco, Cal.)

Panel for the four-tube L-C receiver. The two main controls are provided with vernier adjustment dials. The interstage jacks can be seen at the lower right hand corner of the panel; immediately above is the battery switch.

ates the necessity of an extra bypass condenser elsewhere in the set. Filament rheostats are eliminated by the use of automatic filament cartridges, and the only filament adjustment is the 68 turns of No. 20 cotton covered or bare copper wire, for the secondary, and 7 turns of the same sized wire for the antenna coil. This makes a continuous winding of 75 turns, on a 3 in. exclusively as the secondary, with the 1 mfd. condenser connected between the 1st and 2nd sections. The neutralizing condenser is connected to the junction between the 2nd and 3rd sec-

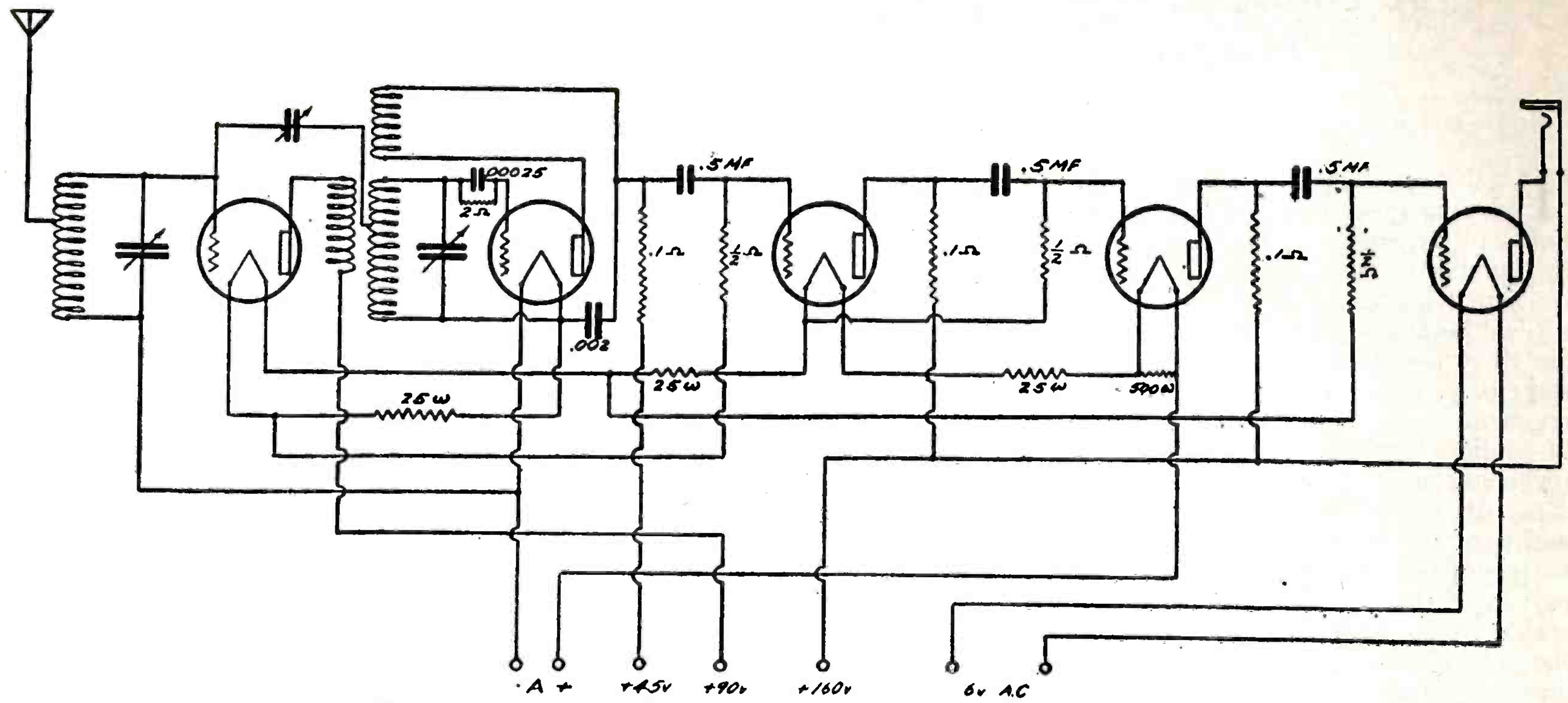


Fig. 1. Schematic wiring diagram of the set clearly showing all the connections.

battery switch mounted on the front of the panel.

The panel layout is shown in Fig. 2, a 3/16 in. panel 7 by 22 in. being used in the experimental set. The holes designated for the tuning condensers are for the type of condenser used in the set illustrated, and if other condensers are used, the template fur-

bakelite or fiber tube, it being only necessary to take a tap for the ground connection at the 7th turn. It would probably be most convenient to wind the coil with No. 20 D.C.C. wire. But for those who have access to a lathe, mount the tube in the chuck, adjust the screw cutting mechanism to 20 threads to the inch, and cut a groove over the

tions, the other side of the condenser being connected to the grid of the r.f. amplifier.

Place the coil in a vertical position, the r.f. amplifier being mounted between the transformer and the antenna coil. It is important to have as great a separation between the two coils as is structurally possible, as coupling will

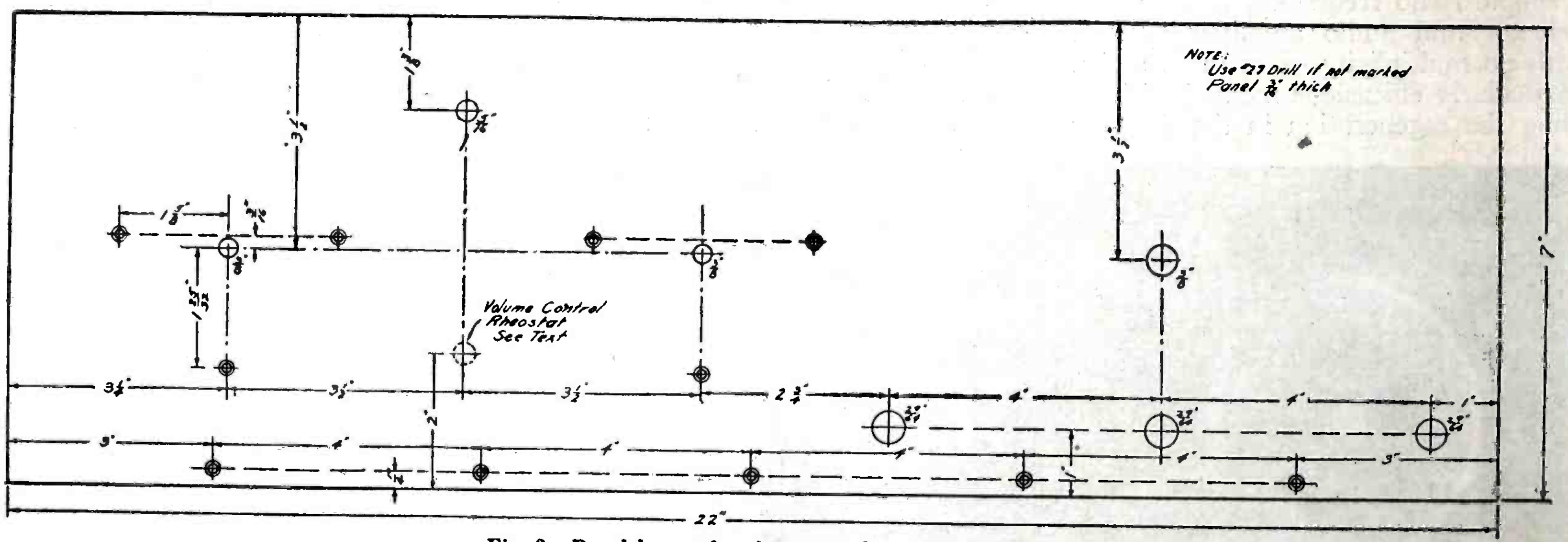


Fig. 2. Panel layout for the set as shown in the photos.

nished by the manufacturer will give the proper mounting directions. A series of countersunk holes should be placed at the bottom of the panel, for mounting to the baseboard, which is 8 by 22 in., of ½ in. stock. The material should be selected from a good grade of non-warping wood.

The accompanying list of parts will enable the selection of appropriate apparatus, the only special parts being the coils, which are easily wound.

The antenna coil, which is shown on the baseboard in a horizontal position at the extreme right end, consists of

entire length of the tube, the groove being deep enough to hold the No. 20 bare wire in place. The wire can be wound on the tubing while still in the chuck, insuring a tight winding.

The radio frequency transformer is wound on the same size tubing, and consists of 3 sections of 25 turns each, wound in the form of a continuous coil, but cut every 25 turns, and the two ends brought out to the proper terminals at the bottom of the coil. The first section of 25 turns is the combination primary and secondary while the next two sections are used

result with close proximity, and no amount of adjustment of the neutralizing condenser will overcome the difficulty. The detector tube socket is mounted next to the r.f. transformer, and as can be seen from the illustration, the audio frequency tubes are next to the panel, with the associated transformers at the rear of the baseboard.

The regenerative feature of the receiver is familiar to all those who have built superheterodynes having a regenerative loop. The same type of variable condenser, having at least 50 mmf.

maximum capacity, should be used. This condenser is connected between the plate of the detector tube and the plate of the radio frequency amplifier, so that energy is fed back from the detector plate to the grid through the primary and secondary windings of the r. f. transformer. While making the neutralizing condenser adjustments this condenser should be set at zero.

The .005 mfd. shunt condenser between the detector plate and filament is of the fixed mica type, and is necessary to bypass a large per cent of the radio frequency present in the detector tube plate, as only a small amount is allowed to pass through the feedback condenser, and it must be provided with a low resistance path to the filament. There may be sufficient capacity in the first audio frequency transformer primary winding, in which case the condenser is not necessary. This can be determined by removing the .0005 fixed condenser and observing the action of the feedback condenser, particularly on the shorter waves.

The tuned circuits have been designed so that the set will tune from 190 to 550 meters, thus insuring good reception of several new high powered stations operating between 200 and 225 meters. If trouble is experienced due to inability to tune to waves below 225 meters, on account of excessive distributed capacity in the r.f. coils, a few turns, say 5 for a starter, may be removed from the grid end of the antenna coil, and a couple of turns can be taken off the grid and plate ends of the r. f. transformer, without materially reducing the efficiency of the circuit.

The 1 mfd. by-pass condenser is mounted on the baseboard as near the r.f. transformer terminals as is possible, with the grid condenser and leak mounted next the grid terminal of the detector tube socket. The Amperites are mounted on the baseboard close to their respective socket terminals, where they are easy of access.

As much of the wiring as possible should be done before the panel is fastened to the baseboard. The pictorial wiring diagram shown in Fig. 3 will be of assistance to those who cannot easily read schematic diagrams. This has been distorted to show all the parts properly.

The filament wiring can be ordinary flexible insulated wire, bus bar wiring being necessary only in the high frequency conductors, and in the grid and plate wiring of the audio amplifier.

The "C" battery, which may be one of the flat flashlight types, should be tapped at the 1½ volt terminal, most easily done by scraping away a small amount of the cardboard covering of the battery at the end nearest the posi-

(*Continued on page* 64)

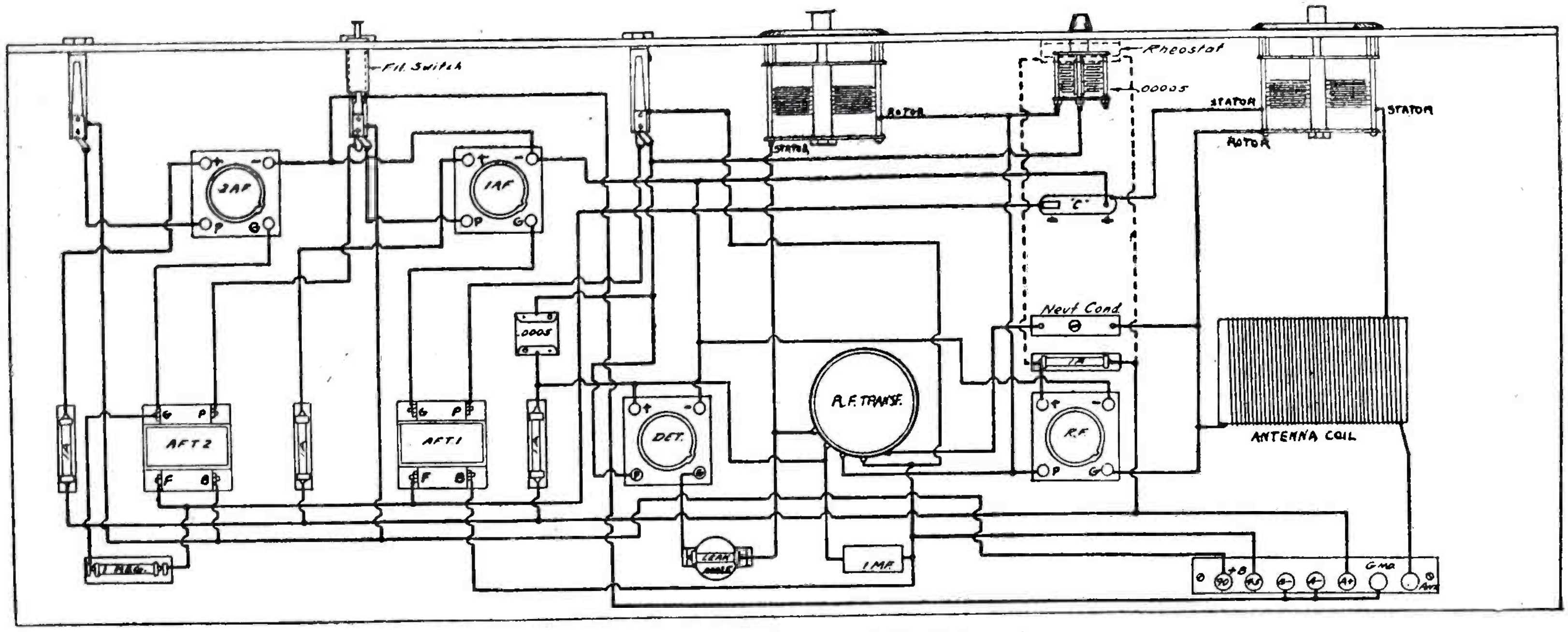


Fig. 3. Layout wiring diagram of the L-C receiver.

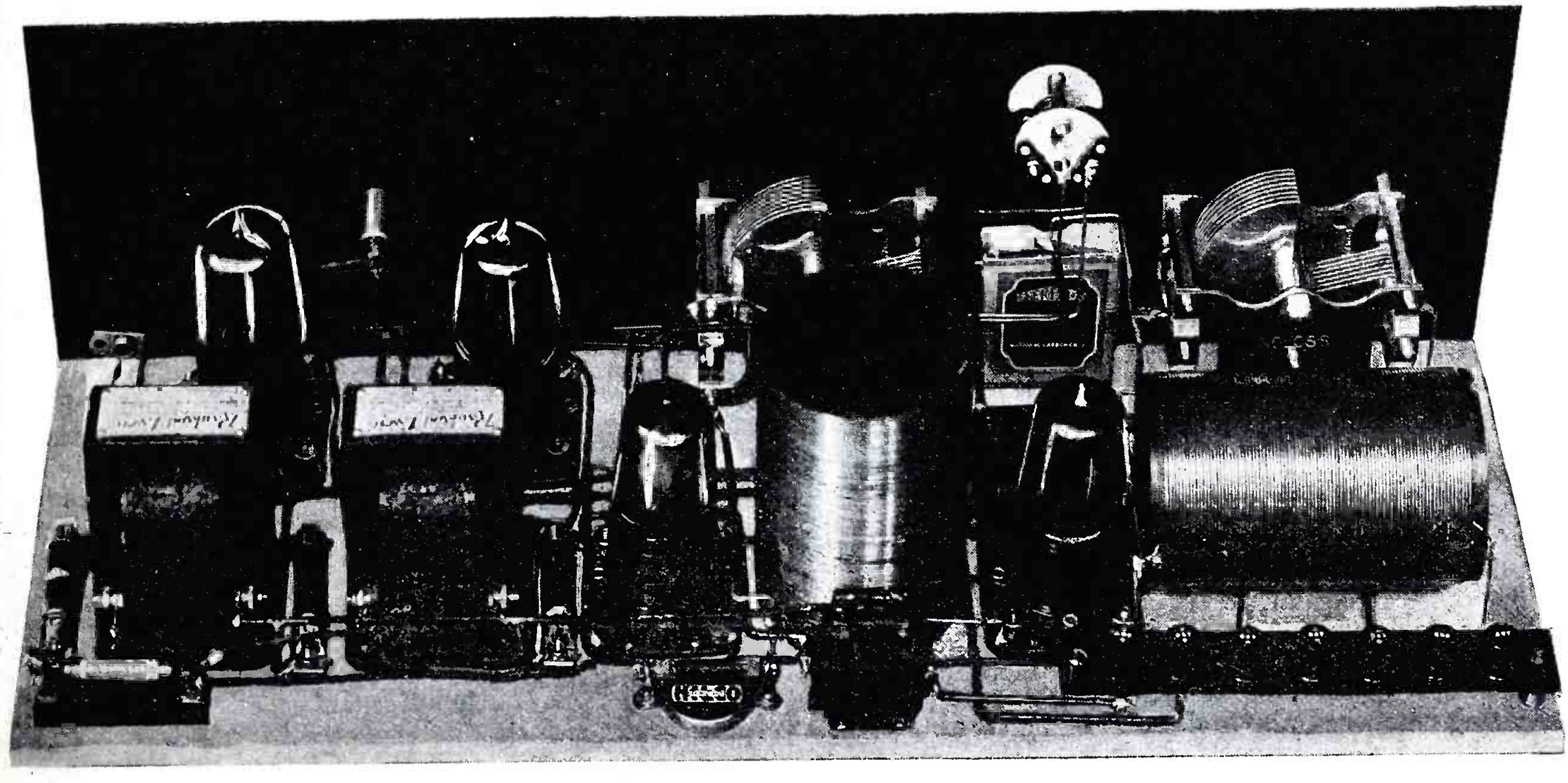
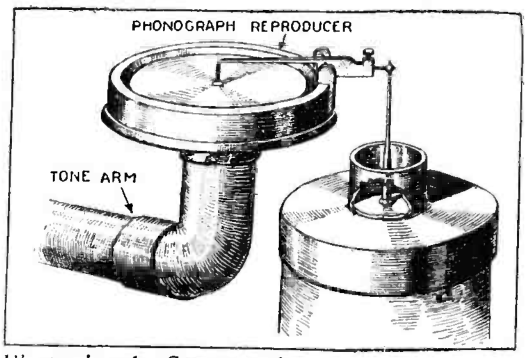


Photo of the set from the rear of the panel. Follow the same arrangement if a set is to be made as described herewith.

A Sensitive Loud Speaker

A Practical Device for Increasing the Volume of Your Set

MUCH has been said regarding the comparative features for efficiency of various circuits employed in modern types of radio sets; but little or no attention is given to reproduction after the necessary provisions are made for audio frequency amplification in order to obtain volume enough to operate some sort of loud speaker. In the following article *Harry M. Wright*, writing in *The Experimenter* magazine, gives a practical suggestion for making a loud speaker device which will not only be a means of increasing the volume of your present set but, in some cases, it will be found that the last audio frequency stage can be eliminated from a set and still be powerful enough to operate the specially constructed speaker with enough volume to be heard within the average size living room in the home. Mr. Wright writes as follows:



Illustrations by Courtesy of The Experimenter (New York)

The completed reproducer showing needle soldered to center of phone unit diaphragm and also to phonograph needle. Using the tone arm in this way results in excellent quality of reproduction.

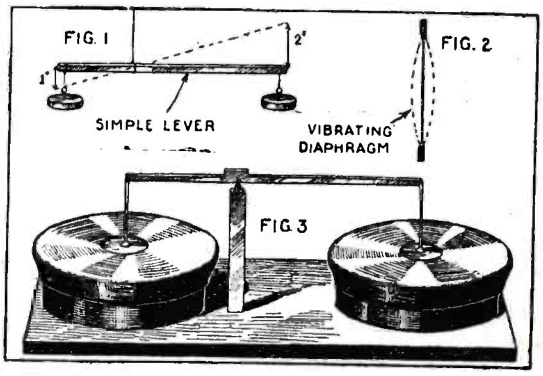
All radio amateurs are desirous of increasing the volume, and clarity of reception. In general, there are three ways of doing this, either improving the set by the addition of more tubes, or by constructing a better circuit, or by employing a more efficient and accurate loud speaker. The first two methods are expensive and to the average young enthusiast who finds radio a drain upon his pocketbook, it is a means he tries to avoid as far as possible. With this in mind, let us turn our attention to the phone unit.

A really good loud speaker is costly, but the results are worth the initial outlay. One of the most successful ideas for increasing the volume was to make use of extra electrical power to excite a magnetic field and thereby augment the signals. This scheme received practical application in several types of speakers, but it has the bad feature of consuming too much of the "A" battery current. Other units merely utilize better electro-magnets or have as their outstanding features an improved winding, a better core, or a more sensitive diaphragm.

While performing some experiments with levers, I hit upon another means of bettering the speaker. Before describing the result of my effort, it would be best to explain a few principles of physics upon which the device depends.

Volume, in the field of acoustics, depends upon the amplitude of vibration. This varies with the distance between the points of maximum refraction and those of maximum condensation of a sound wave, or as shown in the figure of a vibrating diaphragm. (Distance between dotted lines). In simple language, this means that the greater the diaphragm vibrates, the greater will be the intensity of the sound. To realize this, a simple fundamental law of mechanics was put into play. The waves of the ocean have their amplitude defined by their height.

Were we to push down an inch on one side of an evenly balanced lever,



Showing the application of the principle of levers to the loud speaking arrangement suggested by the writer. This is an excellent idea which we recommend to our readers.

the other side would rise an equal distance. But if we move the fulcrum away from the center, we realize a mechanical change. If the lever's short end were pressed down, the other end would go up more (Fig 1). This is practically known to everybody, but has been little used in radio. It was reasoned that if the diaphragm of a unit could be attached to one end of such a lever, a greater amplitude of vibration would be received on the diaphragm of the other (Fig. 3).

It was quite a job to properly devise a satisfactory apparatus that would accurately transmit the sound vibration. The difficulty lay in the requirement of a very rigid and minutely adjusted fulcrum, which was necessary to avoid distortion and loss. I overcame the drawback when I thought of the phonograph and its splendid sound arm. An examination of the machine will show that it has approximately a mechanical "stepping up" of 1½ to 1 when the needle is inserted. I had an ideal apparatus before me and I set out to use it.

Actual Construction

Remove the top of your loud speaker unit so that you can have free access to the diaphragm. Procure an old sewing machine needle, for it is made of the finest steel and just right for our purpose. With the aid of a hot iron and some solder, connect the points of a phonograph needle and the sewing machine needle so that they are at right angles to each other. Then, as is seen in the illustration, solder the free thick end of the sewing machine needle to the centre of the loud speaker diaphragm. See to it that it stands perfectly vertical. The cover can now be replaced on the loud speaker and everything is complete except a small stand to rest the unit upon. Insert the needle in its proper place in the phonograph and, while still holding the unit, measure the distance from the bottom of the case of the speaker to the record disc. With this measurement you can build a correct sized rest for the device. I made mine from a round loop of stiff brass wire, to which were soldered three wire legs of the proper length. A few pieces of felt or rubber tubing, such as spaghetti, stuck on the ends of the feet act as cushions to avoid any scratching or moving of the stand. When finished, the unit is attached to the sound arm by means of the needle that is tightened by the talking machine screw, and the support is properly adjusted.

Advantages of the Device

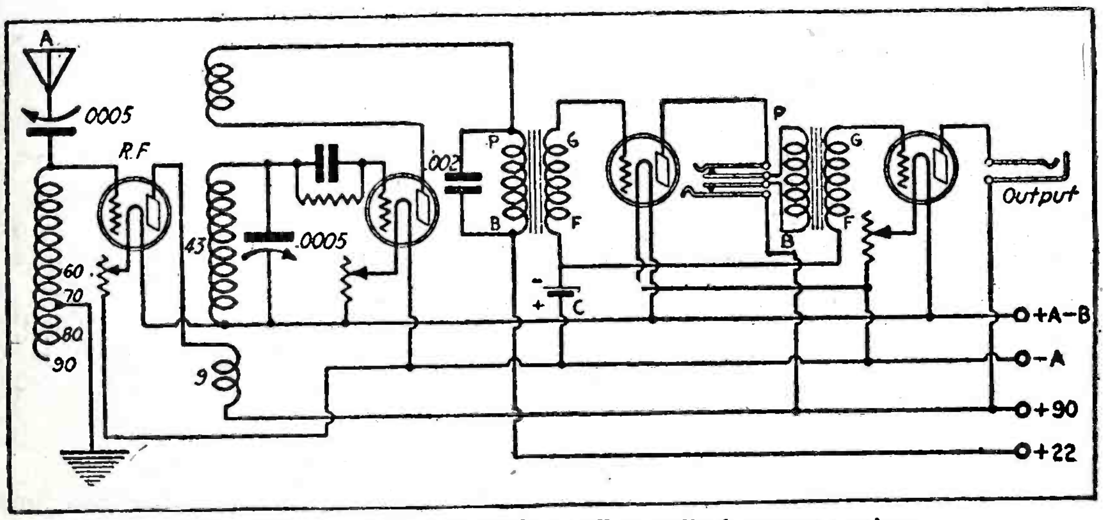
Besides materially increasing the volume of the signals, their clarity is greatly improved. The phonograph is the result of many years of work, and at one stroke we take advantage of the experience of many experts. We actually utilize the sound arm itself and not only the horn as other phonograph attachments do. By employing the sound arm, we use the machine's resonance chamber, a big factor that is missing in most loud speakers.

An Excellent Radio-Frequency Receiver

Employs One Stage of Radio-Frequency Amplification and Has Good Volume and Selectivity with Only Two Controls

HERE is a four-tube radio receiver employing one stage of radio-frequency amplification, detector and two audio-frequency stages—a combination which is ideal for all-around broadcast reception. *George M. Meyer,* author of the article on the construction of the "B" battery eliminator appearing in the September issue of Radio Review, is also author of this very interesting article on the description of his set. Mr. Meyer recently described this receiver in *The Cincinnati Enquirer,* Cincinnati, Ohio, as follows:

How would you like to build a four-tube set that would give volume almost equal to any five-tube receiver on the market? It can be done. The receiver about to be described may be constructed without the use of "low loss" parts or trick wound coils. It is an excellent receiver and as for volume and clarity of reception nothing more could be desired. An actual test of this outfit over a period of about one year resulted in the writer adopting this circuit for his own radio set, which is at present connected up in a discarded Victrola cabinet, the shelves having been removed for the housing of the set and "B" battery eliminator described in September, 1925, issue of Radio Review.



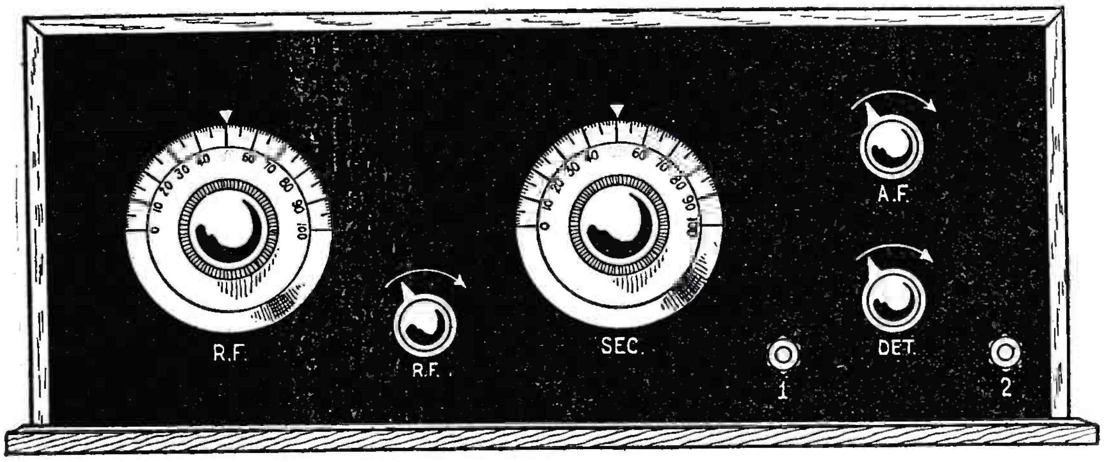
Schematic wiring diagram of the excellent radio frequency receiver.

In order to use a small panel for this two-control outfit to enable it to fit in the cabinet of the talking machine the amplifier circuit was placed in back of the radio-frequency and detector apparatus. This called for deep baseboard. The front panel measured 18 inches long and 7 inches high. Small strips of wood were screwed to the sides of the former music compartment so the set on the baseboard could be removed. This was done so changing the tubes or battery connections could be easily accomplished.

The circuit makes use of a stage of radio-frequency amplification which seems to supply tremendous volume to the detector tube.

Radio Frequency Circuit

It is the writer's opinion that greater radio-frequency amplification per stage can be obtained when the circuit is tuned in single circuit fashion; that is, with a condenser connected in series with the antenna tuning coil rather than across a coil having an untuned primary winding. In past experience with receivers employing a stage of tuned radio-frequency ahead of the detector results have shown that greater amplification of radio-frequency currents is possible with the series circuit. In fact, this type of circuit has been known to produce as much amplification as two stages of tuned radio-frequency employing condensers shunted across secondary coils and non-tuned primaries. It is for this reason that this four-tube set will produce as much volume and receive as much DX as some five-tube tuned radio-frequency receivers.



Illustrations by Courtesy of N. Y. Herald Tribune

Sketch of the four tube set as it appears when completed.

Special couplers or coils are not necessary, as the two coils in this receiver may be home-made. Below is a list of the parts required to complete the set:

1 panel.
2 .0005 variable condensers.
1 .00025 grid condenser with mounting.
1 4-megohm leak.
1 .002 fixed condenser.
1 tube 3 in. diameter, 4 in. long.
1 tube 3 in. diameter, 4½ in. long.
1 pair of audio transformers.
7 binding posts.
4 sockets.
2 single jacks.
2 20-ohm rheostats.
1 10-ohm rheostat.
2 4-in. dials.

A careful selection of the parts is essential: Those having a wide reputation and well known to sets builders should be chosen. Obtain the best parts money can buy and be sure of a good set of vacuum tubes. Have them tested before using.

Battery Wiring

Designers of some of the highest class receiving sets have specified flexible stranded copper wire for all filament and plate battery connections. These leads are all bunched together and tied to keep them out of the radio-frequency circuit. The wires running to the sockets, binding posts and rheostats should be kept near the baseboard of the set. A receiver wired in this fashion will not be subject to squeals or high-pitched notes common to a great many home-made sets in which the "A" and "B" battery circuit is allowed to traverse the tuning circuit.

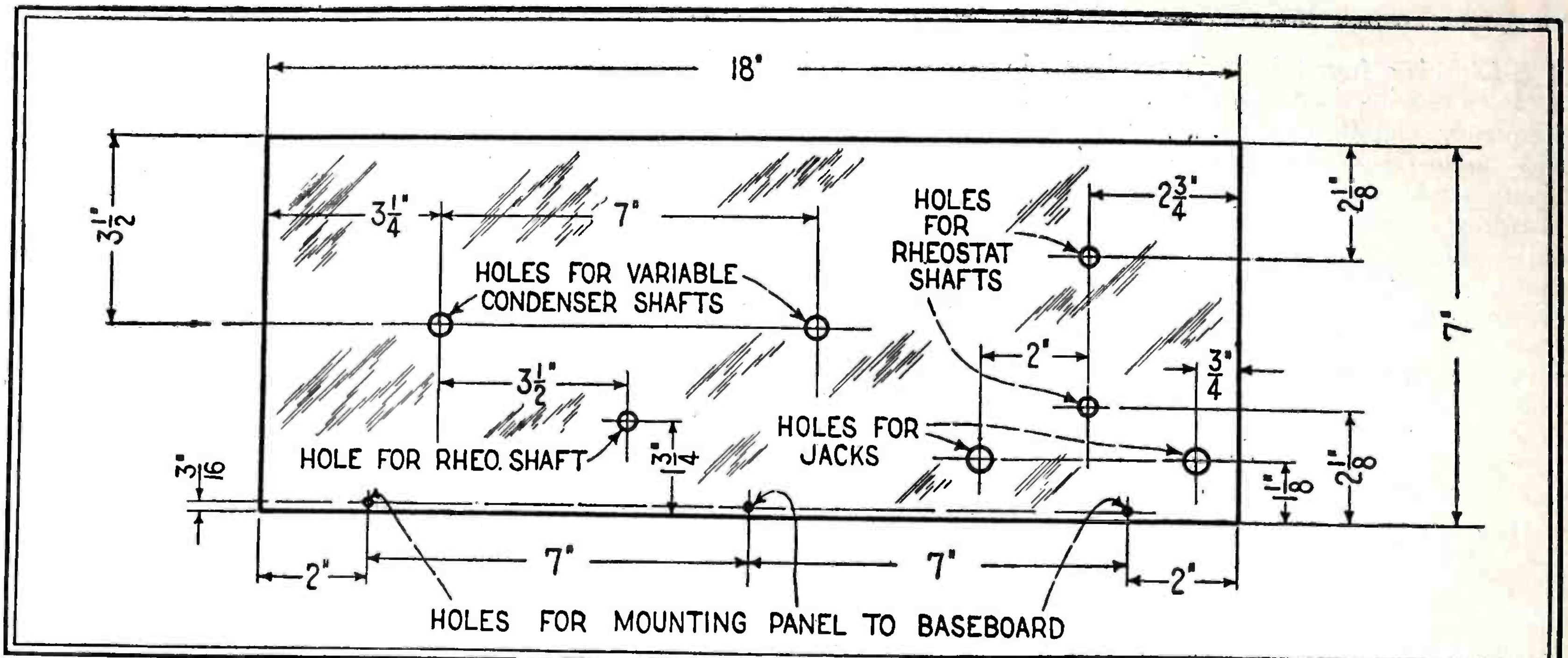
This flexible stranded rubber-covered wire is appearing at many radio shops. If it is not available, use flexible lamp cord and strip the outer cotton-covered insulation off until the rubber shows.

ings should be mounted parallel to the baseboard. The two coils should be a half inch apart. The latter may be mounted on brass brackets or by means of small blocks of wood fastened to the baseboard.

The secondary of this coil is shunted by a .0005 variable condenser. The reversed winding is in the plate circuit

gests getting a 5 or 6 to 1 ratio for the first stage and a 3 or 2 to 1 for the second step.

A "C" battery seems to be in style, and so one has been included in the circuit. It will improve reception as well as prevent excessive drain on the plate batteries. Ninety volts of "B" battery will require a "C" battery of



A panel layout of the set giving dimensions for drilling holes for mounting the parts.

This is a trifle larger in diameter than is used in practice, but will answer the purpose. The set may not appear to be wired as neatly as if bus bar wire were used, but it will probably work better.

Secondary Tuning Coil

The secondary tuning coil which feeds the detector tube should be carefully made and wound tightly with No. 24 D.C.C. or D.S.C. copper magnet wire. There are three separate windings on this coil, one for the plate of the radio-frequency tube, the secondary and the plate coil of the detector circuit. The tube should be 3 inches in diameter and 4½ inches long. Start about half an inch from one end and wind nine turns of wire, being careful to prevent the wire from coming unwound. Fasten each end of this small winding through small holes made in the tubing.

Then in the reverse direction wind the secondary coil with forty-three turns of wire. Leave one-quarter of an inch between the first winding and the secondary. Remember the secondary coil is wound directly opposite to the nine-turn coil. Both ends of the secondary winding should be fastened through holes in the tubing. Skip a half inch and wind nine more turns of wire in the same direction as the forty-three-turn winding. You now have completed the coil. It may be mounted in back of the secondary tuning condenser and placed at right angles to the antenna coil.

If the antenna coil is mounted upright from the base (as shown in the sketch) the coil with the three wind-

of the radio-frequency tube. The end nearest the secondary connects to the "B" battery of the detector tube. The outer end connects to the plate terminal of the radio-frequency amplifier tube. After the set has been tested, it may be well to try reversing these connections.

The nine-turn winding which follows the direction of the secondary is connected in the plate circuit of the detector tube. When the circuit is under test, if it regenerates or squeals, this coil is wound too near the secondary. There are two methods of overcoming the regeneration. One is to slide this coil away from the secondary another quarter inch or about circuit three to five turns. This will prevent the regeneration to the extent of stopping oscillation. There will still be a certain percentage of regeneration present which is necessary in order that the receiver function on distant stations. However, the set should not squeal on any wave-length. It will not radiate, due to the blocking effect of the stage of tuned radio frequency.

Audio Amplification

In building this receiver the writer chose a good set of transformers and used the old reliable transformer coupled audio-amplifier circuit. The quality of reproduction on the loud speaker is entirely governed by the audio amplifiers. Should poor transformers be used distortion may be expected. Never neglect this part of the receiver, but use good transformers. It is a foolish move to purchase two poor transformers. The writer sug-

4.5 volts. If one of the new RCA power tubes is used in the last stage a great increase in volume over the 201A will be obtained.

There is no use putting in a jack for the detector tube, as headphones are very seldom used. A jack has been provided after the first stage of audio so reduced volume on local reception may be obtained. Two stages are not always necessary except for the weaker stations. The jack for the first stage is of the closed circuit type, connected as shown in the diagram.

The output jack for the last stage is of the single circuit type. The plate of the last stage tube is connected to the upper contact of the jack and the "B" battery 90 volts to the other terminal. It is sometimes necessary to place a .002 fixed condenser across the output terminals of the last stage jack. This is recommended for those who use cone type speakers.

Tuning Controls

A word or two of explanation concerning the tuning of this receiver is given to enable those who have constructed similar outfits to obtain the best of results. There are but two controls as far as actual tuning is concerned. One of these to the left of the panel is employed to tune the first stage of radio frequency and the antenna circuit. The second tuning condenser is used to tune the detector circuit. This adjustment is in control of the wave-lengths and may be called the "station selected," as it is used to pick out the stations. If the set has been properly constructed, this tuning dial should be fairly sharp on all stations. It may be logged; that is, the dial settings may be taken down on a card and used for future reference. The readings should never change unless the station is assigned another wave length.

Antenna Coils

The radio-frequency coil is wound on a 3-inch tube about 6 inches long. No. 24 double cotton- or silk-covered wire is required for the winding. The entire coil contains ninety turns of wire, with four taps take-off at intervals. Start the winding about half an inch from the end of the tube, and before taking the first tap wind fifty turns of wire. Make a loop or twist which may be cleaned later for connections. Continue winding the coil in the same direction until the seventieth turn. Take another twist and proceed to the eightieth, where another tap is taken. Finish the coil at the ninetieth turn and leave a short end for connecting the bus bar wire.

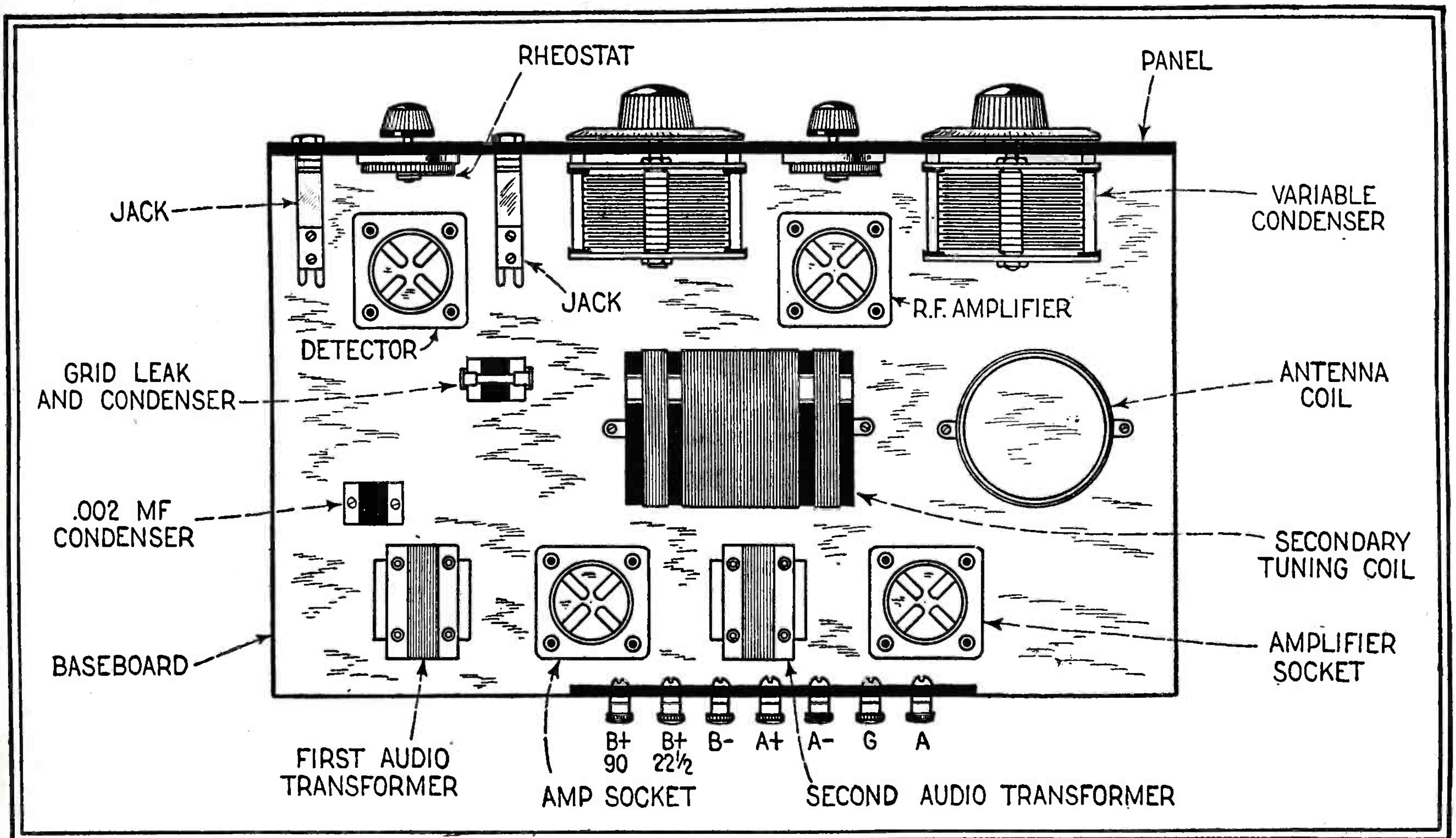
Two small brass braces can be screwed to the bottom of the coil for holding it in an upright position on the baseboard. A block of wood may be fastened to the sides of the form and this screwed to the baseboard in place of the brass braces. The coil should be rigid. Clean the tap twists and run a little solder down the wires to keep them stiff and in shape for tapping purposes.

This coil should be placed directly in back of the aerial tuning condenser and about an inch away. The .0005 variable condenser which tunes this coil is connected to the top turn. This should be made to the fixed or stationary plates of the condenser, in order to avoid any possible "body capacity." The rotor plate connection goes to the antenna binding post on a strip at the rear of the baseboard.

The top of the coil also connects to the grid terminal on the radio-frequency tube socket. Make the lead as short as possible and direct to the socket, avoiding bends and fancy shaped wires.

The socket should be a good one, preferably of glass construction with heavy springs, or a good sturdy composition socket. Side-wiping socket spring prongs are good.

The antenna series condenser aids in bringing about resonance between the primary radio-frequency circuit and the detector circuit. The adjustment of this dial may not be so critical as the other dial across the secondary tuning condenser. It may be well to experiment with the taps on the coil winding. Pick out a tap which will give a dial reading on the antenna condenser which takes in wave lengths between 200 and 550 meters. It is difficult to state offhand which tap will be correct. Once the proper turn is located the lead wire to the condenser may be fixed permanently.



How the parts may be arranged on the baseboard and panel.

Proper Graduations for Dials

(*Continued from page* 53)

4. Every tenth line representing 0, 10, 20, etc., should be marked with the number of the graduation, "0," "10," "20," etc. They may be longer than the other lines, but the marking if suitably placed will often distinguish this line adequately.

5. The thickness of the rulings ordinarily should be about 1/10 of the graduated space between. In closely spaced graduations it may be necessary to accept a slightly greater line width and where the spaces are fairly large a line thinner than 1/10 the space can be used.

6. The mark should be clean cut and as white or black as possible, as the case may be.

7. The pointer or index should be a straight line in the same plane as the graduations.

8. No cross rulings should be used.

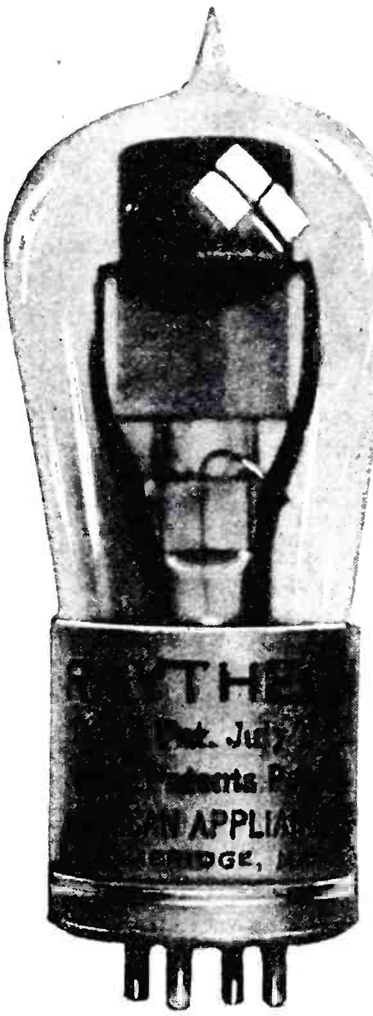
9. The plane of the graduations should be at right angles to the line of sight.

10. The color of the background beyond the dial at the index should be the same as the dial.

The Helium Tube Rectifier

An Account of the Theory and Practical Construction of a New "B" Battery Eliminator.

A SURVEY of the "B" battery eliminator field shows some dozens of varieties, good, bad and indifferent, the majority of them operating with rectifying tubes of the UV-201A or similar types. In an endeavor to obtain a greater current output than is possible with the standard tubes, numerous special types have been



Illustrations by courtesy of Radio (San Francisco, Cal.)

Fig. 1. General appearance of the helium tube.

brought out, notably that of the Radio Corporation. Recently a rectifying tube, employing radical principles has been produced. This tube resembles to some degree the old "S" tubes, being adapted particularly to supplying plate potentials at a nominal current rate. These tubes are outstanding in that they rectify both halves of the alternating current wave. *Edwin E. Turner* has described the new tube and given instruction regarding a complete eliminator. The description of this unit appeared in *Radio*, San Francisco, Cal., and is given in the following.

A rectifier for use in "B" battery eliminators should possess certain qualifications, in order that the device as a whole will prove equal to the exacting task which it is called upon to perform. These are: complete rectification, long life, good regulation, high voltage output, high current output

PARTS REQUIRED

- 1 Raytheon Type B rectifier tube.
- 1 Power transformer, General Radio Type 365, Dongan Type, 509.
- 2 Choke coils, Dongan Type 514, General Radio Type 366 (1 required).
- 5 2 mfd. Tobe Deutschmann, Dubilier-Filter.
- 1 1 mfd. Tobe Deutschmann, Dubilier-Filter.
- 1 .5 mfd. Tobe Deutschmann, Dubilier-Filter.
- 2 .1 mfd. Tobe Deutschmann, Dubilier-By-Pass.
- 1 Variable resistance, 10,000 to 100,000 Bradleyohm, Centralab Potentiometer.
- 1 Fixed resistance, 10,000 ohms, Daven.

and stable characteristics. A new helium tube, which closely approximates the ideal, has been placed on the market under the trade name of "Raytheon." The tube is an outgrowth of the same fundamental electrical laws which gave rise to the "S" tube, but it is a new development in itself. Full wave rectification is performed in the

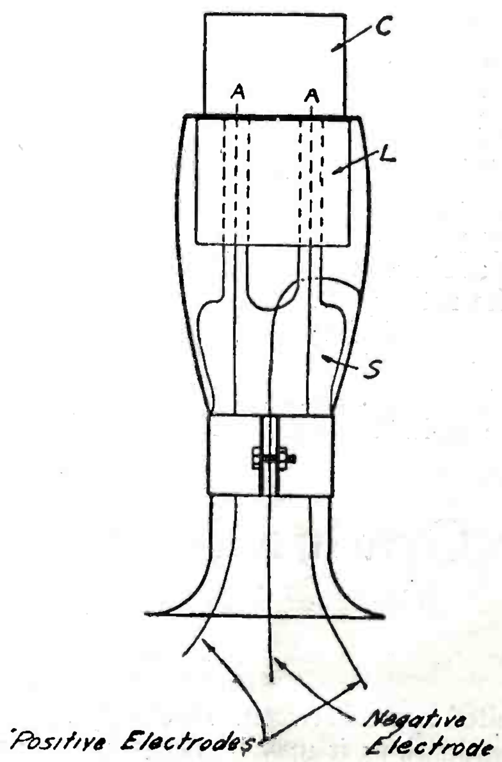


Fig. 2. Construction of the helium tube.

single tube, rectification is unusually complete, the regulation is good and the life of the tube, when subjected to the conditions of ordinary reception, is unusually long.

This gaseous rectifier operates upon "the short path principle," whereby a rarified gas acts as an insulator between points which are in close proximity. This is an apparent contradiction of the observed phenomenon that the smaller the distance between two points the more readily a spark will jump between them due to the ionization of the gas. But if the distance is small enough and a suitable gas is used at sufficiently low pressure an electron may encounter no gas molecules in its path between the points and there will be no ionization by collision. Consequently the inert gas helium may be made to act as a perfect insulator at low pressures.

Furthermore it has been found that when the larger electrode of a gas conduction tube is negative there is a greater current flow than when the smaller electrode is negative and that the smaller the positive relation to the negative electrode the smaller is the back current and hence the more complete is the rectification.

Heretofore the difficulty of insulating the positive electrode in the presence of a gaseous discharge gave a practical limitation to the reduction of its size. But in the tube the "short path principle" eliminates the difficulty.

Fig. 1 indicates the appearance of the tube and Fig. 2 shows its construction. The two small positive electrodes *AA* are carried through two small glass tubes imbedded in a lava insulating block *L* so as to project very slightly into a relatively large cup *C* whose walls constitute the negative electrode, being connected to the negative terminal through the base. The diameters of the small wires and the diameters and position of the holes whereby they enter the cup are so proportioned as to give the necessary short path to the negative electrode. The cup *C* contains helium gas at such low pressure as to prevent gaseous conduction.

This gives an insulation of great reliability and long life. It makes possible extremely small anode surfaces which reduce the back current to a negligible quantity. The urgent necessity for the reduction of back current in a rectifier to be used in battery eliminators is not generally recognized. Beside shortening the life of the insulation as above described, back current increases the load on the filter circuit, making the elimination of the hum almost impossible. It lowers the current and voltage output of the device and makes for poor regulation. The regulation of the model built by the author is shown by the curve of Fig. 3. This regulation is partly a function of the filter circuit used.

A "B" battery eliminator, using the new rectifier is shown in Fig. 4. The schematic diagram of the eliminator is given in Fig. 5, the constants being shown for all apparatus.

The input voltage of 110 volts 60 cycles is passed through a transformer, shown at the right of Fig. 4, which delivers a secondary voltage of 250 on each side of the center tap. The rectifier, operating during both halves of the cycle delivers a pulsating direct current to the filter system L_1, L_2, C_3, C_4 and C_5 in Fig. 5 which smooths out the variations, delivering a pure direct current to the resistances R_1, R_2 and to the external load. The terminal voltage of the device is lowered by means of the voltage divider, R_1, R_2, so that a suitable low value may be obtained for the detector. Condenser C_6 is used in shunt to the fixed carbon resistance R_2 to prevent carbon noises.

For those who want to construct their own power transformer, the following data will be useful: Core is ¾ in. square and is built in the form of a square window having inside dimensions of 1¾ in. on each side. The primary is wound with 1220 turns of No. 28 enameled wire, over which is wound the secondary, which consists of 5440 turns of No. 33 enameled wire, with a tap at the center turn. A layer of thin paper should be placed between each layer of wire, and a piece of empire cloth should be used between the primary and secondary windings.

The choke coil may be made by winding 6000 turns of No. 31 enameled wire on a core having a square window 2 in. on a side, and having a cross section ½ x ¾ in. A 0.003 in. air gap should be provided at one joint of the core pieces.

In constructing the eliminator it should be noted that the cases of the transformer, the chokes and the condensers, together with one side of each condenser, the center tap of the transformer and one side of the fixed resistance R_2 are connected together and to the "B" minus terminal. In order to simplify the construction and wiring, the experimental model was mounted on a brass plate secured to a wooden baseboard, the apparatus being grounded directly to the plate. In this way a major part of the connections are

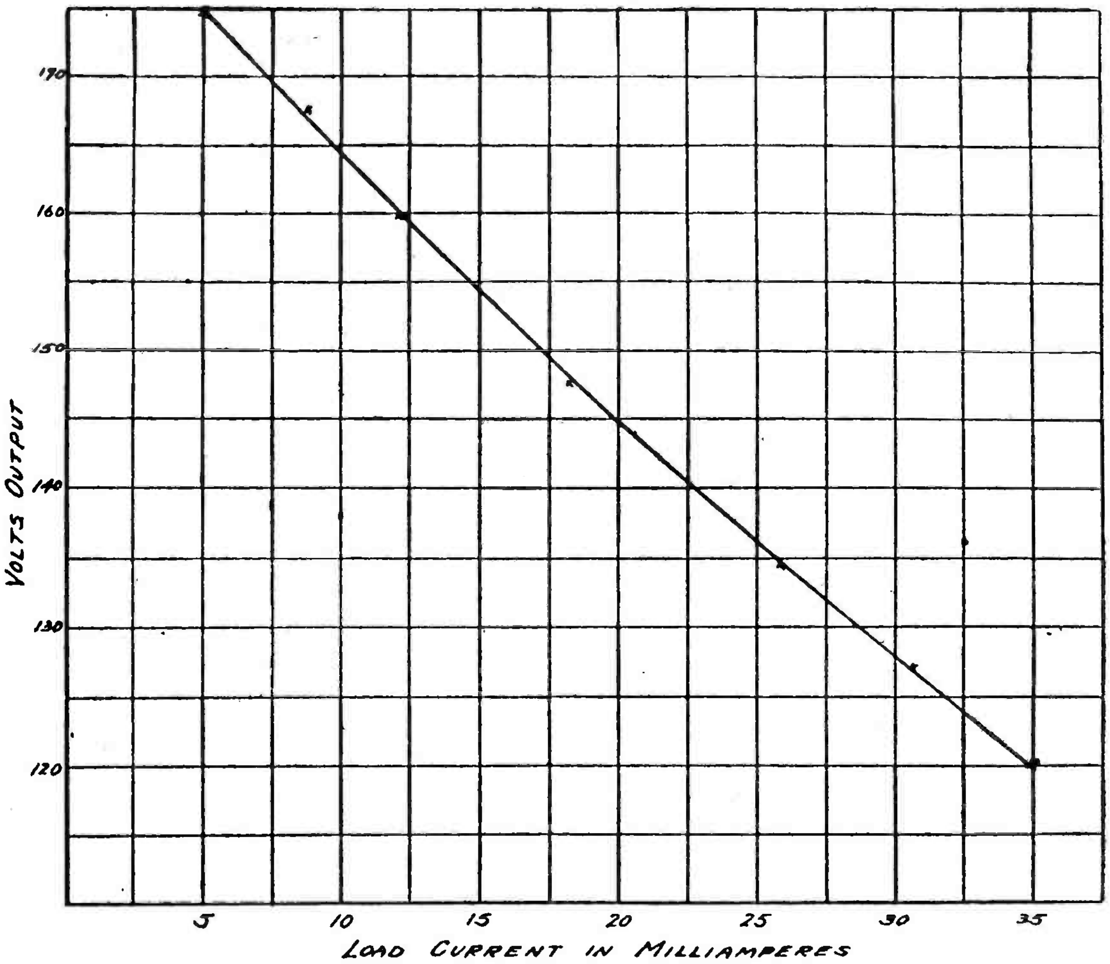


Fig. 3. Regulation secured in the "B" battery eliminator using the helium tube.

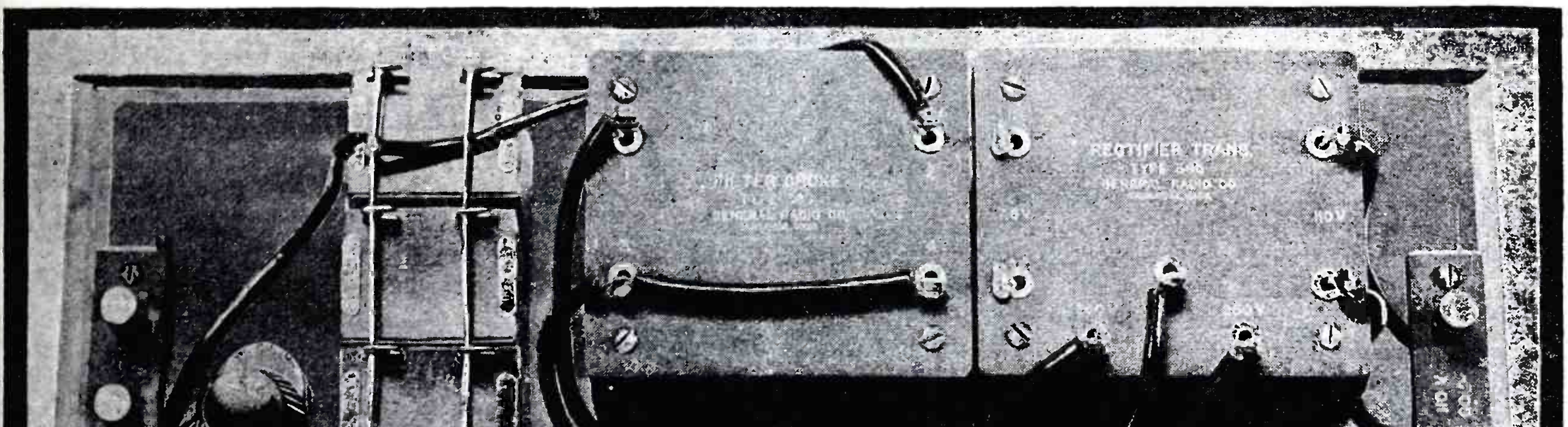


Fig. 4. Photo showing the "B" battery eliminator using a helium tube.

made through the plate, and with this method of construction the wiring is a simple matter.

The rectifier tube is designed to fit the standard 201-A socket. The two anodes, marked *FF* in Fig. 5, correspond to the filament terminals of the socket and the cathode *P* to the plate terminal of the socket. The grid terminal is not used and may be left without connection. The model shown in the photograph uses a second variable resistance of 10,000 to 100,000 ohms set at minimum in place of the fixed resistance of 10,000 ohms called for, since a fixed resistance of this value was not available at the time. The fixed resistance may be used here more economically.

In connecting the choke coils, if both windings are on a single core, care should be taken to have the polarity correct in order that the inductances are series aiding. Particular care should be taken in the selection of condensers for this device. It is important that the condensers have high internal resistance, high dielectric strength and that they agree within 10 per cent of their rated capacity. The choke coils may be had from a number of manufacturers who have built them to very rigid specifications. The filter circuit in this eliminator was designed by Prof. F. S. Dellenbaugh of the Massachusetts Institute of Technology, one of the foremost authorities

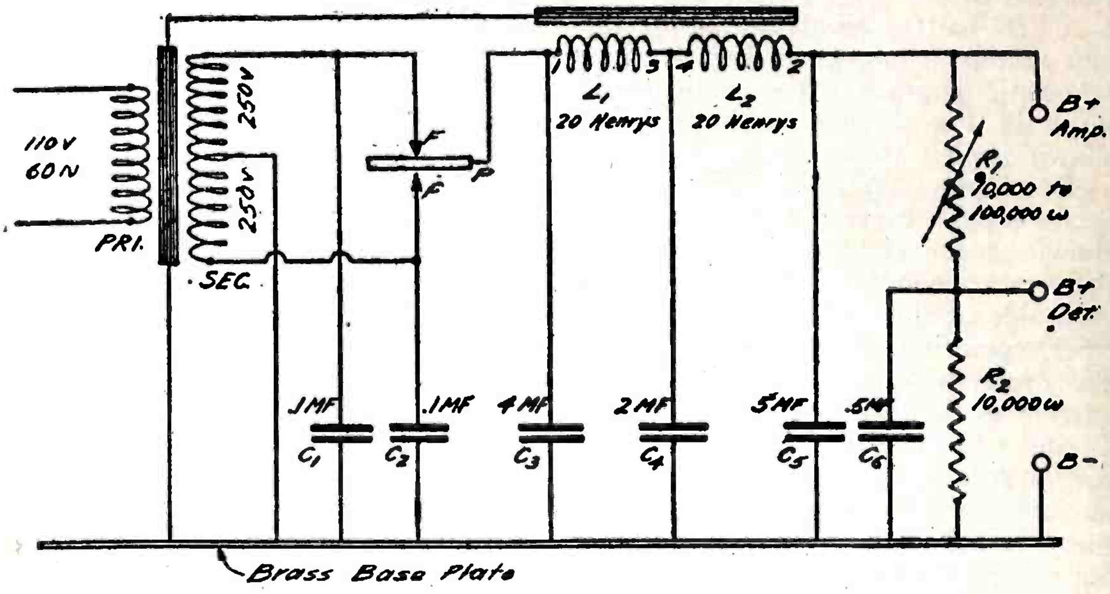


Fig. 5. Wiring diagram of the "B" eliminator.

on filter design. The performance on this particular type of plate supply is extremely gratifying, for it acts as theory dictates it should. On a ten-tube superheterodyne receiver, using *A* tubes with a total current consumption of 37 milliamperes the hum was entirely negligible with the loudspeaker in operation. The quality was equal to that delivered by a storage "B" battery supply, which was alternated with the eliminator. On sets using less tubes the performance was slightly better, the hum being indistinguishable with the receiver unmodulated.

The L-C Circuit

(Continued from page 57)

tive terminal, exposing the zinc covering of the first cell, which will be the minus 1½ volt connection. A piece of flexible wire can be soldered to the zinc, and connection made to the rotor plates of the antenna coil tuning condenser. The 4½ volt negative terminal of the "C" battery is connected, by means of a piece of bus bar wire, to the filament terminals of the two audio frequency transformers.

Battery connections are all brought out to the binding post strip, as are the antenna and ground leads. The terminals on the strip which are marked antenna and ground are placed nearest the ground and antenna taps on the antenna coil, so that the connecting leads will be very short.

After the wiring of both panel and baseboard is complete, the four vacuum tubes should be placed in their sockets and the "A" battery connected. Short circuit each Amperite in turn to see that it is functioning properly, and if the filament of the tube does not become more brilliant, in each case, the filament cartridge is not working as it should. Disconnect the positive "A" battery lead and touch it successively to the positive 45 and 90 volt binding posts. If any of the tubes light, even very dimly, or a spark is seen when the connection is made, a short circuit is present somewhere in the set and should be located before the "B" battery is placed in the circuit.

Upon completion of the inspection, connect the batteries, antenna and ground, and the set is now ready for final adjustments. Turn on the filaments of the tubes and plug the headphones in either the detector or first audio frequency amplifier jacks, according to the volume desired. Tune in a local station to maximum volume, and you will probably find that the set will oscillate when the maximum point is reached.

The neutralizing condenser is adjusted by means of a small screw mounted in the center of the condenser, a rough adjustment being made by turning this screw until oscillation ceases, or is reduced to a very small part of the condenser scale. Then remove the r.f. amplifier tube from its socket and place a piece of paper on top of the positive filament spring, replacing the tube in the socket. The local station will no doubt be heard faintly, and the neutralizing condenser can now be adjusted until no signal is heard, as is customary in the adjustment or neutrodyne receivers. One make of vacuum tube has such a low interelectrode capacity that the neutralizing condenser is not needed, and may be omitted.

After the neutralizing condenser is in order, the piece of paper on the socket spring contact can be removed and the tube filament lighted. If oscillation still persists, the antenna coil and r.f. transformer may be closer than is desirable, and the coils should be separated further, if such a procedure is possible.

Ordinarily, the volume control of this set can be obtained by changing the tuning of either of the variable condensers slightly, but many prefer a separate volume control, and in this case, it will be advisable to mount a 25 ohm wire type rheostat on the panel, between the two tuning condensers and underneath the feedback condenser to replace the automatic filament cartridge in the r.f. amplifier tube positive lead. The position of this rheostat in the circuit is shown in Fig. 1, and in dotted lines in Fig. 3. This rheostat was not used in the experimental layout, as it was desired to make the set as simple as possible in regard to controls.

Radio Builders' Suggestions

Hints for the Constructor's Workshop

WHEN doing experimental work or building radio receiving sets or in fact working in any way with radio, one of the most important things is a good workshop that is well arranged. In an article entitled, "Preparing Your Work Shop For The Winter's Activities," *C. P. Allinson* makes some very good suggestions that will help all experimenters. Mr. Allinson's article appearing in *The Wireless Constructor* of England follows:

The evenings are long, and with the resulting improvement in conditions as affecting radio reception, enthusiasts who have laid by their hobby during the past six months are resuming their work. Many no doubt contemplate rebuilding their sets, using more up-todate instruments than those which were in use last year, others may be improving or overhauling the actual parts themselves where their skill allows, and others are mapping out work ahead for the Winter. All this activity will require the use of tools and small parts; tools, moreover, which have been lying neglected through many months.

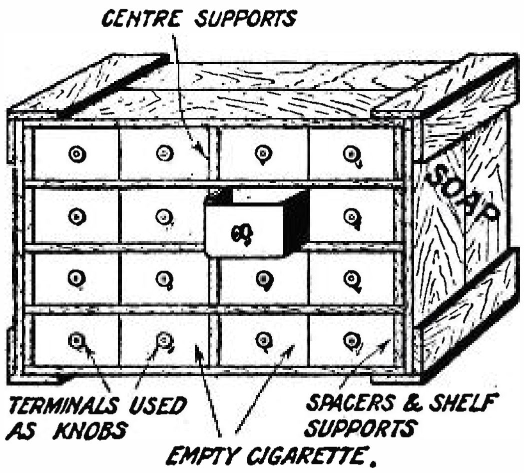
Clearing Up

The first thing to do in preparing for the resumption of work in the workshop is to examine exactly how things stand. Look through the box of spare parts and examine these to see which are suitable for further use and which are merely junk. The latter will generally be received with open arms by some local enthusiastic schoolboy whose purse, like that of all school-boys, is not too well lined; the former can be put aside wherever convenient. If there is a bakelite scrap box look through this and determine what is worth keeping and what not.

In this matter of deciding what to keep and what to get rid of one must be really ruthless. The temptation is great to say, "Well, this might come in useful some time, I won't throw it away just yet." You know it has been lying about for over a year and has never been wanted yet—of course we all know that having got rid of it you will find a need for it within the week!

Keep Screws Together

Next it is a good idea to gather together all the nuts, screws, terminals, wood screws, bits of brass and copper, odd switches, sockets, studs and other metal parts used in the construction of radio receivers (and their name is legion) and sort them out. Place all the nuts together, all the screws together and so on. A small nest of boxes may be made either out of empty cigarette tins or other suitable little boxes into which the various heaps of parts can be placed. This enables any little "gadget" that may be required to be obtained with the least delay. The writer made a very useful cabinet out of an old soap box and empty cigarette tins for this purpose.



Illustrations by Courtesy of The Wireless Constructor (London, England)

Fig. 1. The drawers of the cabinet for screws, nuts, etc., can be made from rectangular tin boxes.

Details of the Cabinet

The sketch shown in Fig. 1 gives the details as to how this was done. First of all three horizontal partitions were fixed by means of wood strips fastened to the inner sides of the box, lengths being cut to size just to slide in, making what are in effect very shallow shelves. The distance between these is a little greater than the depth of the cigarette tins. As each shelf holds four tins, and these are rather heavy when filled with small metal parts, short pieces of wood about ½ in. wide were cut the same depth as the shelves and pushed in to support them in the center. Old binding posts were fixed in the front of each tin to provide a knob or handle for pulling them out and the contents of each tin painted on with black enamel.

Last but not least is the question of tools. Autumns are not exactly renowned for dryness. Under these circumstances it is hardly surprising to find tools become rusty. These should, therefore, be carefully cleaned with a little fine emery paper and then lightly rubbed over with vaseline. Some workers are inclined to use paraffin when cleaning tools as it make the emery cut better; this practice is, however, strongly to be condemned, for once this has been done the metal tends to rust far more easily than before. A little pure vaseline well rubbed in after the tool has been cleaned will not harm, however, and the excess should be rubbed off with a clean rag, as hands should, of course, be kept free from grease when doing electrical work. Other tools that may require attention are screwdrivers, scribers, and other tools that have to have prepared edges or points. All these should be carefully ground up, and if they are correctly tempered they may then be expected to keep their edges or points, as the case may be, over the busy season. Drills should be examined to see whether their cutting edges are sharp and not chipped, and if they are in bad condition should be re-ground. Those who have not the necessary means for doing this, or who perhaps have not the skill, can get them done for a small sum at a local ironmongers or motor repair shop.

Then, of course, files should be examined, and if badly rusted and worn should be discarded, although some may like to try putting them in dilute sulphuric acid as a means of reconditioning them. As a good file, however, can be obtained for a small sum, this practice appears, hardly worth while. Files that are merely rusty may be cleaned with a scratch brush or file card.

Taps and Dies

The more advanced constructor with a fairly extensive kit of tools, such as taps and dies, etc., should look carefully through these and see that they are all in good condition and that none are missing. There is nothing more annoying than to start on a job and when half-way through it, discover that a particular tool is not there. Those who do not possess taps and dies and who have acquired skill in mechanical work may wish to buy a few of these to help them in their work. Taps are obtainable in three types, taper, seconds and plug. Of these the most useful all-round type is the second cut. The taper is rarely needed in wireless work, nor is the plug, this being only required when blind holes are to be tapped.

Home-made Tools

The constructor with limited means who cannot afford to buy many tools can spend a little time in making those he requires most. Taps for bakelite may be made from brass screws or studding (threaded rod) by cutting a couple of slots lengthways along the thread; screw drivers can be made out of lengths of silver steel which can be purchased cheaply. A tang for fitting into a wooden handle is easily made by heating one end to red heat and hammering it out square. A scriber can be improvised from a piece of broken hack-saw blade ground to a narrow chisel edge at one end, while a center punch may be made from a stout wire nail ground to a fine point. Other handy little tools can be made from material at hand or that can be purchased for a few cents, and they are well worth a little time and trouble taken, as with their aid work can be done more quickly and accurately.

Further Tools

The man who does a lot of constructional work and who can afford to spend a little on tools will find such gadgets as an automatic centre punch, a combination rule and set square, a ratchet spiral screw-driver, tool-makers' clamps, etc., of the greatest value in enabling work to be done with despatch and precision.

Above all, method should be employed in constructional work, and every tool should have its own place *to which it should be returned after use,* thus much time will be saved in looking for tools and accessories, which, if mislaid, invariably turn up in the very last place looked in. This, of course, is not good for the temper!

A Home-Made Tuned Radio Frequency Set

(*Continued from page* 52)

The Coils

Audio amplifying transformers vary in their markings. Terminals marked in the diagram as P and B are those of the primary. Those of the secondary are shown as G and F. It is sometimes necessary to reverse P and B of the first audio transformer to prevent howling of the amplifier, caused by tubes oscillating at low frequencies. The other transformer, however, is connected according to the markings.

The radio frequency transformer which couples the antenna to the first tube is "conductively" coupled—that is, a portion of the coil used for the tuning circuit is tapped to form the antenna coupling or primary winding. To suit various aerials, several taps are taken out and the No. 1 lead of coil X (see circuit), is tried on each and permanently soldered to the best one. Coil X is wound with 50 turns of the wire, starting with one end secured in two little holes at about ½ inch distance from the lower end of the tubing. The wire is allowed to project about 4 inches to permit of connection to the grid. A "twist tap" is made at the 36th turn, and also at the 39th, 42nd and 45th. The last turn is secured in two small holes and cut off with about 4 inches extending.

Two holes just opposite each other and very close to the lower end, are made with a number 27 drill to correspond with similar holes in the brackets; ½ inch 6-32 machine screws fasten the tubing to the bracket, the bracket being placed on the inside. No. 3 terminal of the coil X is connected to the grid, and No. 2 to the grid return lead N, with the extending wires long enough to permit considerable movement of the coil.

Coils Y and Z are exactly the same in construction. There is a secondary winding of 50 turns, started at about ¼ inch from the lower end. There is a space of about ⅛ inch between the secondary and the primary. This latter consists of 9 turns, wound in the same direction as the secondary. Primary terminal No. 1, the beginning of the primary winding, is connected to the plate of the previous R. F. amplifier tube via the upper machine screw on the connector block. The end of the primary, terminal No. 2 goes to the amplifier B battery post, by way of the middle machine screw on the block. Terminal No. 4 is for the grid return, connecting to lead N in the case of coil Y and to the plus filament in the case of coil Z.

Care is taken to avoid accidental contact between the terminal wires of the three R. F. transformers and if desired a length of spaghetti may be slipped over each before the soldered connection is made. The approximately correct angles for the coils are shown in the photo, but some readjustment may be necessary.

ACCESSORIES

To complete the installation, other apparatus and parts required are as follows:

5 UV-201A or C-301A amplifier tubes

2 45-volt "B" batteries

1 6-volt storage "A" battery

½ lb. bell wire for connections

1 4½-volt "C" battery

Antenna and ground equipment

Pair headphones if desired, with plug

Loud speaker, with plug

Cabinet, 7 x 24 x 10½ inches, if desired

With radio frequency amplification, good results may be secured with very small aerials, so that reception is assured even though the aerial cannot be a 100 foot span, free and clear. The A and C batteries are connected first, and the rheostats turned to test the correctness of the filament wiring. Inasmuch as an amplifier type of tube has been chosen as the detector, the Det. B binding post is connected to the 45 volt point—the two 45 units being connected in series to supply 90 volts for the amplifier tubes.

The three dials should read in fairly good correspondence, and if C-1 shows much less than C-2 for the same station, it is probable that too many turns are in use on the antenna coupling portion of coil X. The antenna tap should then be moved nearer the upper end, to decrease the number of turns between points 1 and 2. In case of whistling and howling when the three controls are tuned to bring in a station, the angles of the three coils should be adjusted until such noises stop. Once in a while tubes are persistent oscillators, and then it is necessary to remove a turn of wire from the primary coils of the R. F. transformers Y and Z. When necessary, this turn is taken from the upper end, thus making the coils 8 turns instead of 9. Oscillation on very low wave-lengths will usually occur, but since this isn't troublesome on broadcast wave-lengths, no change is required when this is noticed. The wave-length range of the outfit is approximately 180 to 570 meters—a good wide band that will take care of extensions of broadcast wave-lengths in either direction.

INTERNATIONAL RADIO DIGEST

by A. P. Peck and Leon L. Adelman

POPULAR RADIO WEEKLY

Australia, September 23, 1925.—The short wave receivers are still with us in as much force as ever and the first article in this issue is devoted to the construction of a two tube set, tuning between 50 and 100 meters and utilizing tuned radio frequency amplification. The circuit used is neutralized and a peculiar three circuit coupler is employed between the R. F. tube and the regenerative detector. Reflexing is also resorted to with the result that the two tubes employed do the work of three. The set is quite novel in its application to short wave work, although similar circuits have been extensively employed in broadcast reception. We are quite sure that every ham will be very much interested in this article.

* * *

Determining the capacity of a condenser is something that usually gives the average radio worker quite a little trouble. However, reference to the article entitled, "A Chart For Determining The Capacity Of A Condenser" will clear up much of the trouble encountered on this score and the chart given will be of great value in many phases of radio work.

* * *

A novel little crystal detector is described under the heading "How To Make A Crystal Detector From A Spool." Powdered galena is used and the apparatus somewhat resembles an old time coherer, although it is adjusted by rotating the spool.

* * *

"A Frame Aerial Two Valver" is the title of an article telling just exactly how to make a very efficient two tube receiver, employing a loop antenna as a pick-up medium. Here again the reflex principle is used and by its application, one stage of radio frequency amplification, a vacuum tube detector and one stage of audio frequency amplification are obtained.

* * *

"An Adjustable Fixed Condenser" seems to be a rather ambiguous title but it applies to the construction of a condenser whose capacity can be varied and then fixed at any value desired.

* * *

September 30, 1925.—Reflex receiving circuits are completely and thoroughly discussed under that title and the information given in the article is well worth studying and storing away for future reference.

Under the heading "Further Adventures With A Frame Aerial," an expansion of the set described in an article reviewed above is dealt with in detail. Three tubes are employed with a loop antenna and the results obtained from a set of this nature should be quite satisfactory.

* * *

The Wireless World AND RADIO REVIEW

England, October 28, 1925.—"Five Valve Neutrodyne Receiver" is the title of an article describing in minute detail the construction of a receiver of the type indicated by the heading. In the set described, the neutroformers instead of being placed at the conventional angle such as is invariably used in American receivers of this type, are placed so that the windings are all at right angles to each other. This feature, coupled with neutralizing condensers accomplishes perfect neutralization and eliminates squealing and its consequent distortion. The transformers are in part bank wound and complete details for performing this step are given in both picture and text. A series of several photographs accompany this article, and together with a good many line drawings of circuits and parts they give a very great quantity of information to the reader. The article is to be highly recommended for its thoroughness.

* * *

A vacuum tube rectifier of typical British construction is described under the title "Thermionic Rectifier For Battery Charger." This charger is said to be very efficient in operation and is comparatively simple in construction or rather as simple as a vacuum tube rectifier can be made.

* * *

Operating a radio receiving set from the D. C. house mains is quite satisfactory if certain precautions are taken in the construction of the eliminator unit. Under the title "A Three Valve Receiver Operating From The Electric Mains" complete information is given on the construction of a unit that will not only eliminate the "B" battery, but will also do away with the "A" battery. The article is complete in every way and is so well illustrated that the reader should not be able to go wrong in making up a similar unit.

* * *

If you want to know something about the theory underlying radio, you have to start by studying the principles of electricity. Therefore, in a series of articles appearing in this magazine under the general head of "An Introduction To Wireless Theory," an article is presented entitled, "Power And Energy In Electrical Circuits." Anyone desiring to go into the study of radio in its theoretical form should not miss these articles.

* * *

November 4, 1925.—Probably no other piece of radio apparatus has undergone more radical changes in general appearance and construction than the loud speaker. In the article entitled, "Loud Speakers," the author presents a very thorough review of modern practice in the construction of reproducing units of various types. Both horns and cones are dealt with in detail and some most excellent drawings are presented and in them the construction of various loud speakers is detailed. To anyone who desires to know more about his radio reproducer and its history and development, this article is to be recommended.

* * *

In the article entitled, "The Manchester Exhibition," the very latest advances in British radio apparatus are shown and described in detail. The article is interesting from the viewpoint of the old saying that "one-half of the world does not know how the other half lives."

* * *

If you would know something about foreign valves or vacuum tubes, and such a subject is quite interesting, you will like the article entitled, "Valves We Have Tested." Charts accompanying this article give the characteristics of several different types of vacuum tubes.

* * *

While the next article that appears in this magazine is not strictly radio, still it details the construction of a piece of apparatus that can be used with a radio amplifier and loud speaker. In fact, what it does show is how to make an electrical reproducer for phonographs through the medium of which phonograph music can be reproduced on a loud speaker with tremendous volume. Complete constructional details are presented and photographs show the construction so well that any ingenious mechanic should be able to construct a device of a similar type.

* * *

The article under the general head of "An Introduction To Wireless

Theory" in this issue deals with series and parallel connections of batteries and resistances. Several diagrams accompany the article and the various reasons for connecting batteries and resistances in either series or parallel are given. The article is very informative in its own simple manner and well worth reading.

* * *

November 11, 1925.—Did you ever make use of the Neutrodyne principle in a radio receiving set in which a crystal detector was employed? If not, here is something rather new for you to experiment with. A very unusual circuit is described under the title of "A Valve-Crystal Neutrodyne Receiver." Not only is this unusual combination employed but also amplification by the choke coil coupled method is incorporated in this set that when properly constructed and tuned should be highly efficient.

* * *

Is an aerial dangerous in a thunder storm? This query is answered in detail in the article entitled, "Aerials In Thunder Storms" and reasons are given for each statement made. The article is quite informative and well worth studying.

* * *

A remotely controlled receiver of rather unusual construction is completely described and illustrated with both photographs and line drawings in the article entitled, "A New Remote Control Receiver." This sort of receiving set has not been given very much attention on this side of the pond and we are sure that a good many of our American readers will be only too glad to investigate it. Therefore, we heartily recommend the article mentioned.

* * *

Loud speakers and telephone receivers, contrary to the general opinion, furnish material for some most interesting experimental work in the laboratory. Some methods of performing this are described under the title "Simple Acoustic Measurements." We are sure that anyone interested in experimental work will enjoy the details given in this article.

* * *

In this week's "Introduction To Wireless Theory," magnetism and electro-magnetic induction are discussed in detail.

* * *

Wireless Weekly

England, October 21, 1925.—The first article that we find in this issue is one dealing with some simple radio receiving circuits and entitled, "Some Methods Of Connecting Valves In Circuit." Fundamentals of vacuum tube circuits are shown and discussed and from there, the author progresses on through the more complicated hookups including several of the reflex type. The discussion is interesting and very informative.

* * *

The actual distortion in various radio receiving circuits depends upon various things and particularly is it true that distortion takes place in the tuning circuit. In the article entitled, "Distortion In Tuning Circuits," a well known English radio authority discusses the various phases of the subject in a simple, yet clear and concise manner.

* * *

We often wonder where static comes from and in the article entitled, "The Nature And Sources of Atmospherics" we find some very well put observations on this interesting subject. The author has evidently done some extensive research work along the line of atmospherics or static and gives the results in this article. The article is a collection of material well worth thoroughly perusing.

* * *

Working with short waves is one of the most fascinating radio subjects today and in an article entitled, "Notes On Short Wave Calibration," the author puts forth discussions of short wave work that are interesting in the extreme. The article is to a great extent, theory, but in it, methods of coupling and of constructing wavemeters are discussed. The American ham will find much of interest in this article because of the fact that various points are stressed that are not often found in the publications in this country.

* * *

The article entitled, "An H. F. Selector and Radiation Preventer" details the design and construction of a single stage of radio frequency amplification that is designed to be placed between the antenna circuit and the primary of a standard regenerative set. In this way, radiation is practically eliminated, selectivity is improved and volume and "DX" are increased.

* * *

October 28, 1925.—In these days of hundreds of broadcasting stations, the main cry of the radio fan is for sets that are selective in the extreme. A good many sets do not afford this feature and, therefore, we are always looking for something better and some type of circuit that will give us all the selectivity that we can possibly desire, together with comparative ease of handling. Just this will be found in the article entitled, "A Method of Obtaining Extreme Selectivity." A set has been built that gives this feature and is described and illustrated in the article.

* * *

"Are Low-Resistance Coils Practicable" is the title of an article of a rather technical nature in which low-resistance or so-called low loss coils are discussed. Some interesting data is given in this article and it should be of interest to every serious minded radio experimenter.

* * *

It is one thing to build a certain coil for a radio receiving set and then find out about its losses experimentally, but it is another thing to design that same coil properly. If anyone engaged in doing this work will refer to the article entitled, "Designing Coils For A Short Wave Receiver," he will find much information contained therein that will aid him in making really low loss short wave coils. Mounting methods are also discussed and illustrated.

* * *

Transmission using very low power is now engrossing almost the entire attention of radio amateurs throughout the world and, therefore, of particular interest is the article entitled, "Some Notes On Low Power Transmission." The author is an amateur of high standing and his deductions can be relied upon. In the article he illustrates some of the coils that he has used and gives other data on antennas and counterpoises that will be found most valuable. The article is to be recommended to all transmitting hams.

* * *

The latter mentioned group of radio experimenters will furthermore find much to interest them in the article entitled, "Short Wave Notes And News."

* * *

Radio frequency amplifying transformers using variable coupling between the two coils are somewhat of a novelty and, therefore, the article entitled, "A H. F. Transformer With Variable Coupling" is well worth reading. The design and construction of a plug-in type of transformer having the variable feature mentioned are given in detail.

* * *

Neutrodynes of various forms and styles are always interesting, particularly when something a little new or novel is incorporated in their construction. In the article entitled, "Experiments With Neutralizing Methods" some detailed data is given that is rather unusual and, therefore, will be found quite interesting.

* * *

November 4, 1925.—A rather technical discussion of vacuum tubes is contained in the article entitled, "What Controls The Characteristics Of Valves?" Curves on various types

(*Continued on page 77*)

Readers' Problems

THIS Department is conducted for the benefit of our Readers. We shall be glad to answer here questions for the benefit of all, but we can publish only such matter as is of sufficient interest to all.

1. This Department cannot answer more than three questions for each correspondent. Please make these questions brief.
2. Only one side of the sheet should be written upon; all matter should be typewritten or else written in ink. No attention paid to penciled matter.
3. Sketches, diagrams, etc., must be on separate sheets.
4. Please do not ask for construction data on manufactured parts, such as transformers, kits, etc., as such data cannot in all cases be obtained from the manufacturers.
5. We are obliged to request that every inquiry which the reader wants to be answered by mail be accompanied by a remittance of one dollar to defray a part of the cost of the work involved.

(46) Mr. Oliver H. P. Young, New London, Conn.

Q. 1. I have built Baby-Super from data in RADIO REVIEW for July and will say it is the king of four-tubers. However, I have experienced a little difficulty. It would oscillate perfectly between 300 and 400 meters, but above and below I have difficulty in keeping it from spilling over and sometimes oscillations are so fierce as to block signal. I believe my trouble is due mainly to use of fixed 48,000-ohm resistance. I have your letter of September 16th advising the use of a Clarostat or similar variable resistance. This instrument cannot be purchased here. Will you kindly give me manufacturer's address? Centralab puts out a wire-wound resistance of 500,000 ohms called "A Modulator" and a similar instrument called "Radiohm" of several maximum resistances. Would either of these in your opinion be satisfactory? What should the maximum capacity be? Although we have several radio stores here, their stock does not contain this instrument. I have tried many four-tubers, but the Baby Super I have, while not perfect as yet, is the best.

A. 1. Either of the variable resistances you mention would be very satisfactory. The Clarostat can be purchased from the American Mechanical Laboratories, Inc., 285 North Sixth Street, Brooklyn, N. Y. We understand this instrument has a continuously variable resistance from practically zero to 500,000 ohms.

(47) Mr. A. H. DeForest, Kingston, N. Y.

Q. 1. In RADIO REVIEW for the month of October you published the description of a Browning-Drake receiver. I have built the set from the hook-up in your magazine, but the set tunes very broad, and I am writing you for a little information.

In this set I used the standard Nat tuning coils and condensers. I also used a separate .0001 condenser in each lead between the binding post and the connections of the R. F. coil.

I cannot separate WGY and WMBF or KDKA and WGBS, cannot get WGN while WGY is on, and sometimes WGY will spread into WHN; cannot tune in WSB while WLW is on; WSAI, WBZ and WMAF all come in together.

You will see by this that something is wrong, as I have always heard that this set was very selective. I have checked the wiring over several times but cannot find anything wrong.

I know it is very hard for you to form an idea what is the trouble, but thought you might be able to give me a hint or two.

A. 1. First, we would suggest that you make an additional tap on the primary coil midway between "A" and "R" as the notations appear on the diagram on page 15 of the October issue. The aerial tap should be used either connected to "A" or to the new tap.

A. 2. Broad tuning frequently is caused by a high resistance in the circuit, usually in the grid leads of one or more of the tubes. We suggest that you check these leads carefully to see that all connections are securely fastened. Possibly the contact between the grid prong on the tube and the corresponding contact spring in the socket is poor. Clean the contact spring and bend it up slightly to make better contact.

A. 3. Also carefully examine the neutralizing condenser (4) on the diagram. This may be defective and allowing a leakage path.

A. 4. Try another grid condenser, as the one you are using may be short-circuited.

A. 5. A short aerial should be used whenever there is interference present. The long aerial causes any set to tune very broadly on broadcast waves, and the overall length from the aerial binding post on the set to the insulator at the far end of the aerial should not be more than about 75 feet. With an aerial this length the signals are almost as loud and the selectivity is increased greatly.

(48) Mr. T. K. Bungard, Cleveland, Ohio.

Q. 1. In the September, 1925, issue of the RADIO REVIEW you show a "B" battery eliminator which I would like to make. In the list of parts is a Marle type 200 transformer that I have been unable to get. Could you please tell me where I could get it or where it is made?

A. 1. This transformer can be purchased from the Marle Engineering Company, 309 Main Street, Orange, N. J.

(49) Mr. Geo. Pataky, Whiting, Ind.

Q. 1. Will you please send me a one-tube set hook-up that is in your Late Fall Edition of the Radio Listeners' Guide and Call Book? It is on page 20, Fig. 6, and will you please tell me how to wind the tickler coil and how many turns to put on it, and what kind of variable condensers shall I use for this set?

A. 1. See answer to Question 40 in the December issue of RADIO REVIEW. The variable condensers should be 23 plates with vernier control.

(50) Mr. Robert Fisher, Akron, Ohio.

Q. 1. I have tried the set called "Receiving Without Antenna or Loop" in the October issue of RADIO REVIEW. I have followed the directions perfectly and have not found any mistakes. The bulb lights and the ground is very good, but I can't get any results. Could you please give me some reason why I can't get results?

A. 1. First, we suggest that you examine the tube socket very closely. You say the bulb lights, but it is possible that the grid or plate prongs on the tube are not making proper contact

QUESTIONS AND ANSWERS

It is impossible for the editors to answer individually the thousands of letters reaching the offices of this magazine.

If our readers desire information regarding construction data, etc., they are cordially invited to send us their inquiries and we will endeavor to publish answers to same under the department of *Readers' Problems*.

If an individual answer is wanted, please fill out the coupon below and mail it to us with a dollar bill.

Jan. 26

INFORMATION COUPON

To the Editor of *Radio Review*,
233 Fulton Street, New York, N. Y.

I am sending you herewith $1.00 for which I ask you to answer the inquiry contained in attached sheet.

Name ....
Address ....
Town.................. **State**........

with the contact springs in the tube socket. Bend the contact springs in the tube socket up slightly to insure proper connection with the tube prongs.

A. 2. Test your "A" and "B" batteries to ascertain if they are properly charged. If the "B" battery has fallen below two-thirds of the normal voltage it should be discarded, or if it is a storage "B" it should be recharged.

A. 3. Try another fixed condenser across the phones, as the one you have may be short-circuited, which of course would short-circuit the phones.

A. 4. Make certain that your battery terminals are not reversed; be sure that the "A" plus is connected to the "B" minus.

A. 5. Go over all connections and see that they are securely fastened.

A. 6. Substitute another vacuum tube. The one you have may have lost its sensitivity.

(51) Mr. Edw. L. Jury, Wiconisco, Pa.

Q. 1. I am a subscriber of your magazine, RADIO REVIEW. Have gone to the expense of purchasing parts to a hook-up I saw in your magazine and find I have gone wrong, so if you will kindly set me right would greatly appreciate it. On page 41, September issue, you show a five-tube set calling for a Gen Win tuner having 50 turns on tickler coil. The Gen Win people inform me that their tuner consists of 35 turns of D.C.C. Which is right for this set—35 turns or 50 turns?

A. 1. Since this article was written it has been found that approximately 35 turns on the tickler give better results than 50 turns, and Mr. Joseph H. Kraus, who originally built and described this set informs us that he is now using a standard Gen Win tuner and the results leave nothing to be desired.

(52) Mr. Albert Bloch, Torrington, Conn.

Q. 1. I have a three-tube radio receiving set which contains the following parts: Two 23-plate condensers, two Acme No. 2 transformers and a Cockaday coil, and I would like to have a plan for reconstructing this set and adding two more amplifiers in order that I may have a more powerful set and obtain better results. Will you advise me as to what parts to add to the set?

Q. 2. Will you explain the difference between a reflex and a regenerative receiver?

Q. 3. Also advise if I can connect two tubes to one rheostat.

The information you desire follows:

A. 1. We are giving you on page 72 a circuit for a five-tube Cockaday receiver, which uses push-pull amplification. You will need in addition to your present set the following: Two push-pull transformers, two tube sockets, one closed circuit jack, one rheostat, two tubes. Your present loud-speaker jack is to be replaced by the new closed-circuit jack and the open-circuit jack which you take out is placed after the push-pull amplifier.

A. 2. In a reflex receiver the same tube acts first as a radio-frequency amplifier and after the signals pass through this tube they are rectified by either a crystal or vacuum tube detector and are then returned to the first tube to be amplified at audio frequency. In a regenerative receiver a vacuum tube is used as the detector and by means of a tickler coil placed in the plate circuit of the tube and inductively coupled to the main tuning coil, a portion of the radio frequency current in the plate circuit is transferred back to the grid circuit by the coupling effect between the tickler coil and the secondary of the tuner. This serves to reduce the resistance of the grid circuit and produces more current in the output or plate circuit, thus acting as a form of amplifier.

A. 3. It is quite possible to make one rheostat control two vacuum tubes. By referring to the diagram printed herewith you will note that one rheostat controls both audio-frequency am-

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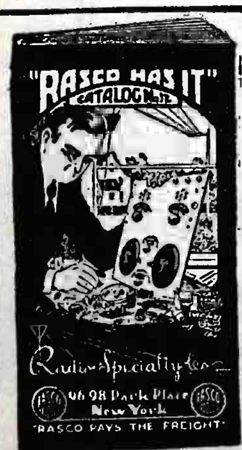

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New 1925 "Rasco" Catalog No. 12

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This Free Book Tells

About the Marvels of Radio—How it Helps All and Brightens Every Home—Gives List of Broadcast Stations—Specimen Programs—And How Programs are Made UP—Answers the Questions, "What Set Shall I Buy," and How Much to Pay—Describes "No-Sod-er" Wiring System—Explains How to Get Your Own Radio Outfit Without Money—How to Save $65.00 in Five Hours—How to Make Money by Going Into Business for Yourself and Building Sets for Others—Tells Where Orders are Awaiting You—Where and How You Can Transact Your Business—CONTAINS DETAILED DESCRIPTIONS AND FINEST ILLUSTRATION OF LARGE NUMBER OF BEST KITS IN EXISTENCE AND QUOTES LOWEST PRICES—Lists Full Line of Radio Parts and Accessories—Explains Our Fair, Easy, Liberal, Golden-Rule Plan of Doing Business. You Need It. Send Coupon or letter NOW.

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Book explains what you want to know

About new revolutionary way of assembling your radio set from our many kits—no solder, no bus bar, no poor connections, no waste of time, no skill required, no dissatisfaction, no tools needed except common screwdriver and pliers. Even a boy can quickly assemble a complicated kit.

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245F Greenwich St., New York.
You may send me, without charge or obligation, your KIT CATALOG NO. 14 ( ) RASCO CATALOG NO. 12 ( ). I am interested chiefly in

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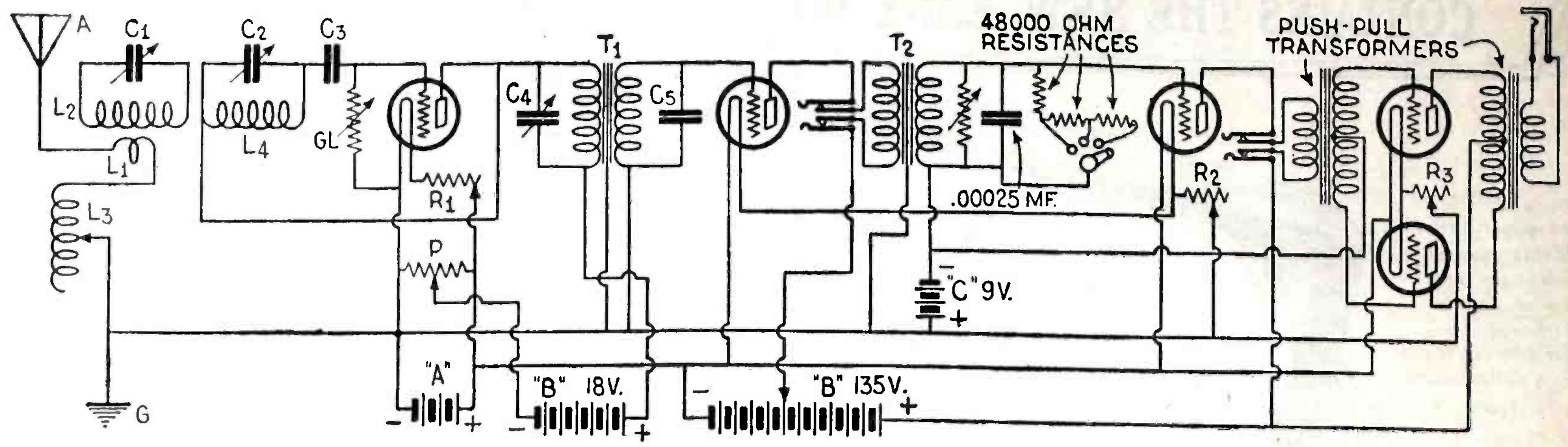
RADIO SPECIALTY CO.

Kit Div. 732E 245F GREENWICH ST. NEW YORK CITY plifier tubes, and one rheostat controls both tubes of the push-pull amplifier.

(53) Mr. C. L. Zimmerman, Maple Grove, Ohio.

Q. 1. I have built a Tropadyne Superadio Set according to instructions in your pattern No. 10, using the New Remler condensers with Accuratune dials, Bradleystats, and Bradley potentiometer, Cutler Hammer sockets, All American audio 3 to 1 ratio transformer, Cutler Hammer battery switch, Carter automatic jacks, and Tropaformer set and coupler furnished by the Radio Industries Corporation; have tried ½ and 1 megohm grid leaks. I have never had the success that I think I should have from it according to what instructions and descriptions tell of the set; it never would do hardly any volume on a loop, and could not get any click out of it as set should do as shown in Fig. 10 when touching ends of a wire together; to get any results I have had to use the fixed antenna coil as shown in original description in RADIO REVIEW of August, 1924. My Tropaformers seem to work best set about 20 to 30 on the dial; instructions show they should do better higher upon dial, about 70 to 80. I am using UV-201 Radiotrons. I had a four-tube set which I built before I built this Tropadyne and I can get further distances with the first set, just as good volume on four tubes as on six on the Tropadyne. I have added another stage of amplification, making it seven tubes, to get enough volume. The set works, but does not seem to be sensitive enough even with antenna coil and outside aerial. I note that first instructions showed four rheostats. Do you think cutting it down to one made any difference? We have checked this set of mine over and everything seems to be all right according to the circuit and instructions. If you can help me any, I would very much appreciate it.

A. 1. When wiring your Tropadyne, carefully follow out the diagram



(52) Diagram of a 5 tube Cockaday Receiver.

as given in Pattern Sheet No. 2, in this way avoiding any possibility of mistakes, which would likely be made in attempting to wire from both perspective diagram, as shown in Pattern Sheet No. 2, and schematic diagram, shown in Fig. 6 of the instruction booklet. Particular attention is called to the connections of the oscillator coupler, as it seems that the cause of most troubles have been due to improper wiring at this source.

You will note that in the schematic wiring diagram, Fig. 6 on page 8 of the instruction booklet, the lead from the rotary blade of the potentiometer is shown connected to the filament terminal of only the second Tropaformer. Unfortunately, this is a draftsman's error, and this lead should also be connected to the point where the lead from the filament terminal of the first to that of the third Tropaformer is shown as a crossing; in other words, the filament terminals of the first, second and third Tropaformers are connected to one another, and together to the rotary blade of the potentiometer.

In some cases it will also be found that the lead from the rotary plates of the variable condenser and loop will operate more efficiently if connected to the negative "A" battery lead of the first oscillator tube, instead of the "A" battery positive lead as it is shown in the blueprint diagram.

It might be advisable, when mounting the apparatus before wiring, to mount the second and fourth Tropaformers at right angles to the first and third. This eliminates any chance of electromagnetic field effect between Tropaformers.

Three separate rheostats will greatly facilitate accurate control of the tubes, the characteristics of which often vary. Therefore, while the tubes also perform different functions in the circuit, it would be best to employ additional filament controls in order to adjust them more accurately.

A 25-ohm rheostat may be used for the oscillator tube, or the first tube, a 6-ohm rheostat for the intermediate radio-frequency amplifiers and detector, or the second, third, fourth and fifth tubes, and a 15-ohm rheostat for the audio-frequency amplifier, or the last tube.

When employing 90 volts for the "B" battery with the Tropadyne as specified in the instruction booklet, it has been found that this receiver gives better results with a "C" battery between 6 and 10 volts.

(54) Mr. A. Moland, Brooklyn, N. Y.

Q. 1. Please give me a diagram of a good super-heterodyne with description.

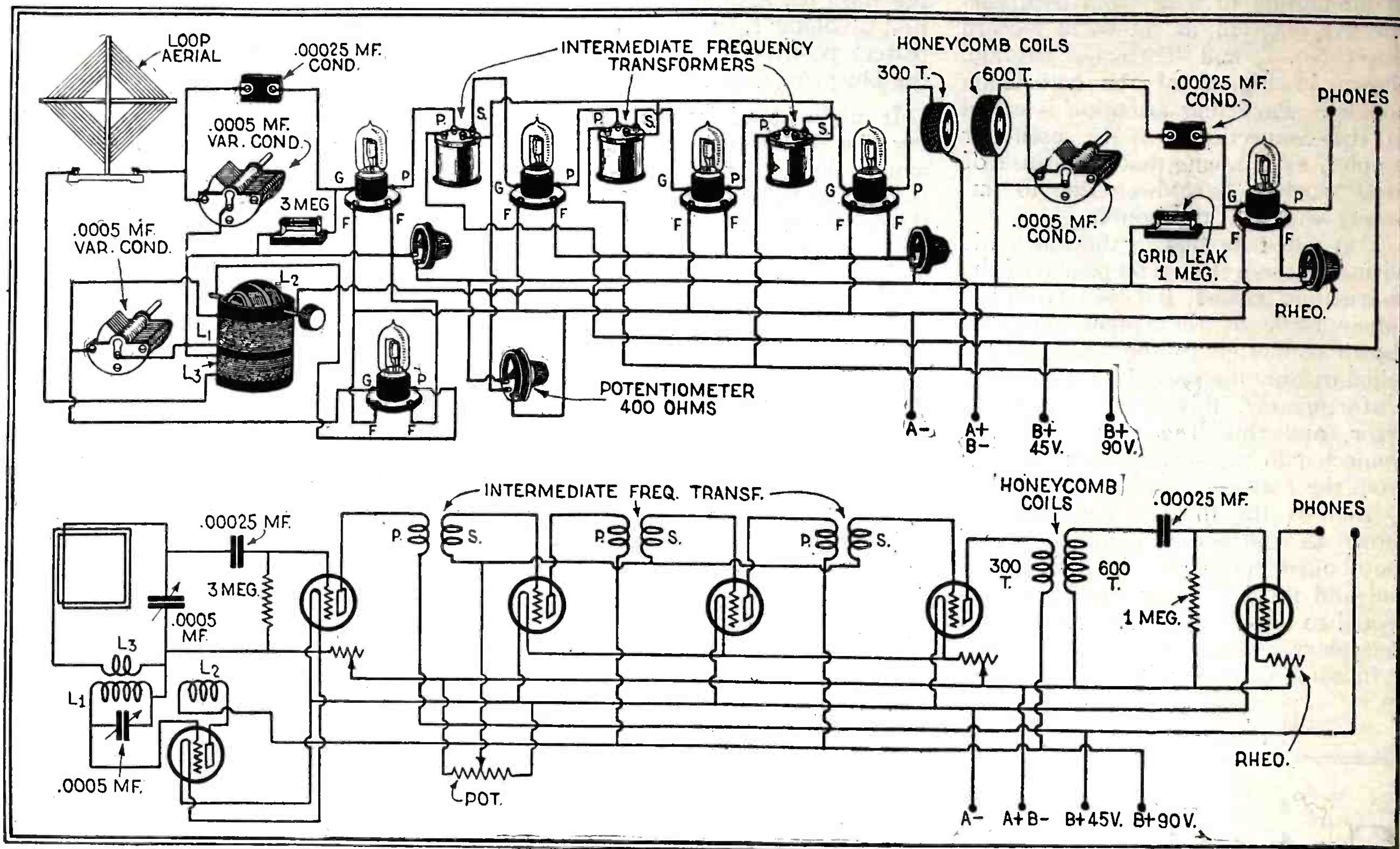
A. 1. We are giving you on page 74 both in schematic and perspective forms the diagram of a good super-heterodyne receiver. You say you have the parts for a super-heterodyne, and this being the case we assume you have purchased a standard super-heterodyne kit complete and accordingly are not giving you any description, as the diagrams herewith will enable you to hook up a kit very easily.

(55) Lucian F. Hunt, Cedar Rapids, Iowa.

Q. 1. Please let me know the address of the company selling "Bruno Ultra-vario Condensers" such as were mentioned on page 49 of your October issue this year.

I wish to build a five-tube set such as described on pages 49 and 50 of the above issue. I will greatly appreciate information as to the purchase of parts and accessories for this set.

A. 1. Bruno Ultra Vario Condensers can be purchased from the Bruno



(54) Diagram of a Super-heterodyne receiver, the upper being in perspective and the lower in schematic form.

Radio Corporation, 220 Fulton Street, New York, N. Y. For obvious reasons we cannot recommend any particular parts or accessories for the various types of receivers, but we suggest you take the circuit to some first-class radio store and ask them to assist you.

(56) Mr. F. A. Lucas, Houston, Texas.

Q. 1. I wish to ask what is the reason the set on pages 28 and 29 of RADIO REVIEW, September, will not cut out local station. It gives fine reception when the local station is not working. I get Chicago, Memphis, Miami, Salt Lake City and a great many others, but cannot do a thing when the local station is on. I have used standard parts; have everything exactly as suggested except the 1 mf. condensers: I had to take a 2 mf. instead. I am using 201A tubes, 75-foot aerial, water pipe ground, storage battery. The lead-in comes in over 6 feet from any wall, double insulation throughout. Kindly answer through your RADIO REVIEW.

A. 1. First we desire to call your attention to an error which occurred in the diagrams on page 28 and 29 of the issue in question. The text on page 29 under "Detector Coil Reversed" describes how this should be done, but this is not shown in the diagrams. The text is correct and should be followed to secure the results the author experienced.

If you are close to your local station you will experience difficulty tuning it out on any set. The listener who is within a mile or two of a broadcasting station is badly handicapped. We suggest that you cut down on your aerial, or better yet, erect a second aerial about 30 to 50 feet long and use this when the local is on. A short aerial makes a set very much more selective. Of course you may notice a slight falling off of signal strength, but this sacrifice is necessary for obtaining the added selectivity. It might be well to install a single pole double throw switch and connect your long aerial to one end, the short aerial to the other and the aerial lead to your set is connected to the middle terminal of the switch. This will provide a simple and quick change over from one aerial to the other. Only experiment will tell whether this short aerial will cut out your local station, but it has been known to do so in many cases.

As you state you are getting distant stations when the local is off, we are wondering if the fault lies with the broadcasting station in that it may have a broad wave. If this is the case of course no alterations to your set would be helpful.

(57) Mr. L. Leitman, Philadelphia, Pa.:

Q. 1. In November RADIO REVIEW you have a 4 tube set, a revision of the Ultra audion circuit that is used on a loop, and the writer claims to have done all kinds of wonders with it, now I built the circuit and get wonderful results with it, but it spills over and on distant stations it goes into oscillation and spills over in a minute. I am using 2 Acme audio transformers and an Acme A-2 Radio frequency transformer. The circuit is a wonder and does wonderfully on locals and KDKA, but on distance I hear the whistle and when I cut down on my potentiometer the whistle instead of coming into the stations, gets weaker and faints away. Could you possibly tell me my trouble?

A. 1. First check over your entire wiring to make sure you have followed the connections properly. When a set is so critical and goes into oscillation too freely it is caused by several things; too much "B" battery on the plate of your detector, burning the filaments of the detector and radio frequency tubes too brightly, defective potentiometer or the resistance there-of incorrect. Cut down on the detector "B" battery and try burning the filaments at a lower brilliancy. Are you sure the potentiometer is of 400 ohms resistance? This is important in this type of set as it is one of the main factors in the control of oscillations in the circuit. The grid and plate leads of the tubes should be kept well apart as if they are too close a "feed-back" effect takes place as in a regenerative with a tickler coil. It is possible that you are unfavorably located for distance reception with a loop set. There are many local conditions which bear upon long distance work, especially with a loop set, for instance metal laths used in the house, higher buildings surrounding, etc.

(58) Mr. T. A. Bland, Nashville, Tenn.:

Q. 1. After several weeks of unsuccessful experimenting with the set you describe in your November RADIO REVIEW it is in desperation that I am calling for help. Your set described on page 5 is a six tube self contained set, has proven of exceptional qualities when in use with headphones but can't get power enough on speaker to even enjoy the locals. Would it be possible to get more information on this set, possibly in the form of a schematic drawing or blueprint. The black and white layout shown in November REVIEW is rather vague in parts.

A. 1. We are sorry to say that we do not publish any additional plans or blueprints of this set, but we would suggest that you communicate with the *Popular Mechanics Magazine*, Chicago, Ill. This article was reviewed from that publication and it is just possible that they may have some additional data to assist you. They may be able to give you the address of the author, Mr. F. L. Brittin.

(59) Mr. S. F. Leese, Chicago, Ill.:

Q. 1. In RADIO REVIEW for November I ran across a set I am deeply interested in, and I want to build the set. It is on page 51 and you call it "An All Wave Tuned Radio Frequency Set." Although your illustrations are clear cut, I don't know as they are enough so to get at the back wiring, so I am coming to you for a little information. Is it possible for me to get a blueprint of the wiring? If so, where can I get it, and how much will it cost.

Q. 2. Have you a dictionary of all the applied terms used in radio, and their correct definitions?

A. 1. There is not available in this office any additional blueprint of the wiring of this set, but as it first appeared in *Radio Broadcast* we suggest that you address a letter to the Doubleday Page & Company, Garden City, L. I., who may have additional plans thereof, or they may refer you to the author for this information.

A. 2. Each issue of RADIO REVIEW contains an installment of "S. Gernsback's Radio Encyclopedia." We have no radio dictionary available.

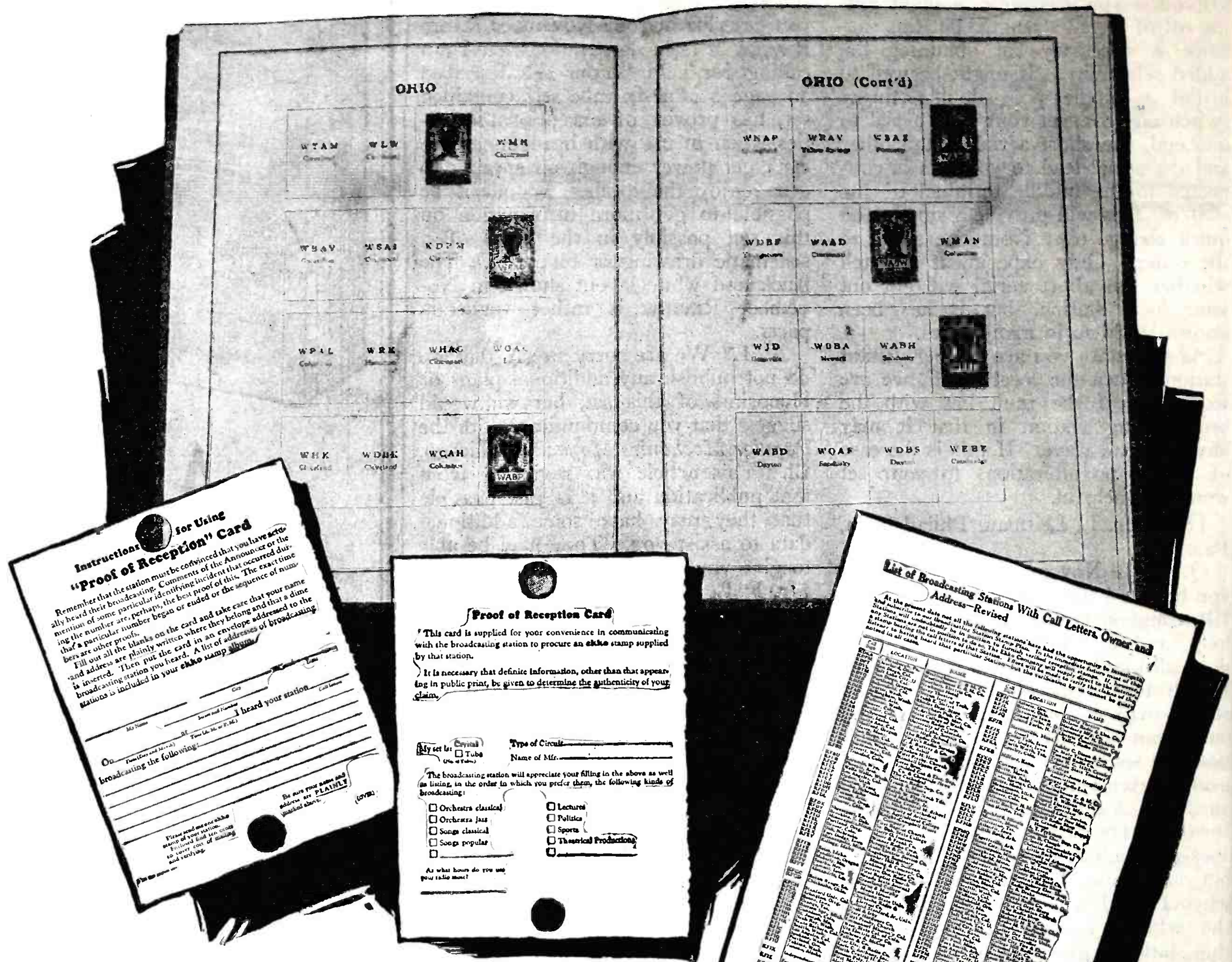
(60) Mr. M. Canizz, Cedar Rapids, Ia.:

Q. 1. In your issue of RADIO REVIEW for November there are a number of summaries from some English Radio publications. I desire to subscribe to one or two of them. Will appreciate it if you would let me know the addresses of several of them to choose from.

A. 1. We are giving below the

The New Radio Stamp Fad

Here is the DX Radio Stamp Album just like the ones we owned in our youth, in which were placed the rare stamps of the countries of the world. Some were hard to get, some couldn't be purchased for love or money; but the fun of the hobby was the seeking of rare stamps and the eventual possession. So it will be with the DX Radio Stamp Album. There will probably be some stamps you will never be able to own, but there will be many you will be proud to have and be able to show to other radio enthusiasts. It's an interesting game. Below the Album is shown the "Proof of Reception Cards" of which a generous supply is furnished with each Album. A dime placed in the hole in the card and sent to the station you heard brings back a stamp for your Album.



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names and addresses of several English and one Irish radio magazines:

Wireless World & Radio Review, Dorset House, Tudor Street, London EC-4.

Wireless Weekly, Radio Press, Bush House, Strand WC-2 London.

Wireless Constructor, Radio Press, Bush House, Strand WC-2 London.

Experimental Wireless, Iliffe & Sons, Ltd., Dorest House, Tudor Street, London CE-4.

Irish Radio Journal, 34 Dame Street, Dublin, Ireland.

International Radio Digest

(*Continued from page* 68)

of tubes are given and the complete discussion is one that should not be missed. Although it is rather technical, anyone with a little radio knowledge should have no trouble in following the discussion if it is studied with care.

* * *

Checking of tuning circuits is something that the average amateur pays little attention to, but if he would do that, he would find a new field of interest open to him. Under the heading, "Check Your Own Tuning Circuits," a complete description is given of an oscillator that can be used for this purpose and furthermore, the author goes into the discussion of the various uses for the instrument. All necessary details are given.

* * *

"Home-Made Neutrodyne Units," is the title of an article detailing the construction of inductances to be used in circuits of this nature. A novel system of plugging in the coils is shown and should prove a valuable tip to radio experimenters in general.

* * *

We all would like to know how to eliminate static and some very good hints towards accomplishing this work are given under the title, "The Elimination of Atmospherics From A Radio Receiver." Static is discussed in general and various coupling schemes that will help in getting rid of this nuisance are outlined and discussed. The article shows nothing particularly new, but still it is interesting because of the fact that a good many details are brought together under one head and thus made available for careful study.

* * *

"How To Make A 45 Meter Transmitter" is the title of a very thorough constructor article dealing with the transmitter used at G6QB. Although the frequency at which this transmitter operates is out of the American band, still there should be no trouble at all in tuning the set to a slightly lower wave-length so as to come within our band. Enough details are given in the article to make it well worth reading.

* * *

The amateur often has to experiment quite a little before he hits upon a good combination of aerial and ground for short wave work. Therefore, the majority will be interested in the article entitled, "Aerials And Earths For Short Wave Reception."

* * *

November 11, 1925.—The calibration of a wave-meter is something that is often very hard to obtain and, therefore, the details given under the heading, "Calibrating An Oscillating Valve Wave-Meter" will be most welcome. The article is complete in every detail and shows how curves for wave-meters are to be made and charted. The complete article is well worth the attention of anyone interested in work that requires the use of a wave-meter.

* * *

"How To Operate A Short Wave Set" is the title of an article dealing in a general way with short wave reception and is worthy of passing notice because of the useful hints contained therein.

* * *

Further details on eliminating static are given in the article entitled, "Some Devices For Atmospheric Elimination."

* * *

A short wave receiver of merit is described in the article entitled, "An Efficient Receiver For 10,000 To 5,000 Kilocycles." Several other articles by the same author, G6QB have been reviewed in these columns and his style of presenting material is to be recommended. Furthermore, the methods that he uses in the building of sets are worthy of attention and the entire article under discussion is one that can be read with very good result. One stage of resistance coupled audio frequency amplification is incorporated in this set, something rather new for an amateur short wave receiver.

* * *

The design and construction of a wave-meter is given under the heading of "Interesting Wave-Meter For Damped or Undamped Waves." This wave-meter is of the buzzer-driven type and all of the necessary details for constructing and connecting the entire assembly are given.

* * *

English amateurs seem to have quite a lot of trouble in deciding whether

they should use small compact inductances such as honeycomb coils or long ones of the solenoid or cylindrical type. The merits of these two forms are given in the article entitled, "Are Long Coils Doomed." Some interesting mathematics are discussed and the reasons for using one or the other of the two types of coils mentioned are given.

* * *

The Irish Radio Review

Ireland, October, 1925.—"A Two Valve Loud Speaker Set" is the title of an article describing a two tube receiver using tickler feed-back and a single stage of audio frequency amplification. It seems that the Irish have not yet gotten away from the use of single circuit tuners as that is just the type of circuit used in this particular set.

* * *

A buzzer is a handy little instrument around any radio laboratory and it can be used in many ways. Some of these ways are discussed in the article, "Some Uses For A Buzzer."

* * *

Whether or not we shall have a standardized universal language is discussed in the article entitled, "The Confusion Of Tongues and Its Remedy." We will let this stand without comment as there are too many things to be said regarding a universal language to incorporate them all in this review.

* * *

The reception of the English station at Daventry seems to be the ultimate of radio reception to those located in the British Isles or on the European continent. Here we find an article entitled, "Daventry On A Crystal" and a set for doing this work is illustrated.

* * *

The Wireless Constructor

England, November, 1925.—A good many experimenters and radio theorists have made statements, mostly unfounded, that vacuum tubes are destined to extinction just as much as the old magnetic detector and the coherer have passed out of the radio field. A discussion of this is given under the heading of, "Will Valves Die Out?" The author's conclusions and historic descriptions are interesting in the extreme and well worthy of careful reading.

* * *

Crystal sets are still in wide use in England today and the English experimenters certainly have succeeded in doing some wonderful work with them. Here we find a description of an exceedingly simple set under the title of "Simplifying The Low Loss Crystal Set." All of the necessary details for building a set of this nature are given and completely illustrated in both line drawings and photographs.

* * *

Instead of having "B" batteries and "C" batteries laying around the table in any position in which they may happen to fall, why not get them all together and place them in a suitable cabinet? Such a unit is described in the article entitled, "A Compact High Tension Grid Unit." This construction is to be recommended for its compactness and because of the fact that it gets the batteries out of the way and keeps them clean.

* * *

A collection of short and to the point paragraphs that are of interest to anyone connected with radio in any way are given under the general head of "Do You Know—?"

* * *

Radio conditions in Spain are outlined in the article entitled, "A Wireless Wanderer In Spain."

* * *

A unique set in both design and construction and one that is quite compact, as English instruments go, is described under the heading of "A Detector And Amplifier In One." Complete constructional details are given and the various photographs accompanying the text show everything about the set that anyone could possibly want to know.

* * *

Some hints on charging storage batteries are given under the title of "Do You Charge Your Own Accumulator?" This article is quite interesting because the details given are valuable.

* * *

Getting the correct "C" battery value is something that is often not given as much attention as it should have. Therefore, the article entitled, "How To Adjust Your Grid Bias" may jog up the memories of a few people and start them off on the right path for accomplishing this object.

* * *

If you only have three vacuum tubes and want to connect them in a circuit, what kind of a circuit would you use? This is a rather difficult question to answer, particularly if one is not familiar with a good many different types of circuits. Under these conditions, the article entitled, "What To Do With Three Valves" will prove of great value as it shows many different kinds of circuits and discusses each one in detail.

* * *

"A Few Don'ts For Crystal Users" is the title of a column in which some very commendable recommendations are given to those who employ crystal detectors.

* * *

The Sun RADIO SECTION

New York, October 31, 1925.—If a radio set is built in units, the entire layout becomes much more flexible and allows changes to be made as may be desired. Therefore, the article, entitled, "Building Your Set In Units" will be found most valuable.

* * *

"A Simple Two Tube 40 Meter Receiver" is the title of an article detailing the construction of a set in which tickler feed-back is used, but in which regeneration is controlled by means of a variable condenser. There is nothing new in this circuit, but all of the details are given and, therefore, the article becomes quite valuable to the ham.

* * *

The Reinartz receiver has withstood the test of time and one experimenter has improved it somewhat and calls it his ideal. He describes the construction of this set in an article contained in this issue.

* * *

A switchboard to be used for controlling the various battery circuits of a radio receiving set is described under the title, "A Control Panel For Your Set."

* * *

Trouble shooting in a radio receiving set is discussed in the third part of an article entitled, "How To Make It Run Again." The other two parts to this article appeared in former issues of *The Sun Radio Section.* Some interesting information on how to find trouble in sets is given in this collection of data.

* * *

We all know that grid resistances or grid leaks are quite necessary to the successful operation of a radio receiving set, but how many of us know why? If you do not, refer to the article entitled, "Why Grid Resistances Are Needed."

* * *

The proper layout of a table for experimental work is something that should be given much more attention than is usually the case. Therefore, the article entitled, "A Handy Test Table For The Experimenter" is to be highly recommended.

* * *

November 7, 1925.—How to properly employ impedance coupling in audio frequency amplifiers is described under the heading, "The ABC Of Impedance Coupling."

* * *

In the article entitled, "A Two Range 'Straight Line' Receiver," a four tube set employing a switch for changing over from short wave to long wave reception is described. Four tubes are used, one as detector, one as a straight audio frequency amplifier and the other two in a stage of push-pull.

* * *

November 14, 1925.—A rather humorous and interesting discussion of radio critics in general is given, by one of them in the article entitled, "Radio Critics Begin With Zoilus."

* * *

A discussion of amplification in general, including both transformer and resistance coupled types, is given under the heading of "How To Select Amplifier Combinations."

* * *

A receiver capable of tuning from 140 to 24,000 meters is described under the title, "It Brings In Code From All Over The World." The article is quite interesting, although there is nothing radically new in it, but there are a good many radio fans today who would like to have a set with such a wave-length range as this one has. To these people, this article is recommended.

* * *

November 21, 1925. A set that it is said will give most exceptional results is described under the title of "Conquers Dead Spots; Annihilates Distance." The circuit is somewhat unique and put forth in an unusual manner.

* * *

It is often said that if the "B" battery becomes connected across the "A" battery, the result will be burned out tubes. This all depends upon the relative connections between the two batteries mentioned and the subject is discussed under the title, "Can Your 'B' Batteries Burn Out Tubes?"

* * *

The Telegram-MAIL Radio Section

New York, October 21, 1925.—A four tube radio set of more or less conventional design but which is said to give most exceptional results in all ways, is described by the techncal editor of *The Telegram-Mail Radio Section* in this issue. Complete constructional details for the set are put forth and the circuit is given in both picture and schematic form.

* * *

This newspaper radio section carries a most excellent ham section in the form of a page entitled, "Below 200." This page appears every week in this magaine and always contains information of great interest to all hams.

* * *

November 9, 1925.—During the past year the so-called Browning-Drake receiver has been the recipient of much attention. Now the circuit has been improved somewhat and its R. F. amplification constant increased. The article entitled, "The 1925 Browning-Drake Has Arrived" gives the details of the improvements.

* * *

Some people say that regeneration must be abolished and others say that this cannot be done. If you would read a discussion on this phase of radio, you will find it in the article entitled, "Arguments For and Against Regeneration."

* * *

Do not forget the ham page that is in this issue as in all others of this newspaper section.

* * *

November 14, 1925.—How to receive short waves on your Super-Heterodyne receiver is discussed in a short article. Constructional details are given.

* * *

More and clearer details on the improved Browning-Drake circuit are given under the title, "Building Data On New Browning-Drake."

* * *

A portable receiver that is quite compact and still has features which will give selectivity and volume is given under the title, "Broadcast Receiver For Ocean Passengers."

* * *

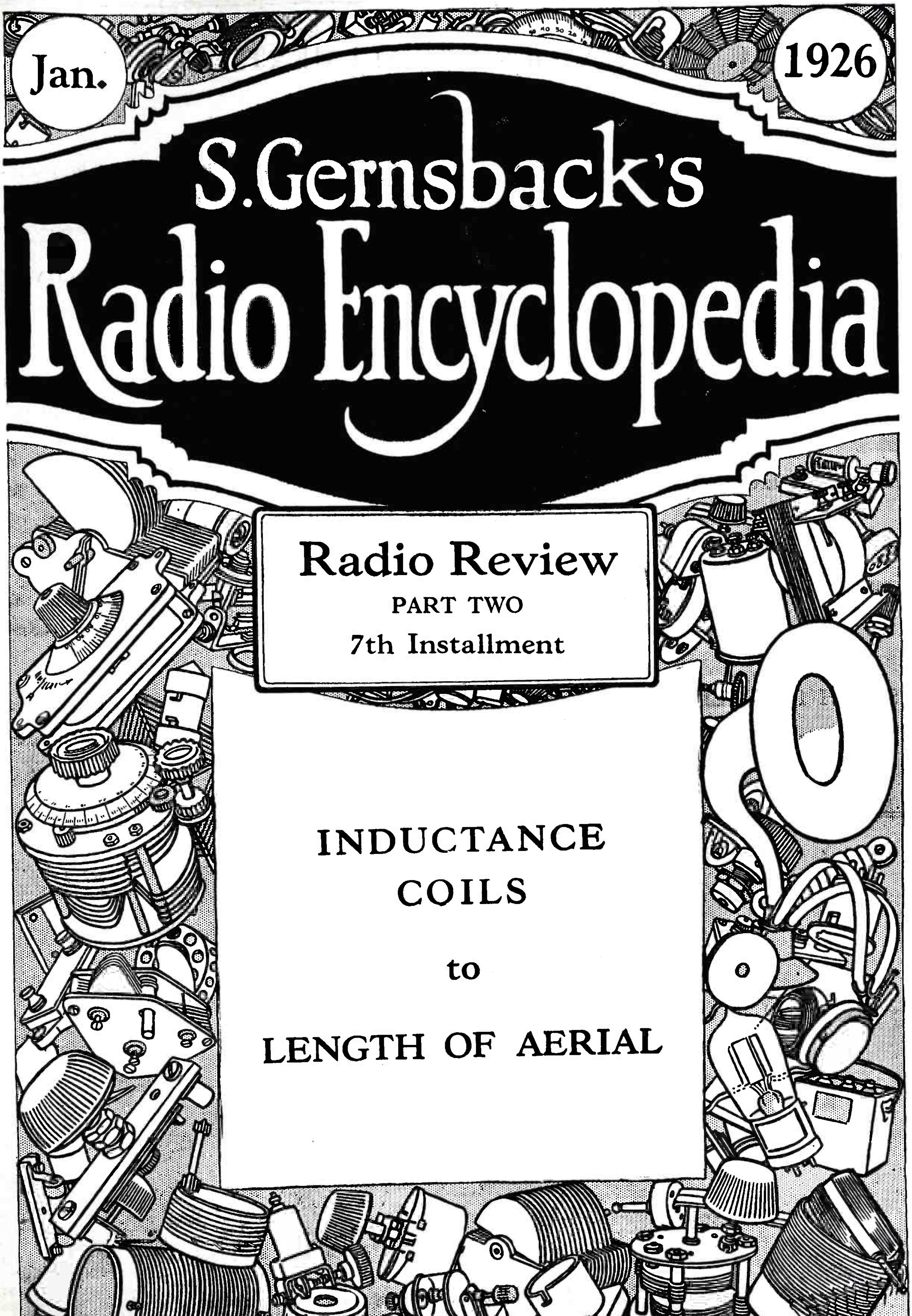
November 21, 1925.—Success in the reception of short waves depends upon many things and in an article of that title the author discusses important of all of these.

* * *

More details on the improved Browning-Drake are to be found in this issue. * * *

More trouble shooting is described in the article, "Sources of Noise in Radio Receivers."

* * *



Jan. 1926

S. Gernsback's Radio Encyclopedia

Radio Review

PART TWO

7th Installment

INDUCTANCE COILS to LENGTH OF AERIAL

PREVIOUS INSTALLMENTS

FIRST INSTALLMENT — Consisting of definitions from "A" BATTERY to ARC OSCILLATOR, contained in May 1925 issue of Radio Review, Vol. 1, No. 1.

SECOND INSTALLMENT — Consisting of definitions from ARC SPARK to CAPACITY OF CONDENSERS IN PARALLEL, contained in July 1925 issue of Radio Review, Vol. 1, No. 2.

THIRD INSTALLMENT — Consisting of definitions from CAPACITY OF CONDENSERS IN SERIES to COUPLING COEFFICIENT, contained in September 1925 issue of Radio Review, Vol. 1, No. 3.

FOURTH INSTALLMENT — Consisting of definitions from COUPLING, DEGREE OF to EDISON, THOMAS A., contained in October, 1925, issue of Radio Review, Vol. 1, No. 4.

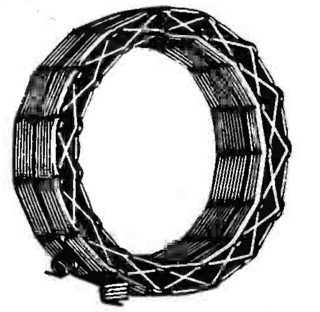
FIFTH INSTALLMENT — Consisting of definitions from EDISON EFFECT to GALVANI, LUIGI, contained in November, 1925, issue of Radio Review, Vol. 1, No 5.

SIXTH INSTALLMENT — Consisting of definitions from GALVANOMETER to INDUCTANCE, ANTENNA, contained in the December, 1925, issue of Radio Review, Vol. 1, No. 6.

INDUCTANCE COILS—Any coil of wire wound in such a manner as to possess the property of self-induction. Such a coil may be in almost any conceivable form, providing the turns are separated or insulated from each other. Inductance coils are a very necessary part of

Honeycomb type inductance coils.

radio circuits, being used in conjunction with condensers to obtain resonance or desired wave-length. Such coils can also be arranged as separate circuits and placed in inductive relation to each other, thus permitting energy present in one to be transferred through induction to the other. The



Low-loss air-wound inductance coil made especially for tuned radio frequency work.

most common example of inductance in a receiving set is that of a tuning coil or vario-coupler. The illustration shows several forms of inductances known as tuning inductances. (See under separate headings as follows: *Inductance, Loading, Tuning, Tapped,* also *Inductance, Units of.*

INDUCTANCE, DISTRIBUTED—Added inductance distributed throughout the length of a cable or telephone line to compensate for the capacity of the line. (See *Distributed Inductance.*)

INDUCTANCE, LOADING—Literally an inductance to load a circuit. The term is used to designate any inductance coil or unit used in series with the antenna for the purpose of increasing the wave-length of the circuit. (See *Inductance, Antenna.*)

INDUCTANCE, MEASUREMENT OF—Any process or means of determining the inductance value of a coil or circuit. The usual method is by formula. (Fully described under *Measurement of Inductance.*)

INDUCTANCE, MUTUAL—Symbol M. The number of linkages of flux lines or the flux that is common or mutual to two circuits which are adjacent to each other or inductively coupled. It is generally defined as the amount of the *flux* (q.v.) which is common to two linked circuits per unit of current flowing in the inducing circuit. In the illustration circuit A contains an inductance L_1 which is being traversed by an alternating electromotive force. Circuit B contains merely an inductance L_2 and a measuring device, M. Now, as the alternating E.M.F. passes through coil L_1 it sets up a field of force, or rather flux lines as shown. These lines link with the coil L_2 and an alternating E.M.F. is set up. Now, suppose that the inducing current flowing in circuit A is changing at the rate of one ampere per second and an E.M.F. of one volt is induced in the circuit B, or rather in coil L_2. We then say that the mutual inductance of the two circuits will be one henry. This is the same unit used for self-inductance and in fact, mutual inductance and self-inductance are virtually the same thing.

The effect of mutual inductance must be taken into consideration when measuring the fundamental wave-length, capacity or inductance of an antenna. That is to say, where a number of parallel wires are used, the mutual in-

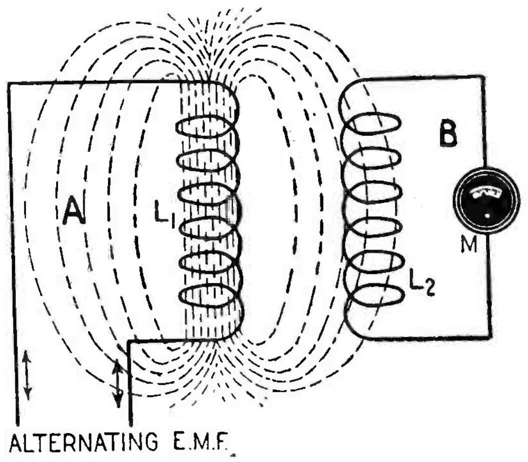


Diagram which illustrates the mutual inductance between coil L_1 in circuit A and coil L_2 in circuit B.

ductance between them must be taken into consideration as well as other values or constants. (See *Self-Inductance, Mutual Inductance, Induction, Coupling* and *Induced E.M.F.*)

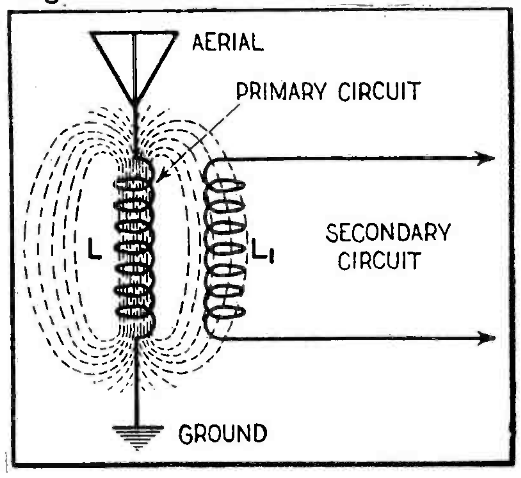
INDUCTANCE, REACTANCE—Symbol x—The *reactance* present in a coil possessing self-inductance. The self-inductance in such a coil opposes the flow of alternating current due to the back *electromotive force* set up as a result of the changing magnetic field of the current. *Inductance reactance* (or *inductive reactance*) is the term used to define this opposition. *Inductance reactance* acts similarly to *resistance* (q.v.) in that it opposes the flow of an electric current. It is measured in *ohms* (q.v.), just as *resistance* is measured. It should be noted, however, that *inductance reactance* only opposes the flow of alternating currents, whereas resistance opposes the flow of both direct and alternating currents. Furthermore, resistance in offering opposition to current flow consumes power, while *inductance reactance* merely takes up energy from the circuit momentarily while current is increasing and thereafter gives it back while the current is decreasing.

The combined opposition offered to the flow of alternating current by the resistance and the inductance reactance of a circuit is called the *impedance* (q.v.) of that circuit. The voltage drop due to resistance is in *phase* (q.v.) with the current. The voltage drop due to *inductance reactance* is 90 degrees in advance of the current.

Expressed as a formula, $x = \sqrt{Z^2 - R^2}$, where x is the inductance reactance, Z is the impedance and R is the resistance, all measured in ohms.

Knowing the *frequency* (q.v.) of the alternating current and the inductance of the circuit through which this current flows, it is possible to calculate the *inductance reactance* by using the formula $x = 2\pi fL$, where π is a constant equal to 3.1416, f is the frequency in *cycles* per second, and L is the *inductance* of the circuit in *henry's* (q.v.). This formula is sometimes abbreviated by substituting the symbol ω (omega) for $2\pi f$. From the formula it can be seen that the *inductance reactance* increases directly both with the inductance of the circuit and with the frequency of the current flowing. (See *Current,* also *Electromotive Force, Resistance, Reactance.*)

INDUCTANCE, RECEIVING—Broadly, any form of inductance used in receiving circuits. The term thus includes

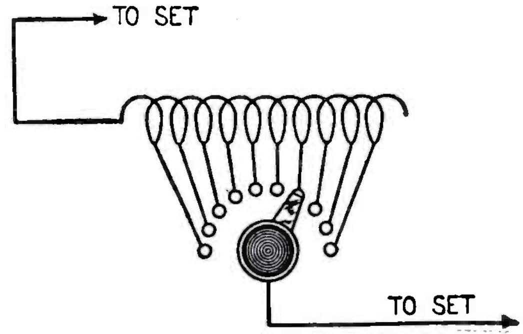


A form of tuning inductance sometimes used in radio receiving sets.

all types of coils for tuning purposes, such as couplers, tuned transformers, variometers, etc. The illustration shows a common form of tuning inductance. Here the coil L is an inductance in the aerial circuit and L_1 the coil in the secondary circuit. Here the energy from the aerial traverses coil L and by induction is transferred to coil L_1. (See *Tuning Coil, Vario-Coupler, Receiving Circuit.*)

INDUCTANCE, SELF—Symbol L—An alternate term with self-induction for the *inductance* (q.v.) due to the field of force produced by the circuit itself. It is virtually the same as mutual inductance. For example, in a coil of wire being traversed by alternating currents the adjacent turns may act upon each other on the principle of mutual induction between two separate adjacent circuits. The induced currents are the result of self-induction. (See *Self-Induction,* also *Mutual Inductance* and *Induction.*)

INDUCTANCE, TAPPED—Any type of inductance having taps for connecting at different points on the coil in order

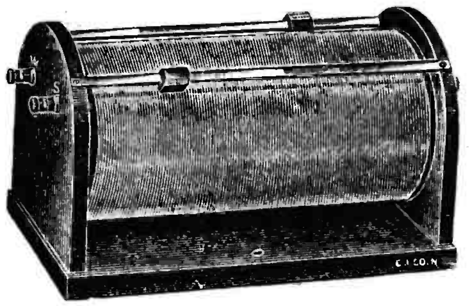


A tapped inductance which permits inductance to be added or taken out of the circuit by rotating the lever switch.

to vary the inductance value. The illustration shows a form of tapped inductance. Here the taps at different portions of the coil are connected to switch points and the switch lever permits instant change to any of the available values. (See *Inductance Coils,* also *Tuning Coil.*)

INDUCTANCE, UNITS OF—The measuring units for inductance. The practical unit is the henry (H), the value of inductance which, if current varies at the rate of one ampere each second, results in an *induced electromotive force* (q.v.) of one volt. When we speak of an induced E.M.F. of one volt, the volt is used as a practical unit. Under the electromagnetic system of units, the absolute unit of induced E.M.F. is known as the abvolt. This unit is very small, 100,000,000 of them being required to equal one volt. We thus say that the volt of induced E.M.F. is equal to $1x10^8$ abvolts. The electromagnetic unit of E.M.F., or the abvolt, is defined as the E.M.F. induced in a conductor cutting one line of magnetic force each second. As we have shown that one volt is equal to $1x10^8$ abvolts of induced E.M.F., and since one ampere is equal to $1x10^{-1}$ abamps of current (see *Units, Electromagnetic*) then the unit of inductance or one henry $= \frac{1x10^8}{1x10^{-1}}$ or) $1x10^9$ abhenrys. The unit of inductance (the henry) being too large for practical purposes, the *milli-henry* (one-thousandth henry) or the *micro-henry* (one-millionth henry) are commonly used. Occasionally the *centimeter* is used as a measure of inductance, being the thousandth part of a micro-henry or a *milli-micro-henry*. The milli-henry is written as $1x10^{-3}$ henry, the micro-henry as $1x10^{-6}$ henry, and the centimeter as $1x10^{-9}$ henry. (See *Induced Current, Induced E.M.F., Induction, Electromagnetic,* also *Units.*)

INDUCTANCE, VARIABLE—Any coil possessing self-inductance and being arranged in such a manner that the value of the inductance can be changed at will. The simplest form of variable inductance is the sliding contact tuner. This is merely a coil of wire of any pre-



A sliding contact tuner formerly used in radio receiving sets.

determined value (maximum) mounted and arranged with a sliding contact moving over the wires, which are bared of insulation at a certain point

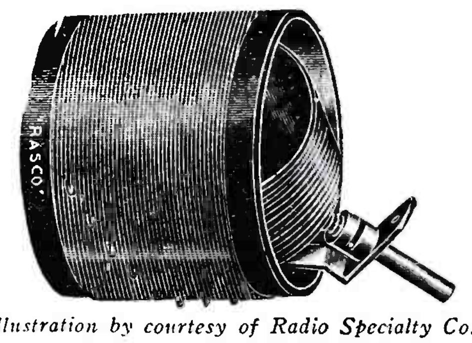


Illustration by courtesy of Radio Specialty Co.
Variable inductance known as a variocoupler.

to permit contact. By using the sliding contact as one connection and either end of the coil as the other lead, the effective value of the inductance in the circuit may be varied within the limits of the coil itself. Other forms of variable inductance include the variometer, vario-coupler and various modifications. The illustration shows the two more common forms of variable

Illustration by courtesy of Radio Specialty Co.
Another type of variocoupler.

inductance. (See *Inductance*, and *Inductance Coils.*)

INDUCTANCES IN PARALLEL—Coils possessing the property of self-induction or self-inductance, connected in parallel or shunt to each other. The illustration shows two standard coils

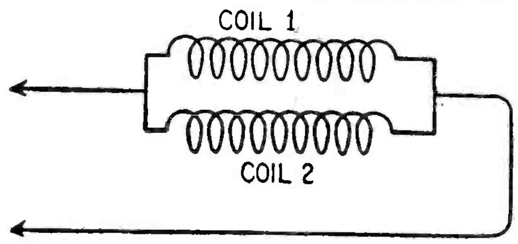


Diagram showing connection of two inductance coils in parallel in a circuit.

connected in a circuit in this manner. The effective inductance is less than that of either coil alone. (See *Inductance Coils.*)

INDUCTANCES IN SERIES—Coils possessing the property of self-induction, connected in series in a circuit. The illustration shows two coils con-

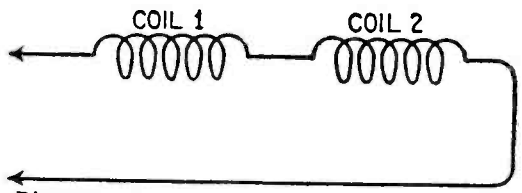


Diagram showing two inductance coils in series in a circuit.

nected in series in a circuit. Here the effective inductance value is the sum of the separate inductances. (See *Inductance Coils.*)

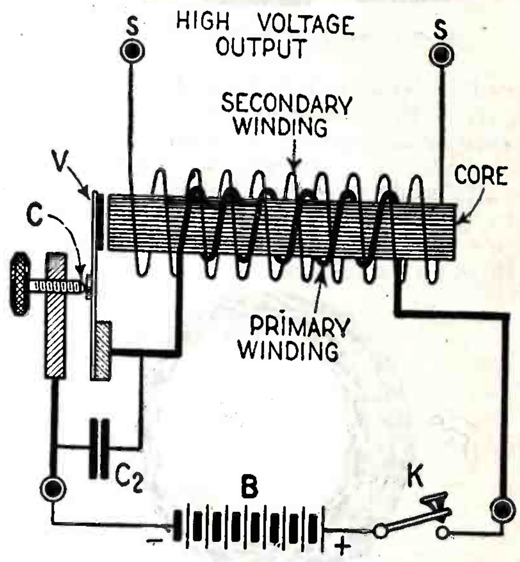
INDUCTION—The influence exerted by one field of force (electromagnetic or electrostatic) on another or on a conductor. Whenever a magnetic field interlinked with an electric circuit is changed, an *electromotive force* (q.v.) is induced in that circuit. The magnetic field is considered to originate from the heart of the conductor, spreading out concentrically from the conductor as the current increases and shrinking back into the center of the conductor as the current decreases. In either case, the conductor is cut by the magnetic field, and in accordance with the *law of electromagnetic induction* (q.v.) an electromotive force is induced in the circuit proportional in amount to the rate of change of the magnetic field and acting in a direction which would, by producing a current, tend to oppose the change.

A bothersome type of electromagnetic induction sometimes occurring in radio takes place when a radio aerial is run parallel to a high-tension line or even a trolley line. The varying field of force about the high-tension line sets up, by induction, a corresponding field in the parallel aerial, thus causing a disturbing hum in the loud speaker. Such a condition can usually be eliminated by running the aerial at right angles to the power line. By doing this, induction between the two conductors is reduced to a minimum.

Electrostatic induction is a rearrangement of an electrostatic field whereby a body in the neighborhood of a charged body will have an opposite charge induced on it. An *induction machine* (q.v.) known as the Wimshurst utilizes the principle of electrostatic induction.

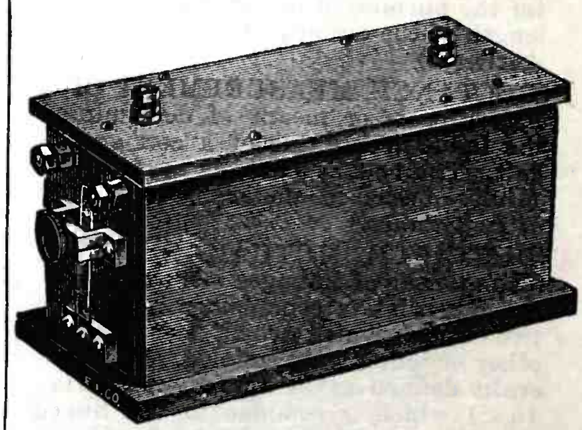
INDUCTION BRIDGE—Also called inductance bridge. A balance arranged similarly to a *Wheatstone Bridge* (q.v.), used in induction measurement. (See *Induction, Measurement of Inductance,* also *Induction Density.*)

INDUCTION COIL—A form of transformer, having a primary winding arranged with a means of making the direct current applied to it, pulsate.



A typical form of induction coil showing diagram of connections, vibrator, core, battery, condenser and key.

Essentially a transformer with open magnetic circuit, carrying a pulsating direct current which induces a high voltage, alternating current in the secondary by means of the step-up effect of the windings. The illustration shows a typical form of induction coil and the associated circuits for producing high voltages. Here, there are two windings, a primary and a secondary, over and insulated from a core, composed of a number of soft iron wires. The primary is arranged with a key, K, and a battery, B, to supply direct current to the circuit. When the key is depressed the current flows through the primary circuit, including the contact C and the vibrator V. The core



A form of spark coil.

becomes *saturated* (q.v.) or magnetized and attracts the armature or spring V. As this spring is drawn toward the core it breaks the contact between the spring and the contact post. This, of course, breaks the circuit from the battery and the flow of current stops, resulting in the collapse of the flux through the core. When the magnetic attraction ceases the spring goes back into normal position and the contact is once more complete, allowing current to flow through the windings. This make-and-break process is more or less rapid and is repeated continuously. By induction, an alternating E.M.F. (electromotive force) is created in the secondary windings, and as these windings have many more turns than the primary winding the induced E.M.F. will be proportionately greater. If the breaks occur at a rate of from thirty to one hundred per second, the key can be used to interrupt the primary current and produce at the secondary terminals a high voltage suitable for spark transmission. (See *Induction, Transformer, Spark Coil.*)

INDUCTION COIL, PRIMARY—The simplest form of induction coil. It consists of an iron core wound with a relatively large amount of low resistance copper wire, which is well insulated. The iron core increases the effect of self-induction and the size or length of the core and the number of turns of wire determine the efficiency of the coil. Such coils are used extensively for low tension ignition. (See *Induction Coil.*)

INDUCTION COIL, SECONDARY—A type of induction coil employing a primary and secondary winding. The primary is wound over an iron core and the secondary is generally wound over the primary. (See *Induction Coil.*)

INDUCTION DENSITY—A term occasionally used to refer to the density of flux in a magnetic or electromagnetic field of force. It is synonymous with flux density, under which heading it will be found more fully defined. (See *Induction, Electromagnetic,* also *Gauss,* and *Induction, Magnetic.*)

INDUCTION, ELECTROMAGNETIC—The production or *inducing* of electric currents in a conductor when it is moved in a magnetic field of force in such manner as to cut magnetic lines of force. The simplest example of this phenomena is the Faraday experiment in which he discovered that a wire with its ends joined, when moved rapidly in the field of a magnet, would result in current being induced in the wire or conductor. All dynamo electric machinery is based upon this principle of electromagnetic induction, as are also alternating current transformers and various other electrical devices.

In the illustration is shown the theory of production of current by electromagnetic induction. Fig. 1 shows a

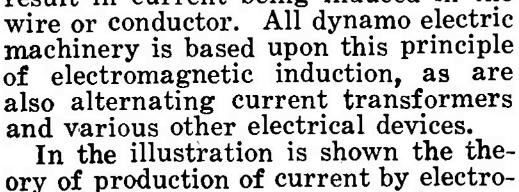


Fig. 1. Coil of wire in a uniform field moving parallel to direction of the field.

coil of wire placed in a uniform magnetic field of force between two magnets. Here the coil is assumed to have been moved from A to B in the same plane. This is known as a *motion of translation,* and the field being uniform at all points the same number of lines pass through the coil at both points. Therefore no current is induced in the coil and a sensitive instrument placed across the leads, C, C, would show no current present. In Fig. 2 the same coil is shown at A in its original posi-

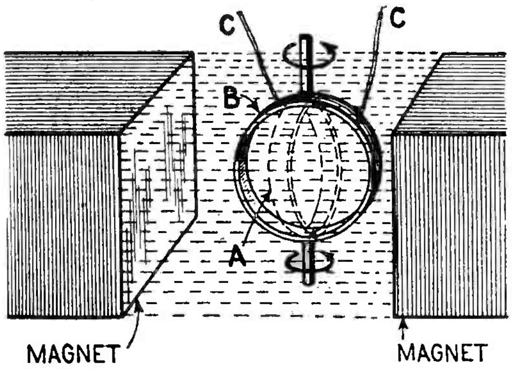


Fig. 2. Same coil, showing cutting of field due to the rotation of the coil.

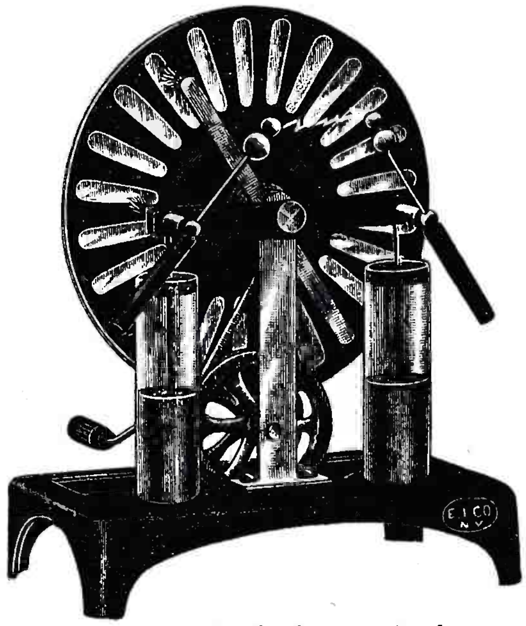
tion. Here, however, it is rotated, and when in position B it is apparent that less lines of force pass through it. We have thus fulfilled the conditions for inducing current, and if the instrument is placed across the leads, C, C, the presence of electric current will be indicated. If the motion of rotation is continued the number of lines of force passing through the coil will continue to increase and decrease and current will be produced in the coil as long as the motion persists. From the above it will appear that current can be induced either by rotating the coil around any axis in its plane, or by tilting it in its motion across the field. The coil of wire in this case is known as an *inductor* because the current is induced in it. It is also referred to as a *conductor* when describing the production of alternating currents.

Now it was stated that current is induced in the inductor whether the lines of force through it are *increased* or *decreased* by its motion through the field. We can reduce the action to two simple rules. First, the relative motion between an inductor and a magnetic field must be such that the number of lines passing through the inductor are altered, i.e., increased or decreased. Second, the electromotive force induced in the inductor circuit will be proportional to the rate of increase or decrease in the number of magnetic lines embraced by the inductor circuit. We know from the *Lenz Law* (see *Alternating Current, Theory of Production of*) that current will flow in the inductor in a direction dependent upon whether the lines of force through it are being increased or decreased, and as the inductor is being rotated continuously the current will change direction with each change in the number of lines. (See *Alternating Current, Alternator, Electromotive Force, Fleming's Rule, Laws of Electromagnetic Induction, Lenz's Law.*)

INDUCTION, ELECTROSTATIC—The production of an electric charge in a body due to the presence of a nearby conductor having an opposite charge. The effect is known as a displacement of electric charge. (See *Electrostatic Induction,* also *Induction.*)

INDUCTION INSTRUMENTS—Measuring instruments used in electrical and radio practice, which make use of the principle of electromagnetic induction. Such instruments are used for measuring alternating currents, the torque or actuating force for the indicator being produced by the effect of a rotating field on a metal disc or drum which is not connected to the circuit carrying the currents. The instruments operate on the same basic principle as the *induction motor* (q.v.).

INDUCTION MACHINE—A machine wherein the primary and secondary windings rotate with respect to each other. Examples of induction machines are induction motors, certain types of frequency converters and induction generators. An entirely different kind of induction machine is one which gen-



A common type of induction machine known as the Wimshurst.

erates low potentials, utilizing the principle of *electrostatic induction* (q.v.). The most common form of this type is known as the Wimshurst (q.v.).

INDUCTION, MAGNETIC—The communication of magnetism to a metal by the presence of a magnet without any actual contact. The effect of the presence of a magnet in the neighborhood of a piece of magnetic material is to induce magnetic poles in it. (See *Magnetism, Magnetic Poles, Induction,* also *Induction, Electromagnetic.*)

INDUCTION MOTOR—An alternating current motor in which the input current is passed through the field coils only, the armature not being connected to the external circuit. Here the armature is rotated by currents induced by the varying field set up through the field coils. The induction motor is the most widely used of the alternating current types, maintaining a practically constant speed from no load to full load and being simple and rugged in construction. This type of motor has two windings, the primary and secondary, and two members called stator and rotor. The primary winding is usually on the stator and the secondary winding, which is therefore customarily on the rotating member, is not connected electrically to the primary. Current to operate the rotor is induced in the secondary windings by the magnetic action of the current circulating in the primary windings. (See *Alternating Current,* also *Induction, Electromagnetic.*)

INDUCTION, MUTUAL—The interference or mutual effect between two electric or magnetic fields, due entirely to their proximity and without electrical contact. The mutual induction or electromagnetic influence of one circuit upon another is measured by the coefficient of mutual inductance or induction. (See *Mutual Induction,* also *Mutual Induction Coefficient,* and *Mutual Inductance.*)

INDUCTION REACTANCE—The value in ohms of the inductance in an electrical circuit as distinguished from the capacity or capacitive reactance. It is the part of the total impedance in an alternating current circuit that is due to the presence of inductance in the circuit. (See *Inductance Reactance, Ohm, Impedance.*)

INDUCTION REGULATOR—A system of regulating the voltage in alternating current circuits, employing a choke coil with removable core, or some form of variable ratio transformer which will assist or oppose the current by readjustment of the ratio. (See *Choke Coil, Reactance,* and *Variable Ratio Transformer.*)

INDUCTION SCREEN—A metal screen or shield placed between two electrified or magnetic bodies to reduce the effect of induction between them. A common example of this in radio usage is the placing of a sheet of metal between two coils, the sheet being generally grounded, or the provision of a metal *shield* (q.v.) entirely around each coil. This reduces the interaction of the fields of the coils, which leads to losses or howling, especially in *tuned radio frequency amplifiers* (q.v.). (See *Shielding.*)

INDUCTION UNIT—The *henry,* defined as the induction in a circuit when the electromotive force induced in that circuit is one *international volt* (see *volt*) while the inducing current varies at the rate of one ampere each second. (See *Henry,* also *Self-Induction.*)

INDUCTION VOLTMETER—See *Induction Wattmeter,* also *Induction Instruments.*

INDUCTION WATTMETER—An instrument for measuring the power delivered to a circuit. The induction type wattmeter operates on a principle used in the induction motor, a magnetic body attached to a pointer being rotated by a changing magnetic field. (See *Induction Motor,* also *Wattmeter.*)

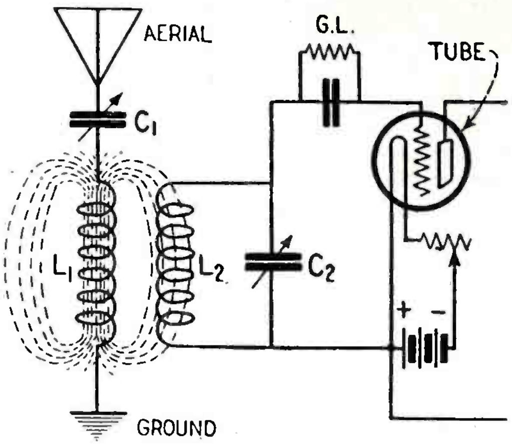
INDUCTIVE CAPACITY—Generally referred to as the specific inductive capacity in rating the dielectric qualities of a substance. It is the quality of any dielectric substance by reason of which it permits electrostatic induction through it. The term is more or less synonymous with *Dielectric Constant,* the latter, however, being generally given in terms of a numerical value representing its comparative specific inductive capacity with some material taken as a standard. (See *Dielectric Coefficient and Constant,* also *Specific Inductive Capacity.*)

INDUCTIVE CIRCUIT—An electrical circuit possessing inductance but not capacity. (See *Inductance,* also *Capacity.*)

INDUCTIVE CONNECTION—A connection between two circuits entirely through the property of induction and without any metallic contact. The two coils, primary and secondary, of a vario-coupler as used in radio receiving circuits, are said to have inductive connection where the windings are separate. Thus, the primary coil will be in one electrical circuit and the secondary coil will receive energy from it by means of induction. (See *Induction, Coupling, Vario-Coupler.*)

INDUCTIVE COUPLER—The inductances or coils placed in inductive relation or inductively connected with each other for the purpose of transferring energy by electromagnetic coupling. Any device consisting of a primary and secondary inductance and used to transfer energy from one circuit to another by means of induction. (See *Coupler, Induction, Vario-Coupler.*)

INDUCTIVE COUPLING—The coupling or connection between two circuits by means of electromagnetic induction.



The utilization of a vario-coupler to inductively couple the aerial system with the rest of a receiving circuit.

The most common example of inductive coupling is in radio receiving circuits where coupling coils are used to associate the primary or aerial circuit with the secondary circuit. In the illustration L_1 is the primary of a vario-coupler and L_2 the secondary. The primary is inserted between the ground and aerial and the secondary is connected to the grid and filament of the detector tube. The variable condenser C_1 tunes the primary circuit, the primary coil also being variable by means of taps if desired. The variable condensed C_2 tunes the secondary inductance and the condenser and grid leak GL are the customary elements in the detector grid circuit. As the high frequency currents traverse the primary circuit, passing through coil L_1, lines of force are set up as shown and some of these lines embrace the secondary coil L_2, inducing similar currents in the secondary or vacuum tube circuit. The balance of the circuit is not shown for obvious reasons. This type of coupling between circuits is much more selective than the straight coupling or conductive coupling. (See *Coupling,* also *Conductive Coupling.*)

INDUCTIVE DISTURBANCE—The disturbing effects sometimes experienced in radio broadcast or telegraph reception due to induction from nearby power or telephone lines. This sometimes occurs when an aerial is strung close to and parallel with a line carrying high voltages, and occasionally is experienced with telephone wires near the receiver. (See *Induction.*)

INDUCTIVE DROP IN VOLTAGE—The drop or diminution of voltage in an alternating current circuit due to the presence of inductance. Inductance in a circuit carrying alternating current tends by reason of the self-induction to set up a counter-electromotive force which opposes the original E.M.F. (electromotive force), thus reducing the effective voltage in the line. (See *Inductance,* also *Inductance Reactance.*)

INDUCTIVE EMF—The electromotive force due to induction. That is to say, the electromotive force induced in a circuit. (See *Induction, Induced EMF.*)

INDUCTIVE REACTANCE—The reactance or portion of the total impedance in a circuit, due to the presence of self-inductance. (See *Inductance Reactance,* also *Impedance.*)

INDUCTIVE RESISTANCE—A resistance element possessing inductance, as for example a resistance coil, which also has the property of self-inductance. (See *Resistance,* also *Inductance.*)

INDUCTIVE RISE—The rise in voltage noted in transformers or other alternating current apparatus due to the presence of a *leading current* (q.v.). (See *Inductance,* also *Transformer* and *Angle of Lead or Lag.*)

INDUCTIVITY—Another term used alternately with dielectric constant and conductive capacity, referring to the dielectric properties of materials. (See *Dielectric Coefficient or Constant,* also *Inductive Capacity.*)

INDUCTOR—The coils or conductors in which current is induced through electromagnetic induction, as in an induction motor. Any conductor in which current is induced due to a change in magnetic flux may be called an inductor. (See *Induction, Inductor Alternator,* and *Induction Motor.*)

INDUCTOR ALTERNATOR—An alternator for producing high frequency currents. It employs the *armature* and *field windings* on projections inside the *stator,* the rotor consisting of a drum carrying a magnetic material. By using a *rotor* of solid steel, very high speeds and consequently high frequency currents are obtainable. The *Alexanderson Alternator* (q.v.) is an inductor type alternator. (See *Alternator,* also *Inductor.*)

INDUCTOMETER—A device or instrument used to measure self or mutual inductance. The basic principle depends on the relation of two coils, a primary and secondary, one of which can be moved in its relation to the other, the inductance, either self or mutual, being registered on a scale calibrated in units of inductance. (See *Inductance, Mutual,* also *Inductance, Self.*)

INERTIA—In physics, the property of a body which tends to keep it in a state of rest or to resist any change of motion. (See *Inertia, Electric.*)

INERTIA, ELECTRIC—Term occasionally applied in place of *self-inductance* (q.v.). When a current flows in a circuit possessing inductance and the circuit is broken, current continues to flow for a short time. It thus appears that in this instance the resistance alone will not stop the flow of current on the instant of breaking the circuit, an interval of time being required as in the act of bringing to rest a moving material. (See *Inertia, Inductance, Self,* also *Resistance.*)

INERTIA, ELECTROMAGNETIC—The same as electric inertia, being, in effect, the energy required to start or stop a current in a circuit possessing self-inductance. (See *Inertia.*)

INFERRED ZERO—A term used in connection with certain instruments having extremely high sensitivity, where the zero is removed from the scale. In a galvanometer, for example, the zero position on the scale may be merely assumed, an electrical or mechanical force being applied to bring the zero off the scale entirely, only a part of the full range of the full scale being utilized. (See *Galvanometer.*)

INFLUENCE—A broad term signifying action at a distance, as by electrostatic induction, without any actual physical contact. It is considered as the effect of a charged body on a neutral body or conductor coming within its field. (See *Field*, also *Induction.*)

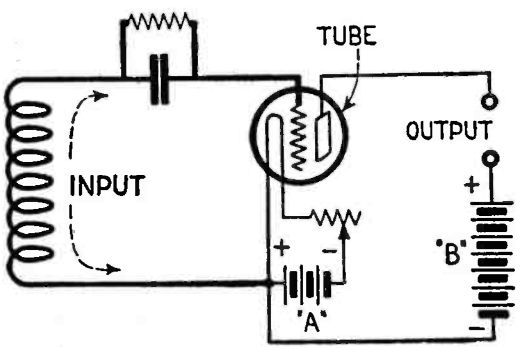
INFRA-RED RAYS—The heat waves or rays which lie between light waves and electromagnetic (radio) waves. The infra-red lies at the extreme low frequency end of the invisible spectrum, the wave-length being extremely high and the frequency conversely low. (See *Wave*, also *Ether Waves.*)

INFRA-SATURATION PART OF CHARACTERISTIC—In a characteristic curve of a vacuum tube, this is the portion over which the tube is operable, or the operating portion of the curve. (See *Characteristic Curve*, also *Vacuum Tube, Theory of Operation.*)

INITIAL MAGNETIZATION—The initial stages of magnetization as distinguished from the effect after saturation has been approached or reached. (See *Saturation, Magnetic.*)

INPUT—Generally speaking, the energy absorbed by a machine as distinguished from the output energy. (See *Input Voltage*, etc.)

INPUT CIRCUIT OF VACUUM TUBE—Vacuum tube circuits are generally divided into three separate classes or circuits. The first is the circuit including the filament, i.e., the "A" battery circuit through the filament. The



Input and output circuits of a vacuum tube receiver. Heavy lines show the former, light lines the latter.

second is the circuit between filament and grid and the third is the circuit between filament and plate. The filament grid circuit is called the input circuit because the incoming oscillations are impressed on this circuit. The filament plate circuit is known as the output because the rectified or amplified currents are taken from across the plate and filament. The illustration shows both input and output circuits, the former in heavy lines and the latter in light lines. The input circuit of a tube is also known as the *grid circuit.* (See *Grid, Filament, Plate*, also *Vacuum Tube, Theory of Operation.*)

INPUT VOLTAGE—The voltage impressed on a circuit or machine as distinguished from the output voltage. (See *Input.*)

INSTANTANEOUS CURRENT—The value of current in an alternating current circuit measured at any instant, as distinguished from the average current value. (See *Instantaneous Values.*)

INSTANTANEOUS VALUES—The actual value of an alternating current, E.M.F. (electromotive force), etc., measured at any instant. This value may be anything from zero to maximum or peak It must be remembered that in an alternating current the current and voltage are both variable factors, rising to a maximum in one direction, then falling to a minimum, and then rising to a maximum in the other direction. Thus, a wattmeter measures the actual value of current and voltage at each instant and the instantaneous torque at each instant is proportional to the instantaneous power. The average torque acting on the moving element during each cycle of the current and voltage is then proportional to the average power. If we measure an alternating current with an ammeter, and then measure the voltage with a volt-meter, the product of the two will be the apparent power, (apparent watts). It should be noted that these instruments measure effective and not instantaneous values. In order to ascertain the true *watts* (q.v.), it is necessary to multiply the apparent watts by the power factor. A wattmeter measures true watts. (See *Effective Electromotive Force, Power Factor*, also *Wattmeter.*)

INSTANTANEOUS VOLTAGE OR PRESSURE—The voltage or pressure in an alternating current circuit measured at any instant, as distinguished from the average value of E.M.F. (electromotive force). (See *Instantaneous Values.*)

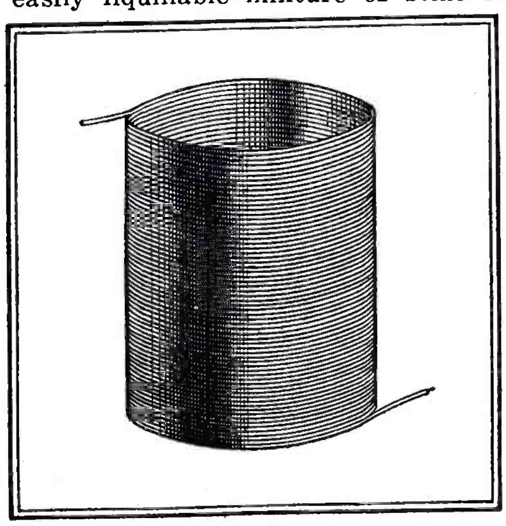
INSTRUMENTS, MEASURING—In electricity or radio, any device or instrument for recording or indicating values, such as an ammeter for indicating the current in amperes, or a voltmeter to indicate the electromotive force in volts. (See *Ammeter* or *Ampere Meter, Voltmeter, Wattmeter.*)

INSTRUMENT SHUNTS—In electrical measuring instruments, a branch conductor, generally of relatively heavy wire or metal strip, joining the meter circuit at two points and forming a parallel circuit, thus dividing the current and protecting the delicate windings of the instrument. (See *Shunt*, also *Ammeter*, or *Ampere Meter, Hot Wire Ammeter.*)

INSULATE—To provide a protective covering or shield for a part or conductor, preventing flow of electricity from it or the passage of electricity through it. A conductor of electric currents is generally insulated to prevent the flow of the electricity through contact with other parts or conductors except where contact is intended to be made. (See *Insulated Wire.*)

INSULATED WIRE—Wire, generally copper, covered with insulating material to prevent leakage of the electric current. Standard insulated wire of the heavier gauges is usually covered with a layer of rubber and an outer covering of braided cotton. (See *Lead-In*, also *Insulation.*)

INSULATING COMPOUND—Liquid or easily liquifiable mixture of some in-



Air core coil made rigid by use of insulating compound.

sulating material, used in radio to coat cardboard tubes and to cover any open point of contact in an otherwise insulated conductor or part. Coils are very often coated with shellac or some other liquid and quick-drying substance. This serves to hold the windings in place and also acts as a protective covering. A very valuable application of an insulating liquid is shown in the illustration. Here an inductance is wound on a form of stiff paper or cardboard tube and after being completed is coated with one or two treatments of collodion or similar liquid. (Shellac introduces losses through the medium of *distributed capacity.*) The form is then cut away and the coil remains self-supporting as shown. This method produces a coil having the least possible dielectric and distributed capacity loss for a cylindrical shape. (See *Dielectric, Inductance Coil, Low Loss Coils, Collodion.*)

INSULATING MATERIALS—Non-conducting substances, for example, glass, hard rubber or porcelain, which do not conduct electric currents. Strictly speaking, there are no perfect insulating materials. The most perfect insulators are certain gases, although at low pressure these may act as very good conductors. The more common insulating materials in radio are the following: mica, glass, bakelite and hard rubber, the insulating values being in that order. When we speak of the insulating property of a material we are actually referring to its resistance, a good insulator offering infinite resistance to the passage of electric currents and poor ones being relatively good conductors. The term *specific resistance* is used extensively in connection with the insulating properties of materials. This term is defined as the resistance of a piece of material of unit length and unit cross-sectional area at a given temperature, the value being given in ohms. (See *Dielectric Coefficient and Constant, Table of*, also *Ohms, Resistance* and *Insulate.*)

INSULATING PROPERTY—The ability of any material to *insulate* electric currents. Accepting mica as an insulator, we say that its insulating properties are superior to glass or hard rubber. (See *Insulating Materials*, also *Dielectric Coefficient and Constant* and *Insulation of Aerial.*)

INSULATION—Broadly any material or gas used to insulate electric currents. In radio, insulation plays a most important part, providing protective coverings or separators between conductors of the electric current and between the conductors and the ground. Insulation is really a material or gas having extremely high specific resistance; the better the insulating property, the higher the resistance to passage of electricity. There is no clearly defined line of demarcation between an insulator and a conductor, a poor insulator being to some extent a conductor. (See *Bakelite, Conductor, Dielectric Coefficient and Constant, Insulations of Aerial, Panel.*)

INSULATION OF AERIAL—The means used in connection with an aerial for

Aerial Insulator.

reception or transmission of radio waves, to prevent leakage or grounding of the currents. The insulation of an aerial for reception purposes should be given very careful consideration. The wires may be suspended by means of small glass or porcelain insulators and the lead-in rubber covered wire, entering the building through a *lead-in insulator* (q.v.). The aerial for transmission must be accorded specially careful attention as far as insulation is concerned. The bare wires must be suspended with heavy duty insulators, capable of withstanding high voltages without "*breaking down.*" The lead wire must be conducted into the building through a high-tension insulating tube or other lead-in device to prevent leakage of the current to the ground. (See *Aerial, Insulation of Aerial* and *High Tension Insulators,* also *Lead-In Insulator.*)

INSULATION RESISTANCE—The actual resistance in ohms, generally megohms, of the insulation of any conductor or piece of apparatus. If we assume two conductors, carrying separate currents and crossed so that the only protection would be the actual insulation of the wires, the insulation resistance would be the actual resistance in megohms from one path to the other. Conceivably a small current might leak from one conductor to the other, this current, of course, depending on the resistance of the insulation. The term "insulation resistance" is more easily understood when it is considered that an insulator or insulating material is merely a very poor conductor, or one having extremely high resistance to electric currents, there being actually no perfect insulator. (See *Insulation, Insulated Wire,* also *Conductor* and *Resistance.*)

INSULATION TESTER—An instrument or set of meters for testing the resistance of an insulator in fractional ohms, generally megohms. (See *Insulation Resistance.*)

INSULATOR — Any substance having insulating properties. *Insulators* are used to keep electric currents flowing in predetermined paths. It is necessary to use insulators on all electric circuits in order to prevent *grounds, leakage* and *short circuits.* Insulators are of the utmost importance in radio. At the transmitting end, where high voltages as well as high frequencies are used, the insulators must be specially designed to prevent leakage. A typical installation of insulators in use on the aerial system of a modern broadcasting station utilizes a 12-inch pyrex insulator at each end of each wire between the spreaders. A standard porcelain strain insulator is used every 14 feet on each guy wire. At each end of each guy wire a standard 24-inch porcelain insulator is used.

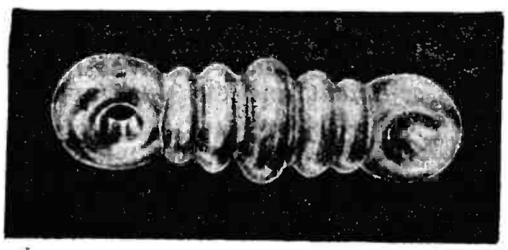
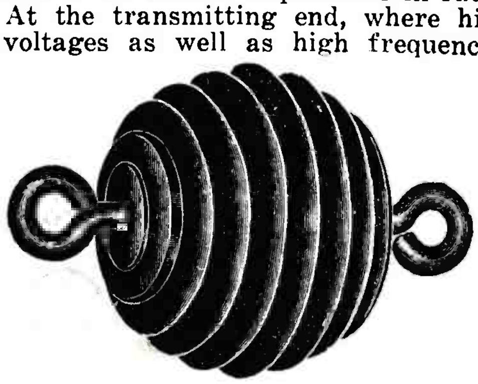


Illustration by courtesy of Corning Glass Works.
A typical small antenna insulator, showing corrugated surface.

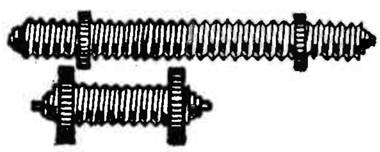


A corrugated ball insulator.

Insulators used on receiving antennas are made of porcelain, pyrex, rubber and composition. These are usually about 4 inches in length. Sometimes porcelain tubes are used as insulators to bring a *lead-in* (q.v.) into a building, but these have been generally superseded by flat *window lead-ins.*

INSULATOR, LEAD IN—The insulating tube through which a lead wire from a radio aerial enters a building, used to prevent grounding or leakage of the current by contact with another conducting surface. (See *Lead-In Insulator.*)

A flat window lead-in which permits entrance of lead-in into building without the necessity of boring holes.



Lead-in insulators of conventional type.

INTEGRATING DETECTOR—The name sometimes given to any detector which yields a response proportional to the total energy received from a spark train rather than to the maximum value of the current or voltage in the train.

INTEGRATING INSTRUMENTS — Meters so designed as to record the total quantity of electricity (ampere hours) or the total energy (watt-hours) passing in a circuit in a given time. (See *Ammeter* or *Ampere Meter,* also *Integrating Wattmeter.*)

INTEGRATING WATTMETER—An instrument which measures and records the total amount of electrical energy being consumed in a circuit. These instruments are also known as *recording watthour meters* (q.v.), *integrating watthour meters,* and sometimes are simply referred to as *watthour meters* (q.v.).

Broadly speaking the *integrating wattmeter* is a type of small motor whose rotations are counted by means of a worm on the armature shaft engaging a set of cogs working a counter. The construction is such that the average *torque* (q.v.) exerted by the motor is proportional to the average power taken by the load. In other words, the motor rotates at a speed directly proportional to the energy being expended. For direct current work, *integrating wattmeters* are either of the commutator type, such as the Thompson, Westinghouse and Duncan meters or of the no-commutator type, such as the Sangamo. The commutator type instruments operate on the *dynamometer* (qv.) principle. Meters of the no-commutator type are essentially motors whose armatures always cut the same direction flux. That is to say, they are essentially *homopolar* (q.v.) motors. The principle of operation of these meters is the law of motor action which states that a conductor, free to move and carrying a current whose direction of flow is at right angles to a fixed magnetic field, will be moved out of this field, and in a direction at right angles both to the direction of current flow and to the field. For alternating current work, *integrating wattmeters* are of the *induction* (q.v.) type. The principle of operation of these meters is identical to that of *induction motors* (q.v) having shunt and series windings stationary and so related and located as to produce a rotating field acting upon a closed rotable secondary. In the induction meter the secondary consists of a light aluminum disc. These meters may be either of *single phase* (q.v.) or *polyphase* (q.v.) construction. (See *Electro-dynamometer.*)

INTEGRATOR—A device which automatically, by means of clockwork, adds up and records on a dial items of calculation or measurement. The system used in a recording or integrating wattmeter. (See *Integrating Wattmeter.*)

INTENSIFICATION — Broadly an intensifying or increasing of the density of electric current, but specifically in radio it refers to the tendency of radio signals to increase in intensity under certain conditions. The phenomena of intensification is naturally closely related to fading, as obviously the intensification process must necessarily follow or be followed by a fading process. The tendency toward intensification is more pronounced toward night and generally on the shorter wavelengths, it being noted that quite often signals from a distant station will be increased in volume or intensity as much as fifty per cent or more between the late afternoon and late evening. While the periodic *fading* of signals and the subsequent increase in volume over regular periods, usually of a few minutes' duration, may be considered as *fading* and *intensification,* it is preferable to think of fading as one operation together with the subsequent increase in volume, and the term *intensification* as referring strictly to the change to greater volume that takes place toward night. (See *Fading,* also *Phenomena of Electric Wave Propagation.*)

INTENSITY OF ELECTRIC CURRENT—A term more or less in use to imply the strength of an electric current in amperes, the symbol I for current being derived from it. (See *Ampere, Current Density,* also *Intensity of Field.*)

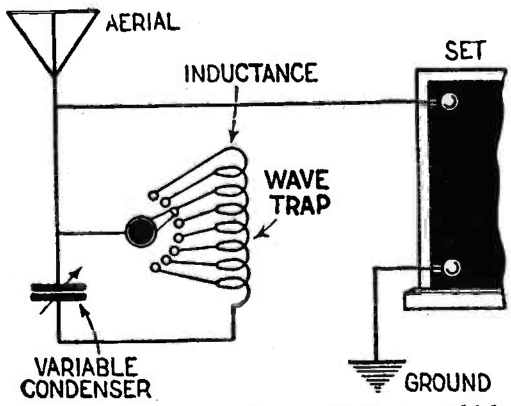
INTENSITY OF FIELD—The intensity or strength of the force exerted in a magnetic field. It is measured by its action or effect on a unit pole placed at any point in the field, the intensity of the field, of course, varying at different points. (See *Flux Density, Intensity of Magnetic Flux.*)

INTENSITY OF MAGNETIC FLUX—The strength of the force exerted in a magnetic field. (See *Intensity of Field,* also *Flux Density.*)

INTENSITY OF MAGNETIZATION—The density of force per unit cross-sectional area of a magnetized material. The extent of the magnetizing effect on a material placed in a magnetic field of force. This applies only to material in a magnetic circuit and should not be confused with the lines of force due to a field arising from the presence of neighboring currents or magnets. (See *Magnetization,* also *Intensity of Magnetic Flux.*)

INTERFERENCE—The interruption or interference with desired electromagnetic waves by undesired or extraneous waves. The interference of undesired broadcast or radio-telegraph signals with the desired signals. Also, broadly, the detrimental effect of power lines and other electric circuits on radio communication. Interference is encountered chiefly in receiving sets having poor *selectivity* (q.v.). In some instances interference may be due to the fact that another transmitter is operating on the desired wave-length, and being sufficiently close as to make it practically impossible to obtain clear signals from the desired station. Ordinarily, and where the effect is due to lack of sharp resonance or tuning, certain changes can be made in the receiver to sharpen the tuning, or if the disturbance is due to the transmitting stations and the receiver is normally sharp, various circuits can be employed to filter out the undesired signals. (See *Interference Preventer*, also *Wave Trap.*)

INTERFERENCE ELIMINATOR—A device or system as shown in the illustration for reducing or preventing reception of undesired signals in radio work. Practically all *interference eliminators* make use of a separately tuned inductance across the aerial and ground and in parallel with the receiving set.

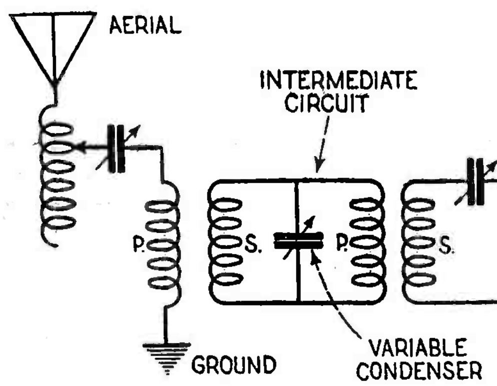


A wave trap or interference eliminator which dispenses with the ground connection.

The inductance is usually tuned by means of a variable condenser which allows it to be tuned to the wave-length of the interfering signal. The interference can thus be by-passed to the ground. *Interference eliminators* of the kind described are generally known as *wave traps* (q.v.). A special form of interference due to atmospheric and electrical disturbances is known as *static* (q.v.). (See *Static Eliminator.*)

INTERFERENCE PREVENTERS—Any arrangements either within the receiving set, or external to the set, for limiting or preventing interference. In addition to *interference eliminators* (q.v.) and static *eliminators* (q.v.) various other methods are utilized in radio to prevent interference. Thus the arrangement of a receiving set to give sharp tuning and great selectivity, results in the prevention of much interference. A method of preventing interference which has been used, is the utilization of filter circuits which can be tuned to pass any desired frequency and exclude all others. The use of the *loop aerial* (q.v.) results in great selectivity. The loop has a very pronounced directional effect and this in itself acts to narrow the field of stations offering possible interference. For example, if stations of very nearly the same wave length are in opposite or different directions and are sending at the same time, the loop permits selection of the station wanted, with no interference from the others.

INTERMEDIATE CIRCUIT—A closed circuit consisting of two inductance



A multiple tuner intermediate circuit.

coils shunted by a variable condenser. One coil acts as primary to the secondary coil of the detector circuit and the other coil acts as secondary to the primary of the aerial circuit. A circuit such as this is sometimes referred to as a *multiple tuner intermediate* circuit and may be used as an interference eliminator.

INTERMEDIATE FREQUENCY—This is a frequency higher in number of oscillations than *audio frequency* (q.v.) but lower than *radio frequency* (q.v.). It is generally around 30,000 cycles or 10,000 meters wave-length. In the *super-heterodyne* (q.v.) the incoming signal is converted from the broadcast frequency to the so-called *intermediate frequency* at which it can be amplified by means of fixed winding transformers to almost any extent desired. The method of converting the incoming signal in a *super-heterodyne* from radio frequency to *intermediate frequency* is by the *beat* method. In this case an oscillating circuit controlled by means of a variable condenser so as to obtain any desired frequency, is brought into interference with the first detector and produces a *beat note* (q.v.) for the *intermediate frequency* which has all the characteristics of the original signal. In this way, no matter what the frequency of the intercepted signal may be, the intermediate frequency amplification is always carried on at a fixed wave-length, thus making for high efficiency. (See *Beat Frequency; Beats.*)

INTERMEMEDIATE FREQUENCY AMPLIFIER—An arrangement of tubes and transformers for stepping up the current, used in the *super-heterodyne* (q.v.) circuit. The intermediate frequency amplifier is located between the first detector and the second detector. (See *Intermediate Frequency.*)

INTERMEDIATE TRANSFORMER—The name given to the transformers used in the *intermediate frequency amplifier* (q.v.) of the *super-heterodyne* circuit. *Intermediate transformers* are often referred to as *intermediate frequency transformers.* They are *radio frequency transformers* (q.v.) but have an iron core and instead of tuning to a maximum of 550 or 600 meters they are designed to cover wave-lengths of 10,000 meters or higher. (See *Intermediate Frequency.*)

INTERMITTENT CURRENT—A current which flows irregularly or which is interrupted at intervals, or without continuity. The current obtained from a *magneto generator* (q.v.) is an interrupted or *intermittent current.* Such a current may be either alternating or direct. A magneto generator constructed to give direct current is equipped with a two segment commutator having a stationary brush in contact with it. (See *Pulsating Current.*)

INTERNAL RESISTANCE—Resistance within an electric source. In the case of a primary cell such as a dry battery, the internal resistance causes an interference with the flow of current. This varies in amount with the construction and materials of the battery.

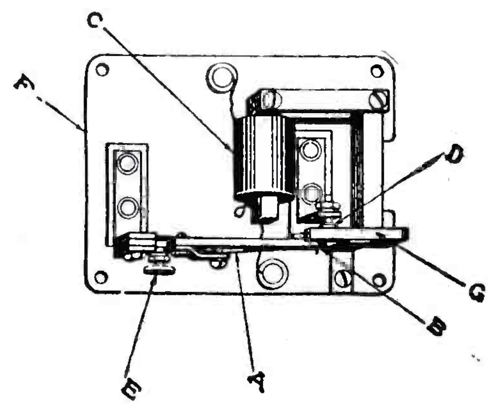
INTERNATIONAL MORSE CODE—This is also known as the *Continental code.* (See *Code.*)

INTERPOLE—A small magnetic pole placed between the main field poles of an electric generator for the purpose of obtaining better commutation. Interpole windings are connected in series with the armature winding and the load. The action of the interpole is exactly analogous to the shifting of the brushes, but when interpoles are used, brush shifting is dispensed with and the magnetic flux is shifted instead.

INTERRUPTED CONTINUOUS WAVES—abbreviation I.C.W.—These waves are obtained by the modulation at audio frequency, during signalling, of an otherwise *continuous wave* (q.v.). (See *Continuous Waves Key Modulated,* also *Continuous Waves Modulated at Audio Frequency.*)

INTERRUPTED WAVES—abbreviation I.W.—Interrupted waves are waves produced by modulation at audio frequency, of otherwise continuous waves. (See *Interrupted Continuous Waves.*)

INTERRUPTER—A combination of an electro-magnet with a vibrating armature which carries a contact point on a piece of spring steel fastened to the armature. When the electro-magnet attracts the armature the contact points are drawn apart thus interrupting the circuit. This action



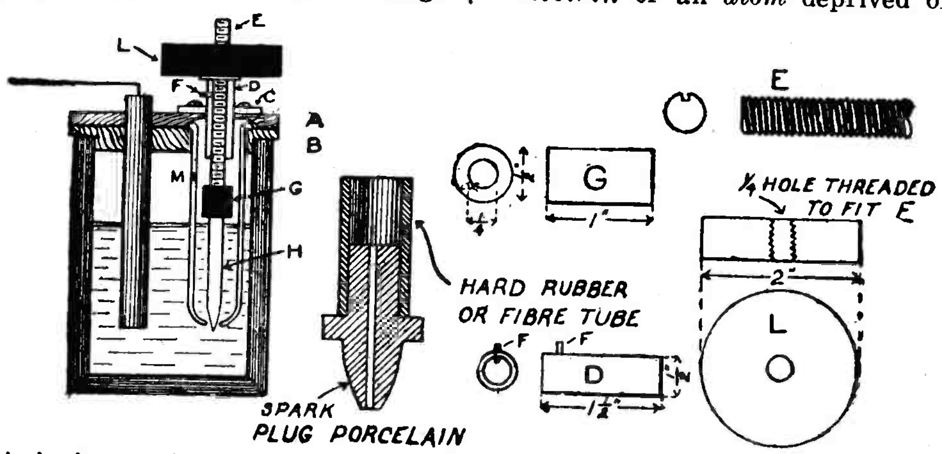
The vibrator panel of an efficient type of mechanical charger.

is only momentary for the spring again brings the circuit back to its original condition. The most important use of the interrupter in radio is as a *rectifying valve* (q.v.) in in mechanical chargers. A typical vibrator panel is shown in the illustration. The armature, A, is the moving element. This carries at its outermost end a heavy Tungsten contact, B, which is caused to vibrate in synchronism with the supply current, by the actuating coil, C. When the current from the transformer is of the correct polarity and value the actuating coil attracts the armature, closing the charging circuit to the battery through the fixed contact, D. The contact end of the armature, A, vibrates within the air gap of the pole shoe, G.

A common use of the *interrupter* is in the ordinary electric bell. In this apparatus, the electromagnet pulls the armature carrying the spring and contact point, breaking contact and opening the circuit. This immediately de-energizes the magnet since its coils are in series with the circuit. The spring tension pulls the armature back to its original position thus again closing the contact. As soon as the contact is closed, the electromagnet is again energized and it again attracts the armature, opening the circuit. This action keeps on indefinitely as long as a difference of potential is maintained at the terminals of the bell.

The *interrupter* is used in the *induction coil* (q.v.) for breaking up the direct current into a series of impulses, thus producing an intermittent current. (See *Circuit Breaker.*)

INTERRUPTER, ELECTROLYTIC—A jar containing diluted sulphuric acid as the electrolyte, a large sheet of lead as one electrode and a platinum needle point introduced through a glass tube as the other electrode. If these electrodes are connected through



A simple type of Wehnelt interrupter. The positive pole of the direct current supply is connected to the brass part C, while the negative pole is attached to the lead rod. L is a fibre handle; E is a threaded rod, which is constructed to fit the threaded handle, but slotted so as to engage the pin F and prevent it from turning; H is a copper or platinum rod; D is a brass tube; M. is the overflow hole in the fibre tube, into the lower end of which a portion of an old spark plug porcelain part has been driven; finally C is a small brass block as shown. This is the adjustable type of Wehnelt interrupter, since the fibre handle can be operated to allow more or less surface to be exposed to the acidulated water.

an inductance to a source of current supply, the current in the circuit will be rapidly interrupted. *Electrolytic interrupters* are suitable for radio transmitters using small spark coils and are also used in X-ray work. (See *Electrolytic Interrupter.*)

INVERTED "L" AERIAL—A flat top aerial (antenna) in which the down lead is tapped off one end of its horizontal span. (See *Length of Aerials, Horizontal Aerial.*)

INVERSE DUPLEX CIRCUIT—A circuit in which the vacuum tubes are utilized both for radio frequency and

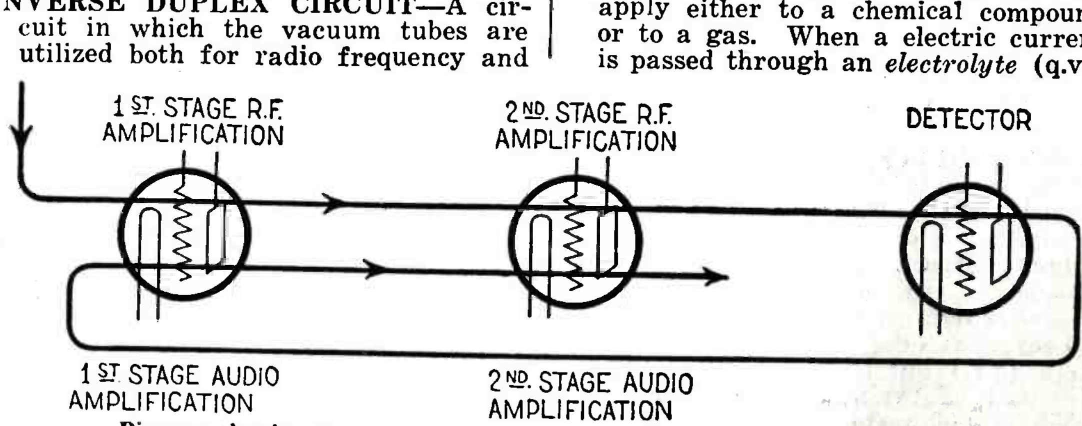


Diagram showing the current path and reflexing in an ordinary reflex circuit.

for audio frequency amplification as in the *reflex* (q.v.) circuit with this important differentiation that the first radio frequency tube is utilized as the second audio frequency tube and the second radio frequency tube is used as the first audio frequency tube. In the ordinary reflex circuit the first radio frequency tube is also the first audio tube and the second radio frequency tube is the second audio tube. The *inverse duplex* circuit has the advantage over the reflex in that the

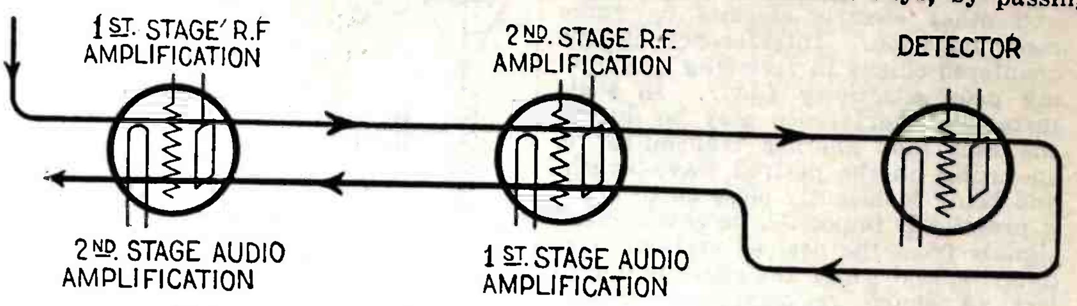


Diagram showing method of reflexing in an inverse duplex circuit.

tubes which are reflexed operate more efficiently since the relatively weak radio currents pass through the same tube as the stronger audio currents and vice-versa. The *inverse duplex circuit* is the invention of David Grimes.

ION—An atom of matter carrying an *electron* or an *atom* deprived of electrons. *Monad-ion* refers to a unit charge, *dyad-ion, divalent* carries two units, the *triad-ion* carries three unit charges. The positive *ion* is an *atom* minus an *electron.* A negative *ion* is an *atom* plus an *electron.* (See *Anion,* also *Cathion, Electron, Electron Theory.*)

IONIZATION—sometimes spelled **IONISATION**—The splitting up of *molecules* into *ions* (q.v.). *Ionization* may apply either to a chemical compound or to a gas. When a electric current is passed through an *electrolyte* (q.v.) the constituents of the electrolyte which are liberated or deposited at the *electrodes* (q.v.) are called *ions* and this process is called *ionization.* Gases at or near atmospheric pressure are normally good insulators. They are said to undergo *ionization* when they are made conductive, that is when they allow the flow of electricity. A gas may be made conductive by passing *X-rays* (q.v.) through it, by the action of ultra-violet light, by subjecting it to radium rays, by passing it close to a flame or hot piece of metal or by forming in it a brush discharge or *corona* (q.v.). Gases which have been made conductive carry current because of their dissociation into *ions,* which carry positive or negative charges of electricity. (See *Electrolysis, Electrolytic Action,* also *Valve Detectors.*)

I.R. DROP.—The voltage drop due to the resistance in a current-carrying conductor. It is directly proportional to the current flowing in the circuit multiplied by the resistance of that circuit.

I^2R LOSS—The power loss in any circuit due to the resistance offered to current flow. It is proportional to the square of the current flowing in the circuit multiplied by the resistance of the circuit. Whenever current flows there is an I^2R loss. This is measured in *watts* (q.v.) or *kilowatts* (q.v.).

IRON PYRITES—Formula FeS_2—This is a mineral, a disulphide of iron, found in large quantities. It was formerly used in radio as a crystal detector mineral but has been almost entirely superseded by vacuum tube detectors. *Iron pyrites* is flaked with shiny spots which have the appearance of gold, and for this reason it is sometimes called "fools gold." *Iron pyrites* is very hard and brittle. The present commercial use of *iron pyrites* is in the production of sulphuric acid. Ferrous Sulphide, FeS, has also been employed in the past as a radio detector. This substance is chemically formed by fusing equivalent quantities of sulphur and iron together. The resultant substance has a smooth surface. (See *Crystal Detector.*)

ISOCHRONOUS—A term applied to two or more oscillatory circuits, meaning that they have the same *natural frequency* (q.v.). Stated in another way, two or more radio frequency circuits are isochronous when they are in electrical *resonance* (q.v.). Circuits are said to be in resonance when they have the same *oscillation constant* (q.v.). The *oscillation constant* of a circuit is equal to the square root of the product of the inductance multiplied by the capacity of that circuit. Circuits having equal oscillation constants will have the same discharge frequency.

ISODYNAMIC LINES—Lines on a magnetic map connecting all parts of the earth where the magnetic intensity is the same. In other words, these lines pass through points of equal horizontal component of the earths magnetic field.

ISOGONIC LINES—Lines on a magnetic map passing through points of equal *declination.* Lines connecting all points of equal variation of the magnetic meridian from the geographic meridian.

ISOTHERMS—Lines on a meteorological chart joining all points having the same temperature.

ISOTROPIC CONDUCTIVITY—Equal conductivity in every direction. A conductor is said to be *isotropic* when it offers the same resistance to the flow of an electric current in every direction through its mass.

J

JACK—An arrangement of spring terminals as shown in the illustrations which can be connected together or separated thus closing or opening circuits through the insertion of a *plug* which also forms a part of the circuit. The *plug* (q.v.) has a tip and

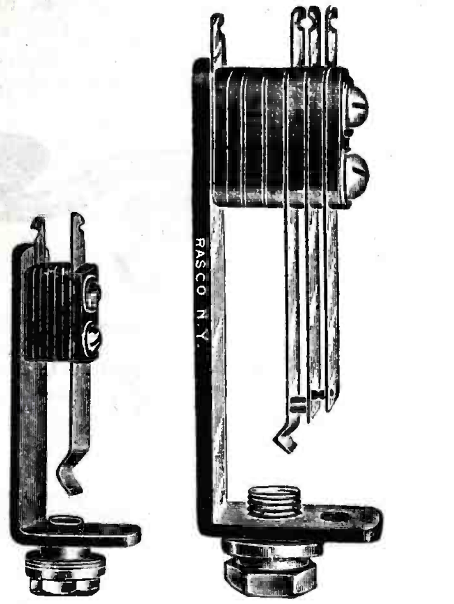


Illustration by courtesy of Radio Specialty Co.

Illustration at left shows one-spring open circuit jack. At the right is a three-spring jack.

a sleeve at one end (that is at the end inserted into the jack) and at the other end it has the two terminals for connecting the apparatus to be cut into the circuit. As an example, the terminals of the plug may be connected to a *loud speaker* (q.v.). The jack in this case is of the *open circuit* variety. That is to say, the springs of the jack are separated when not in use and the circuit is normally open. When the plug is inserted, the tip of the plug makes contact with one spring and the sleeve makes contact with the other thus closing the circuit through the *loud speaker*. In cases where the plug is used to open a circuit, that is to make the *jack* springs break contact with each other, the *jack* is called a *closed circuit jack* since its spring terminals are normally making contact. In cases where the jack is used not only to put the loud speaker in the circuit, but also to act as a filament switch, it is known as an *automatic filament control jack*. Jacks which are used to control a single circuit only, are referred to as *single circuit jacks*. Those controlling two or more circuits simultaneously are known as *multiple circuit jacks*. *Jacks* are usually mounted on a panel so that the plug can be inserted from the outside of the panel while the spring terminals are concealed behind the panel.

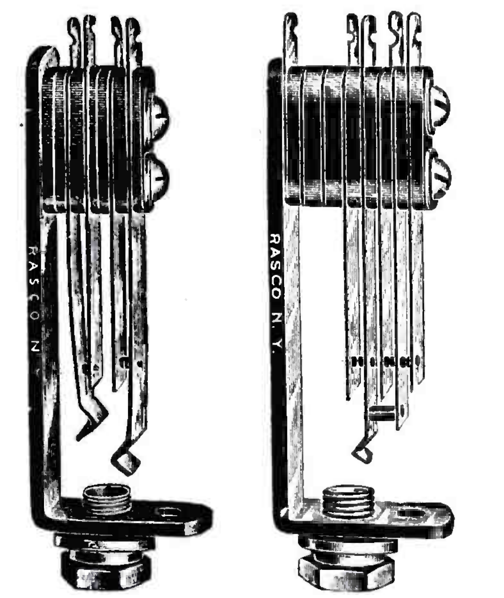


Illustration by courtesy of Radio Specialty Co.

The jack shown at the left is a four-spring double circuit jack. At the right is a five-spring automatic jack.

JAMMING—An expression denoting interference at a receiving station caused by a transmitting station not desired to be heard. More specifically, such interference, prevents the reception of signals, *jamming* the receiving station by drowning out with stronger signals or noises the station desired.

JANET, PAUL—Born in Paris, January 10, 1863. Educated at Lycee Louis-le-Grand and at the high school. He was Professor of Physics at the University of Paris and University of Grenoble. Professor Janet was the author of several important works, and first to make the experiments in electrical resonance successful. The results of these experiments are applied in present day wave meters.

JAR—A unit of electrostatic capacity. It is mainly used in the British Naval service. One *jar* equals 1000 *centimeters* which equals .0011 *microfarads* (q.v.).

JIGGER—A term generally accepted to denote an *oscillation transformer* (q.v.). Used for transforming trains of oscillations from one circuit to another. Dr. J. Erskine Murray refers to high frequency oscillations as *Jigs*. *Jiggers* are also known as *magnetic coupling transformers* (q.v.). They are also sometimes referred to as *auto-jiggers*.

JOULE—symbol J—The practical unit of electrical energy. It is equal to 10^7 *ergs* (q.v.). The *joule* is also the unit of electrical work. It is equal to the work done or the heat generated by a *watt second* (q.v.); or an *ampere* (q.v.) flowing for a second through a resistance of one *ohm* (q.v.). Expressed another way the *joule* is the work done by one *coulomb* (q.v.) flowing under the pressure of one *volt* (q.v.). One *joule* is equal to .73732 foot pounds, or .24 calories (q.v.).

JOULE EFFECT, or JOULEAN HEATING—This occurs when an electric current traverses a resisting conductor. The rate of generation of heat in the conductor by a steady current equals the square of the current multiplied by the resistance.

JOULES EQUIVALENT—The amount of energy equal to a heat unit.

JOULES LAW—The heat produced in an electric circuit is directly proportional to the square of the current, to the resistance of the conductor and to the time of current flow.

K

KANALSTRAHLEN—A German word meaning Rays of Canal. It has been found that by perforating the cathode of a tube producing *cathode rays* (q.v.), faint luminous streaks will come through these perforations in a direction opposite to that of the *cathode* rays. These are called *kanalstrahlen*. They communicate a positive charge to an insulated conductor. In terms of the *electron theory* (q.v.) they are positively charged *ions* (q.v.) The cathode particle is an electron traveling in one direction, and the kanalstrahlen particle traveling in the opposite direction is what remains of the atom which has lost an electron.

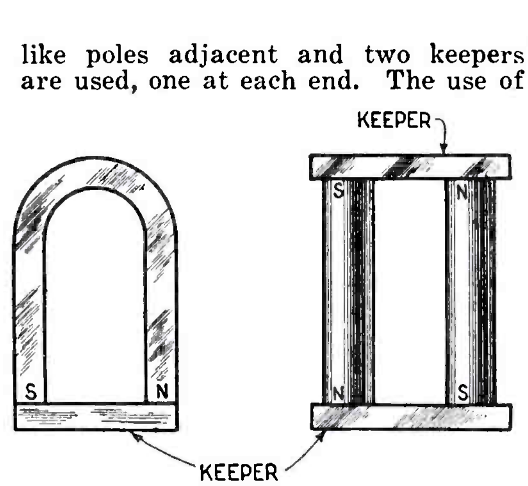
KATHODE—This is a negative *electrode* (q.v.). (See *Cathode*, also *Electrolysis*.)

KATHODE OF CELL—The positive pole of a cell. This is indicated by the plus (+) sign. (See *cell*.)

KATHODE RAYS—The stream of *electrons* (q.v.) thrown off by the *kathode* of a vacuum tube. These produce a glow when they strike the walls forming the tube. They can be deflected by a magnet. (See *Cathode Rays*.)

KATION—The charged particles or *ions* (q.v.) moving in the direction of the *cathode* (q.v.). (See *Cathion*.)

KEEPER—The piece of iron used to close a magnetic circuit to protect it from external disturbances. The term *keeper* is generally used to refer to such a piece of iron when used with a permanent magnet such as a horseshoe magnet. In the case of the piece of iron which closes the magnetic circuit of an electromagnet, this is more often referred to as an *armature* (q.v.). The *keeper* may be used with a straight bar magnet also. In this case, two bar magnets are laid side by side with unlike poles adjacent and two keepers are used, one at each end. The use of



At left is shown keeper used with a horseshoe magnet. At right two keepers are shown used with two bar magnets.

a keeper avoids the demagnetizing effect of *leakage lines* (q.v.). (See *Horseshoe Magnet*.)

KELVIN, LORD (William Thomson) was born at Belfast in 1824; he entered Glasgow University as a student at 10 years of age; graduated at Cambridge in 1845. When only 22 years of age he was called to occupy the chair of natural philosophy in the University of

Lord Kelvin (William Thomson)

Glasgow, a chair which he adorned by his genius for fifty years. He was for 40 years or more regarded as the acknowledged leader of British science on its physical and mathematical side. His great inventions in telegraphy, his magnetic compass and sea sounding apparatus brought him fame and fortune. He was knighted in 1866; and in 1892 was raised to the peerage as Baron Kelvin of Largs; he died on December 17, 1907.

KELVIN'S BRIDGE—A method of measuring low resistance in which the voltage drops, produced by the same current in the resistance under test and in a standard low resistance slide wire are balanced against each other. This *bridge* is a modification of the *Wheatstone Bridge* (q.v.) and was designed by Lord Kelvin to eliminate the errors introduced when measuring resistances much less than one *ohm* (q.v.). In the case of the *Wheatstone Bridge,* such resistances could not be measured accurately on account of the errors produced by the terminal and contact resistances.

KELVIN'S ELECTROSTATIC VOLTMETER—A voltmeter used for measuring high, and in some cases low, alternating current voltages. It is constructed on the principle of an air condenser. One type of electrostatic voltmeter is a high potential instrument having the needle made of a thin aluminum plate suspended vertically on delicate knife edges, with a pointer extending from the upper part to a scale. Two quadrant plates, metallically connected together, are placed on either side of the needle and parallel to its face. These serve as one terminal of the circuit to be measured. The needle acts as the opposite terminal. When there is a difference of potential between the needle and the plates, the needle is deflected out of its neutral position. The value of the scale indications can be changed by hanging calibrated weights on the bottom of the needle.

KENOTRON—A type of *vacuum tube rectifier* (q.v.) in which the vacuum is

Illustration by courtesy of Radio Corp. of America
A kenotron tube.

extremely high and the discharge is carried almost entirely by electrons,

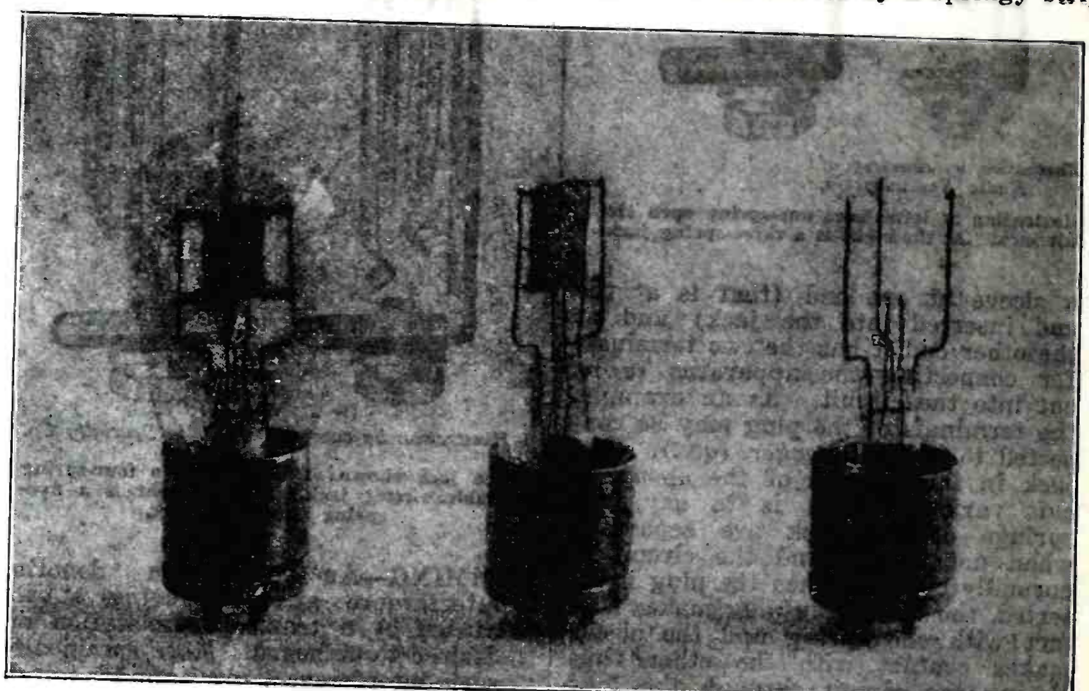


Illustration by courtesy of Radio Corporation of America.
Stages in the construction of a kenotron.

not by gas ions. In these tubes, the plate current is always less than that actually emitted by the hot filament. *Kenotrons* are made sufficiently large to rectify several kilowatts.

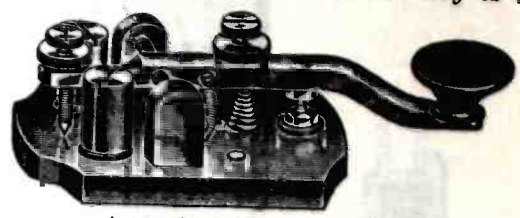
KENNELLY, A. E.—Anglo-American radio expert. Born at Colaba, Bombay, December 17, 1861, he was educated in England, Belgium, France and Italy. In 1875 he became a telegraph operator in the employ of the Eastern Telegraph Company, and in 1886 became the principal electrical assistant to Thomas Alva Edison in the laboratories at Orange, N. J., a post he held until 1892.

He was engineer-in-chief with E. J. Houston, of the Thomson-Houston Company, for the laying of the cables from Vera Cruz to Campeche, 1902. Since 1902 he has been Professor of Electrical Engineering at Harvard University, and since 1914 professor of the same subject at Massachusetts Institute of Technology.

Kennelly has written a large number of books on electricity and radio, and is the author of one of the standard elementary text-books on same. He has written a very large number of papers on radio, and he is an authority on alternating currents.

He is past president of the American Institute of Electrical Engineers, was president in 1916 of the Institute of Radio Engineers, and vice-president of the International Electrical Congresses, held in Paris and Turin. He is a member of many scientific societies, and has received many honorary degrees. In 1921 he was appointed a delegate to the Interallied Radio Technical Committee in Paris.

KEY—A form of switch for conveniently and quickly opening and closing a transmitting circuit, in the act of transmitting signals. An *operating,* or *telegraph,* so-called *Morse key* is a

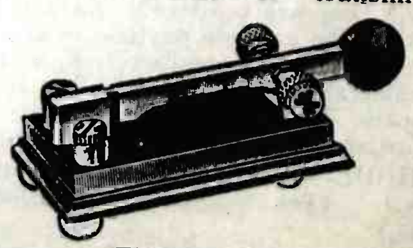


A standard transmitting key.

form of *tapping key* designed especially for the rapid sending of signals by the dot and dash code. A tapping key has one contact carried by a springy strip of metal. In signalling, this key is depressed by the fingers, thus closing the circuit by bringing the contact together with a fixed contact. A standard type of *transmitting key* (q.v.) such as used in sending wireless messages is shown in the illustration. These keys must necessarily be made with larger contacts and of more solid construction than those used to interrupt the smaller currents used in wire telegraphy.

KEY, ANTI-CAPACITY—This is in reality a form of switch. (See *Switch.*)

KEY, HIGH-SPEED—A transmitting



High speed key.

key usually operated from side to side instead of downwards, which makes contact both on the right and on the left side. Such a key requires only half the travel of the ordinary transmitting key and thus facilitates high-speed manual transmission of code signals.

KEY SWITCH—A type of switch adapted for operation by a removable portion in the form of a handle or key. In radio work, *key switches* are sometimes used to lock a receiving set so that it cannot be operated unless the filament circuit is closed by the insertion and turning of the key. Key switches are generally operated by a hollow slotted key, although there are other types on the market. The slot in the key fits a projection or pin on the spindle or shaft of the switch which carries the movable contact. When the key is inserted in the socket and turned, it turns the shaft and brings the movable contact against a fixed contact. *Key switches* are also used for turning on or off electric lights and for locking or unlocking the ignition systems of automobiles.

KILO—Symbol K—A prefix placed before the name of a unit to indicate the multiple 1000 or 10^3. In cases where standard units are too small for convenient use, it is customary to utilize this prefix as, for example, in stating the voltage of a high tension transmission line. This would often be given as 10 kilovolts (K.V.) rather than as 10,000 volts. In like manner, in referring to large amounts of power, it would be preferable to give the amounts in kilowatts rather than in watts. Thus the better way to express 10,000,000 watts would be to divide by 1,000, thus converting to 10,000 kilowatts.

KILOAMPERE-TURN—One kiloampere-turn is equivalent to 1,000 ampere-turns. In referring to the magnetic circuits of electrical machinery it is usual to specify the magnetomotive-forces in kiloampere-turns rather than in ampere-turns. (See *ampere-turns*, also *magnetomotive-force*.)

KILOCYCLE—1,000 *cycles*—Two immediately succeeding half waves of an alternating current constitute a *cycle* (q.v.). The number of *cycles* per second is called the *frequency* (q.v.). In house-lighting and similar circuits, where a comparatively low frequency is used, it is usual to refer to the *frequency* in cycles per second. However, in radio circuits, where currents as high as 300,000,000 cycles per second are used, it is preferable to divide by 1,000, thus converting to *kilocycles*. If the wave-length in meters is known, it is a simple matter to determine the frequency in *kilocycles*. This is calculated as follows: The speed of light is 186,000 miles per second and experiments have shown that this is practically the same as the velocity of electromagnetic or radio waves. Expressed in meters this is equal to 300,000,000 (appx.) meters per second. Assuming that a transmitting station is using a wave-length of 500 meters, the frequency will be obtained in cycles per second by dividing the velocity of the waves by the

KILOCYCLES TO METERS, OR METERS TO KILOCYCLES

Meters	Kilocycles
10	29980
20	14990
30	9994
40	7496
50	5996
60	4997
70	4283
80	3748
90	3331
100	2998
110	2726
120	2499
130	2306
140	2142
150	1999
160	1874
170	1764
180	1666
190	1578
200	1499
210	1428
220	1363
230	1304
240	1249
250	1199
260	1153
270	1110
280	1071
290	1034
300	999.4
310	967.2
320	936.9
330	908.6
340	881.8
350	856.6
360	832.8
370	810.3
380	789.0
390	768.8
400	749.6
410	731.3
420	713.9
430	697.3
440	681.4
450	666.3
460	651.8
470	637.9
480	624.6
490	611.9
500	599.6
510	587.9
520	576.6
530	565.7
540	555.2
550	545.1
560	535.4
570	526.0
580	516.9
590	508.2
600	499.7
610	491.5
620	483.6
630	475.9
640	468.5
650	461.3
660	454.3
670	447.5
680	440.9
690	434.5
700	428.3
710	422.3

Meters	Kilocycles
720	416.4
730	410.7
740	405.2
750	399.8
760	394.5
770	389.4
780	384.4
790	379.5
800	374.8
810	370.2
820	365.6
830	361.2
840	356.9
850	362.7
860	348.6
870	344.6
880	340.7
890	336.9
900	333.1
910	329.5
920	325.9
930	322.4
940	319.0
950	315.6
960	312.3
970	309.1
980	305.9
990	302.8
1000	299.8
1010	296.9
1020	293.9
1030	291.1
1040	288.3
1050	285.5
1060	282.8
1070	280.2
1080	277.6
1090	275.1
1100	272.6
1110	270.1
1120	267.7
1130	265.3
1140	263.0
1150	260.7
1160	258.5
1170	256.3
1180	254.1
1190	252.0
1200	249.9
1210	247.8
1220	245.8
1230	243.8
1240	241.8
1250	239.9
1260	238.0
1270	236.1
1280	234.2
1290	232.4
1300	230.6
1310	228.9
1320	227.1
1330	225.4
1340	223.7
1350	222.1
1360	220.4
1370	218.8
1380	217.3
1390	215.7
1400	214.2
1410	212.6
1420	211.1

Meters	Kilocycles
1430	209.7
1440	208.2
1450	206.8
1460	205.4
1470	204.0
1480	202.6
1490	201.2
1500	199.9
1510	198.6
1520	197.2
1530	196.0
1540	194.7
1550	193.4
1560	192.2
1570	191.0
1580	189.9
1590	188.6
1600	187.4
1610	186.2
1620	185.1
1630	183.9
1640	182.8
1650	181.7
1660	180.6
1670	179.5
1680	178.5
1690	177.4
1700	176.4
1710	175.3
1720	174.3
1730	173.3
1740	172.3
1750	171.3
1760	170.4
1770	169.4
1780	168.4
1790	167.5
1800	166.6
1810	165.6
1820	164.7
1830	163.8
1840	162.9
1850	162.1
1860	161.2
1870	160.3
1880	159.5
1890	158.6
1900	157.8
1910	157.0
1920	156.2
1930	155.3
1940	154.5
1950	153.8
1960	153.0
1970	152.2
1980	151.4
1990	150.7
2000	149.9
2010	149.2
2020	148.4
2030	147.7
2040	147.0
2050	146.3
2060	145.5
2070	144.8
2080	144.1
2090	143.5
2100	142.3
2110	142.1
2120	141.4
2130	140.8

Meters	Kilocycles
2140	140.1
2150	139.5
2160	138.8
2170	138.1
2180	137.5
2190	136.9
2200	136.3
2210	135.7
2220	135.1
2230	134.4
2240	133.8
2250	133.3
2260	132.7
2270	132.1
2280	131.5
2290	130.9
2300	130.4
2310	129.8
2320	129.2
2330	128.7
2340	128.1
2350	127.6
2360	127.0
2370	126.5
2380	126.0
2390	125.4
2400	124.9
2410	124.4
2420	123.9
2430	123.4
2440	122.9
2450	122.4
2460	121.9
2470	121.4
2480	120.9
2490	120.4
2500	119.9
2510	119.5
2520	119.0
2530	118.5
2540	118.0
2550	117.6
2560	117.1
2570	116.7
2580	116.2
2590	115.8
2600	115.3
2610	114.9
2620	114.4
2630	114.0
2640	113.6
2650	113.1
2660	112.7
2670	112.3
2680	111.9
2690	111.5
2700	111.0
2710	110.6
2720	110.2
2730	109.8
2740	109.4
2750	109.0
2760	108.6
2770	108.2
2780	107.8
2790	107.5
2800	107.1
2810	106.7
2820	106.3
2830	105.9
2840	105.6

Meters	Kilocycles
2850	105.2
2860	104.8
2870	104.5
2880	104.1
2890	103.7
2900	103.4
2910	103.0
2920	102.7
2930	102.3
2940	102.0
2950	101.6
2960	101.3
2970	100.9
2980	100.6
2990	100.3
3000	99.94
3020	99.28
3040	98.62
3060	97.98
3080	97.34
3100	96.72
3120	96.10
3140	95.48
3160	94.88
3180	94.28
3200	93.69
3220	93.11
3240	92.54
3260	91.97
3280	91.41
3300	90.86
3320	90.31
3340	89.77
3360	89.23
3380	88.70
3400	88.18
3420	87.67
3440	87.16
3460	86.65
3480	86.16
3500	85.66
3520	85.18
3540	84.70
3560	84.22
3580	83.75
3600	83.28
3620	82.82
3640	82.37
3660	81.92
3680	81.47
3700	81.03
3720	80.60
3740	80.17
3760	79.74
3780	79.32
3800	78.90
3820	78.49
3840	78.08
3860	77.67
3880	77.27
3900	76.88
3920	76.49
3940	76.10
3960	75.71
3980	75.33
4000	74.96
4020	74.58
4040	74.21
4060	73.85
4080	73.49
4100	73.13

Meters	Kilocycles
4120	72.77
4140	72.42
4160	72.07
4180	71.73
4200	71.39
4220	71.05
4240	70.71
4260	70.38
4280	70.05
4300	69.73
4320	69.40
4340	69.08
4360	68.77
4380	68.45
4400	68.14
4420	67.83
4440	67.53
4460	67.22
4480	66.91
4500	66.63
4520	66.33
4540	66.04
4560	65.75
4580	65.46
4600	65.18
4620	64.90
4640	64.62
4660	64.34
4680	64.06
4700	63.79
4720	63.52
4740	63.25
4760	62.99
4780	62.72
4800	62.46
4820	62.20
4840	61.95
4860	61.69
4880	61.44
4900	61.19
4920	60.94
4940	60.69
4960	60.45
4980	60.20
5000	59.96
5050	59.37
5100	58.79
5150	59.22
5200	57.66
5250	47.11
5300	56.75
5350	57.11
5400	55.52
5450	55.01
5500	54.51
5550	54.02
5600	53.54
5650	53.07
5700	52.60
5750	52.14
5800	51.69
5850	51.25
5900	50.82
5950	50.39
6000	49.97
6050	49.56
6100	49.15
6150	48.75
6200	48.36
6250	47.97
6300	47.59
6350	47.22

Meters	Kilocycles
6400	46.85
6450	46.48
6500	46.13
6550	45.77
6600	45.43
6650	45.09
6700	44.75
6750	44.42
6800	55.09
6850	43.77
6900	43.45
6950	43.14
7000	42.83
7050	42.53
7100	42.23
7150	41.93
7200	41.64
7250	41.35
7300	41.07
7350	40.79
7400	40.52
7450	40.24
7500	39.98
7550	39.71
7600	39.45
7650	39.19
7700	38.94
7750	38.69
7800	38.44
7850	38.19
7900	37.95
7950	37.71
8000	37.48
8050	37.25
8100	37.02
8150	36.79
8200	36.56
8250	36.34
8300	36.12
8350	35.91
8400	35.69
8450	35.48
8500	35.27
8550	35.07
8600	34.86
8650	34.66
8700	34.46
8750	34.27
8800	34.07
8850	33.88
8900	33.69
8950	33.50
9000	33.31
9050	33.13
9100	32.95
9150	32.77
9200	32.59
9250	32.41
9300	32.24
9350	32.07
9400	31.90
9450	31.73
9500	31.56
9550	31.39
9600	31.23
9650	31.07
9700	30.91
9750	30.75
9800	30.59
9850	30.44
9900	30.28
9950	30.13

length of a single wave, which in this case would be equal to 300,000,000 (appx.) divided by 500, equalling 600,000 cycles per second or (reduced to kilocycles by dividing by 1,000) 600 kilocycles. On the preceding page is given a chart for converting kilocycles to meters, or meters to kilocycles.

KILOLINE—This is equal to 1,000 *lines of force*, or 1,000 *maxwells* (q.v.). The *maxwell* or the *line of force* is the unit used to measure *magnetic flux*. (See *Line of Force, Maxwell, Magnetic Flux.*)

KILOVOLT — abbreviated K.V. — The kilovolt is equal to 1,000 volts.

KILOVOLT-AMPERE — Abbreviated K.V.A. or kv-a.—The product of the effective volts across the terminals of a circuit by the effective amperes flowing in that circuit, divided by 1,000. Alternators are rated in *kilovolt-amperes* because their load determines the power factor. Thus with a zero *power factor* (q.v.) the *true power* (q.v.) in kilowatts would equal zero even if the alternator were delivering maximum amperes and maximum volts. At 50% power factor the kilowatt capacity would be half that at 100% power factor. On the other hand the kilovolt-ampere capacity remains the same no matter what the power factor.

KILOWATT — abbreviation K.W.—The kilowatt is a unit of electrical power having the value of 1,000 watts. One kilowatt equals 1,000 watts. To reduce the power expressed in kilowatts to watts, it is necessary to multiply the number of kilowatts by 1,000. Most electrical formulas use watts rather than kilowatts. Therefore, in solving such formulas, where the power is given in kilowatts, it is necessary to multiply this by 1,000 before using it in the formula. For example, suppose the power expended in an electrical circuit carrying 100 amperes is 20 kilowatts. The voltage will equal the power in watts divided by the current in amperes. This is $\frac{20 \times 1,000}{100} = 200$ volts. Motors are often rated in kilowatts instead of horsepower. For practical calculations, the horsepower rating of a motor is equivalent to four-thirds of its kilowatt rating. (See *watts.*)

KILOWATT-HOUR—The energy expended when work is done for one hour at the rate of one kilowatt. It is possible to calculate the energy expended in an electrical circuit over a certain period of time, knowing the current in amperes and the resistance of the circuit. Using the following formula the energy expended will be obtained in kilowatt-hours:

$$\text{Work performed or energy expended} = \frac{\text{Current}^2 \times \text{Resistance}^* \times \text{Time}^\dagger}{3,600,000} = \text{kilowatt-hours.}$$

KIMURA SHUNKICHI—Japanese radio authority. Kimura was born in 1866, and educated at the Scientific College of the Tokyo Imperial University, his special study being physics, which he continued to study at Harvard and Yale Universities, United States.

In 1901 Kimura entered the Japanese Navy and first began to study wireless telegraphy, particularly for naval use. In 1906 he was appointed the Japanese delegate to the International Wireless Telegraph Conference, Berlin, and after his retirement from the Navy, 1912, he became the director of the Nippon Radio Telegraph and Telephone Company. Kimura has written largely on radio subjects for various scientific journals.

*Ohms. †Seconds.

KINETICS—That branch of dynamics dealing with forces that produce or change motion. Energy is usually classified either as *potential* or *kinetic.* When energy is available for the production of work it is referred to as potential energy. Energy at work is *kinetic energy* (q.v.). The term *kinetic* refers to motion.

KINETIC ENERGY—The work a body is able to do by reason of its motion. The unit of energy is the *erg*. This unit is also used to measure work. (See *Erg.*) It should be noted that *kinetic energy* is stored in the magnetic field. It requires more energy to start a current in a circuit having great inductance than in one having small inductance. This greater amount of energy is stored in the magnetic field and is returned to the circuit when the current decreases to zero.

KINRAIDY SPARK GAP—A form of *quenched spark gap* (q.v.) consisting of two water-cooled flat terminals close together and between which discharge occurs.

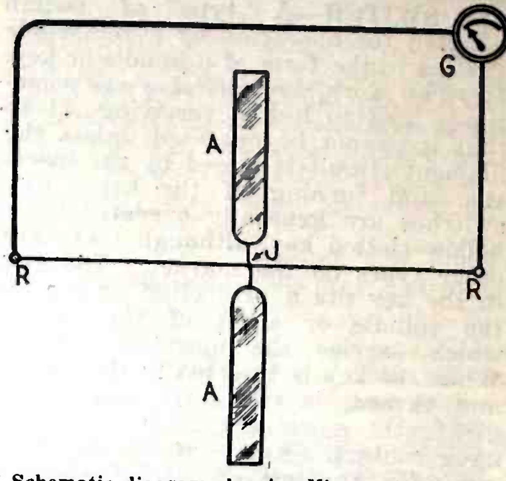
KIRCHOFF'S LAWS—These are two in number. First Law: The sum of the currents flowing to a point, in any electrical circuit, is equal to the sum of the currents flowing away from that point. Second Law: In any closed electrical circuit, the sum of the impressed *electromotive forces* (q.v.) will equal the sum of the *voltage drops* (q.v.). This statement requires modification, in so far as "addition" of voltages is concerned. Voltages are added provided that they are in the same direction, but must be subtracted if in opposite directions. These two laws depend on *Ohm's Law* (q.v.) and constitute a further application of that law to more complicated electrical circuits. In addition to simple electrical circuits, conductors may be connected in various complicated networks, all of which come under the heading of *divided circuits*. By means of *Kirchoff's Laws*, the current in any part of a divided circuit may be found, if the resistances of the various parts, and the electromotive forces are given.

KITES AS AERIAL SUPPORTS—During the early experiments with wireless, kites were successfully employed by Marconi as aerial supports.

KLEIN, RENE HENRI—Anglo-French radio expert. Born at Soults-sous-Foret, France, in 1880, he first became interested in wireless telegraphy in 1908. He was the founder and first honorary secretary of the Wireless Society of London, 1913-20, and became a vice-president of the society. He was one of the inventors with H. L. McMichael of the synthetic galena crystal Radiocite, and has written many articles on wireless subjects.

KNIFE SWITCH—A switch in which the movable arm wedges in between two parallel spring clips. Knife switches may be either of the *single pole* (s.p.) or *double pole* (d.p.) types and also may either be *single throw* (s.t.) or *double throw* (d.t.). Knife switches are often referred to as *Lever* switches They are used on direct current circuits up to 250 volts and on alternating current circuits up to 500 volts (See *Ground Switch; Double Throw Switch.*)

KLEMENCIC THERMAL JUNCTION—A device consisting of two thin sheets of brass, designated in the illustration as A, A. These are 4 inches by 11.8 inches and are placed about 1 inch apart. Soldered to one plate is a fine platinum wire and to the other plate



Schematic diagram showing Klemencic thermal junction.

is a fine platinum-nickel wire. These two wires are connected together at J to form a *thermal junction* (q.v.) and are then led off at right angles and are soldered at their other ends to the leads R, R, of a sensitive *galvanometer* (q.v.). This resonance system is fixed at the focal line of a suitable cylindrical metallic reflector. When electric waves, with the electric force parallel to A A fall on this receiver, electric oscillations between A and A produce heating at the junction J which is the point of contact between the two dissimilar metals. In consequence, the heat developed gives rise to a thermoelectromotive force at the junction and consequently to a current in the galvanometer. This instrument can be used to detect and measure electric waves.

KOEPSEL PERMEAMETER—An instrument used for measuring the *permeability* (q.v.) of an iron or steel bar. In its principle of operation, this device is a movable coil milli-voltmeter in which the permanent magnet is replaced by an electromagnet. The sample to be tested forms a part of this electromagnet. The flux produced in the sample and in the pole pieces of the instrument is measured by a movable coil similar to those used in direct current voltmeters. The coil is supplied with energizing current from a small dry battery. Deflections are indicated by a pointer on a dial, the scale being calibrated directly in magnetic densities.

KOHLRAUSCH'S LAW—This law states that the rate of motion of each atom in a solution undergoing electrolysis for a given liquid is independent of the element with which it may have been in combination.

KOLSTER, FREDERICK A.—American radio authority. Born at Geneva, Switzerland, January 13, 1883, he was educated at Cambridge, Mass., and Harvard University. From 1902-08 he was assistant to J. S. Stone, the radio expert, and from 1909-12 to Dr. Lee de Forest. He was appointed chief of the Radio Section of the Bureau of Standards, a post he held until 1921, when he became research engineer to the Federal Telegraph Company.

Kolster has written a large number of articles on radio subjects, including those on the "Effects of Distributed Capacity in Coils," "Reinforced Harmonics in Radio Transmission," etc. He is the inventor of the Kolster decremeter, of a radio compass, of directional radio systems, etc., and is a member of the American Institute of Radio Engineers.

KOOMANS, NICHOLAS—Dutch radio authority. Born at Delft, 1879, he was educated there as a mechanical and electrical engineer. In 1908 he received his doctorate for his dissertation "Regarding the Influence of Self-Induction in Telephone Conducting Wires." He was one of the founders of and editor of the "Monthly Review of Telephony and Telegraphy," and was also one of the founders of the Dutch Society for Radio Telegraphy. Koomans is a member of the International Electrotechnical Commission and professor in physics and theoretical electrical engineering at the school of the Dutch Post and Telegraph Administration.

KORDA AIR CONDENSER—A variable *condenser* (q.v.) using air as the *dielectric* (q.v.) consisting of two sets of semi-circular plates, one set being connected together and fixed in position and the other set being also connected together but capable of being rotated about a central axis. Rotating the movable plates brings a greater or less area of the two sets of plates into interlapping positions, thus permitting the capacity of the condenser to be varied. This condenser was patented by Korda in Germany in 1893.

KORN, ARTHUR—German radio expert. Born at Breslau, Germany, 1870, Korn was educated at Leipzig and Paris and became professor of physics at the University of Munich, 1903-8, and afterwards professor at the Polytechnical High School, Charlottenburg, Berlin.

Korn is well known for his experiments on and the invention of a method of transmitting photographs by telegraphy, the first photograph being telegraphed from Munich to Berlin in 1907 by his methods. He is the inventor of a system of telautography and wireless phototelegraphy, and the author of a number of standard books on electricity.

L

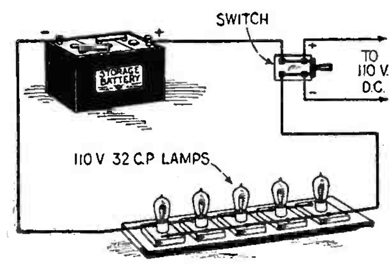
L—The symbol of *inductance* (q.v.) or the *coefficient* of *self-induction.* In general, the co-efficient *L* by which the rate of change of current in any circuit must be multiplied to obtain the value of the self-induced *electromotive force* (q.v.) is called the *coefficient* of *self-induction* or simply the *inductance.* (See *Self-induction, coefficient.*)

LAG—One *alternating current* quantity reaching its maximum at a later time than a second alternating current quantity. As an example,—the current is said to *lag* behind the impressed voltage when maximum current occurs after maximum voltage. In other words, the current and voltage in such an alternating current circuit are out of *phase* (q.v.). In the above example, since the current *lags* behind the voltage, the voltage is said to lead the current. *Inductance* (q.v.) in an alternating current circuit will cause the current to *lag* behind the impressed voltage. *Capacity* (q.v.) in such a circuit will cause the current to *lead* (q.v.) the impressed voltage. The word *lag* may be applied to magnetic quantities as well as electrical quantities. Thus, one magnetic flux may *lag* behind another as in the case of an induction motor where the induced *magnetic flux* (q.v.) *lags* behind the impressed magnetic flux. Another type of magnetic *lag* is the retardation of magnetic effects behind their causes, due to *hysteresis* (q.v.) in the magnetized substance. (See *Lead*, also *Leading Current.*)

LAMINATED—Composed of a number of thin plates, one on top of another. Examples of laminated construction are *laminated brushes, laminated cores laminated conductors,* etc.

LAMINATED CORE—An arrangement of soft iron plates or stampings forming the core of a transformer, or of an armature of a motor or generator. Cores are laminated in this way, principally to reduce *eddy current* (q.v.) losses. In the case of an armature core, this must be laminated parallel to the direction of rotation (in other words, perpendicular to the axis of rotation). Laminations are insulated from each other by means of japan, varnish, shellac or simply rust.

LAMP BANK—A bank of incandescent lamps arranged so that they can be connected in series or parallel. *Lamp banks* are used in laboratories in conjunction with electrical machinery under test. In this case, the lamps act as the *load*, the more lamps being connected in *parallel*, the greater the amount of current being drawn. *Lamp banks* are sometimes connected in *series* in a circuit for the purpose of reducing voltage. An example in this connection is the use of a lamp or bank of lamps in charging a 6-volt storage battery from a 110-volt direct current source. Lamp banks are sometimes called *lamp panels* or *lamp batteries.*

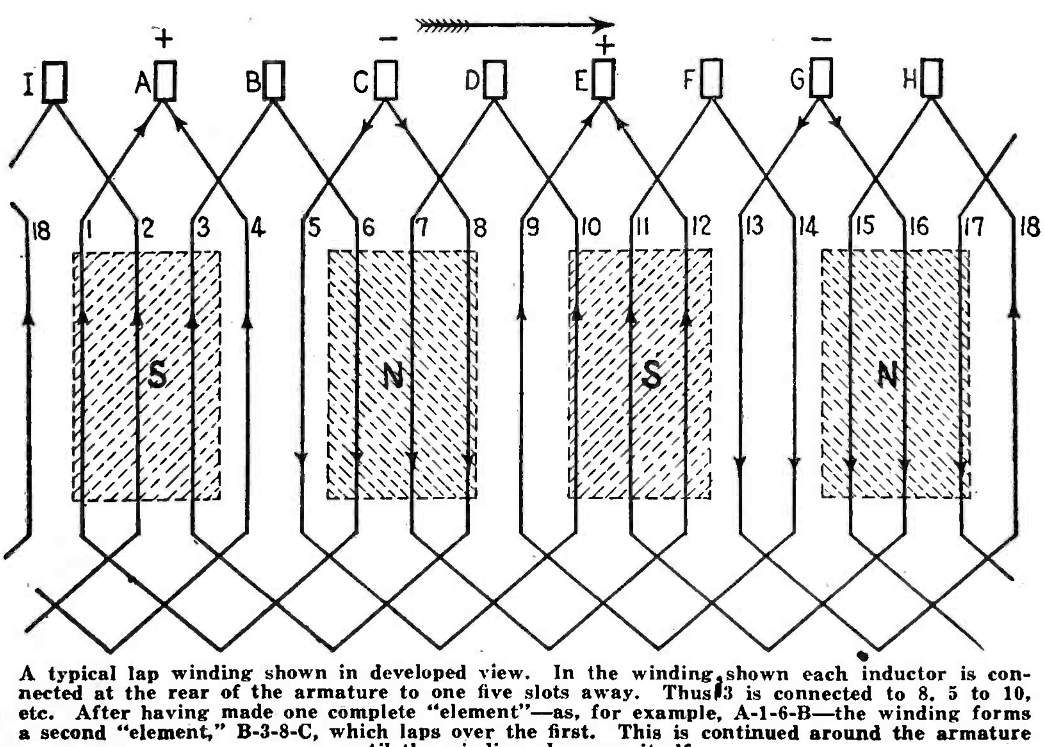


Use of lamp bank in charging storage battery.

LANGMUIR, IRVING—American radio authority. Born at Brooklyn, New York, January 31st, 1881, he was educated at the School of Mines, Columbia University, and was for some time assistant to Professor Nernst at the University of Gottingen. In 1906-9 he was instructor in chemistry at the Stevens Institute of Technology, and in the latter year he became a research assistant to the General Electric Company, at Schenectady. He has carried out a series of brilliant researches on apparatus used in wireless telegraphy and telephony, on electron discharge apparatus, atomic and molecular structure, etc.

Langmuir has paid particular attention to high-vacuum valves, and is the inventor of the Langmuir valve. To him is due the discovery that by treating the tungstic oxide used in the construction of tungsten filaments with certain compounds of thorium the filament becomes thoriated tungsten and the electronic emission is enormously increased. These filaments are the ones used in dull emitter valves, the electrons being given off at comparatively low temperatures Langmuir is the author of many papers to scientific and technical journals, including those on pure electron discharge, thermionic currents in high vacua, etc. He is also well known for his mercury condensation pump for high vacua.

LAP WINDING—An armature winding in which the opposite ends of each coil are connected to adjoining commutator segments. As a result the windings lap back and upon themselves forming loops. *Lap winding* is also called *loop winding, parallel winding* and *multiple winding.* In the elementary form of *lap winding* the method of connection to the commutator bars is as follows: One side of a coil is connected to a commutator bar, and the other side of the coil, which is located 180 electrical degrees (the distance from the center of a north pole to the center of the adjacent south pole) away, has its end connection brought back and soldered to the next adjacent commutator segment. This method of overlapping the ends is continued all the way around the armature until all the slots have been filled and the circuit has been closed on itself. The coils must all be symmetrical. This means that if there is a forward throw of a certain num-



A typical lap winding shown in developed view. In the winding shown each inductor is connected at the rear of the armature to one five slots away. Thus 3 is connected to 8, 5 to 10, etc. After having made one complete "element"—as, for example, A-1-6-B—the winding forms a second "element," B-3-8-C, which laps over the first. This is continued around the armature until the winding closes on itself.

ber of slots on the first coil, all the other coils must have the same forward throw. In like manner all the return throws must be the same. In the *lap wound* generator there are as many paths for the current as there are poles. Hence the name *parallel* or *multiple winding*. This necessitates the use of as many sets of brushes as there are poles. An increased number of paths in parallel means increased current capacity. In the case of a motor, the greater the number of armature paths between brushes, the greater will be the speed, other conditions remaining equal.

LAW OF ELECTROMAGNETIC INDUCTION—Also known as the "*Law of Generator Action*" and as "*Faraday's Law*." If there is relative motion between an electrical conductor and a magnetic field, such that the conductor cuts *flux*, an *electromotive force* (q.v.) will be induced in the conductor. The amount of the induced electromotive force will depend upon the strength of the magnetic field, upon the speed of cutting, upon the length of the conductor cutting the field and upon the direction of motion between the conductor and the field. Thus the stronger the magnetic field, the greater the induced electromotive force. The induced electromotive force will also increase with increased speed of cutting and with increased conductor length. When the conductor cuts the flux at right angles, the induced electromotive force is maximum. If the flux is cut in any other direction, the induced electromotive force will be less. The induced electromotive force decreases from maximum to zero as the angle of cutting decreases from 90 degrees to zero degrees. If a conductor is of such length and moves in such a direction, and at such a speed, as to cut 100,000,000 lines of force in one second, one *volt* (q.v.) will be induced in it. Expressed as an equation the induced electromotive force (in volts) will equal the flux cut (in *lines* or *maxwells*) divided by the product of the time (in seconds) times 100,000,000. This equation refers to the average value of the electromotive force induced in a single conductor. If a number of conductors are used the same electromotive force will be induced in each. If the conductors are so connected that their electromotive forces add up, the total average electromotive force can be found by multiplying the above equation by the number of conductors.

LATOUR, MARIUS—French radio expert. Born in October, 1875, he was educated at the University of Paris and the Ecole Superieure d'Eléctricité, Paris. He was for many years consulting engineer to the General Electric Company, and he specialized in the construction of high-frequency machines. Latour is the designer of the so-called S. F. R. alternator, in which there are a smaller number of stator slots than usual.

During the World War Latour was engaged in research work under General Ferrie, and he invented a system of elimination of the interference produced in telephone lines by neighboring high-tension power lines which has been installed throughout the greater part of France. Latour is the inventor of the now widely used system of high-frequency multiplex telegraphy and telephony, using the three-electrode valve for generation and reception. He is a member of many scientific societies, including the Institute of Radio Engineers, and of the American Institute of Electrical Engineers. He has written many articles on radio for scientific and technical journals, and is the inventor of a great many important radio developments covering practically the whole range of the art.

LEAD—Pronounced LEED—One alternating current quantity reaching its maximum at an earlier time than a second alternating current quantity. Thus in an alternating current circuit, the current is said to *lead* the voltage if maximum current occurs before maximum voltage. If the current reaches its maximum 90 *electrical degrees* ahead of the voltage, current and voltage are said to be in *quadrature* (q.v.) with current *leading* and voltage *lagging*. (See *Degrees, Electrical*, also *Leading Current* and *Lag*.)

LEAD SULPHATE—Formula $PbSO_4$—A white insoluble salt which is found in native form in the ground and which can be formed artificially by adding sulphuric acid to a soluble lead salt. The active elements of a lead *storage battery* (q.v.) consists of (PbO_2) *lead peroxide* on the positive plate and (Pb) *spongy lead* on the negative plate, with dilute *sulphuric acid* (H_2SO_4) as the *electrolyte* (q.v.). The final result, on discharge of such a battery is the formation of *lead sulphate* on both the positive and negative plates. This is a part of the process of producing current. After a normal discharge, the sulphate is finely crystalline and of such nature that it is easily reduced by the current flowing through the battery on charge. If charging is neglected and the battery is allowed to stand in a discharged state, the sulphate gradually ceases to be crystalline. It fills the pores of the plates and finally makes the active material hard and dense, thus lengthening the time required for a charge. A battery in this condition is said to be *sulphated*. If sulphating proceeds too far, it will result in *buckling* of *plates* (q.v.), loss of active material, greatly decreased capacity, lower efficiency and an increased internal resistance. A moderately sulphated battery can be restored by means of a prolonged charging at a moderate rate. In a badly sulphated battery, a number of successive charges and discharges may be necessary.

LEAD-IN—The wire leading from the aerial to the radio apparatus. *Lead-in* wire, as used for receiving sets, is usually rubber covered wire although bare antenna wire can be used provided it is properly insulated from the walls of the building. A poorly insulated lead-in will greatly reduce the efficiency of the finest antenna. (See *Down Lead*.)

LEAD-IN INSULATOR—Any form of insulator used for passing aerial lead-in through window, wall or roof. These insulators are usually made of porcelain, electrose or insulated copper strips. (See *Insulator, lead-in*, also *Window Lead-in*.)

LEADING CURRENT—An alternating current which reaches its maximum value at an earlier time than the voltage. When an inductance is inserted in an alternating current circuit, the self-induced *electromotive force* (q.v.) will combine with the *impressed* electromotive force and the resultant of the two will be the active electromotive force which causes the current flow. The current will always be exactly in *phase* (q.v.) with and proportional to the resultant electromotive force. The induced electromotive force is 90 degrees behind the current and therefore behind the resultant electromotive force, which is in phase with the current. The impressed electromotive force will lead the current and will be higher than the resultant electromotive force by an amount which at each instant is equal to the counter-electromotive force of the inductance. When a condenser is inserted in an alternating current circuit the current will charge the condenser. As the amount of current stored in the condenser increases, the electromotive force of the condenser increases also until the impressed and the condenser electromotive forces are equal. The condenser electromotive force, being a counter pressure, the current flow will cease when the two electromotive forces balance. The current being zero at this point and the condenser electromotive force a maximum, it follows that the condenser electromotive force is 90 degrees in advance of the current and hence of the resultant electromotive force which is in phase with the current. The impressed electromotive force lags behind the current which in this case is a *leading current* and moreover the impressed electromotive force is greater than the resultant electromotive force. It follows that if either capacity or inductance be placed in an alternating current circuit, the phase of the current with respect to the impressed electromotive force will change and the current flow will be reduced. Capacity sets up an electromotive force 90 degrees in advance of current flow, while inductance sets up an electromotive force of 90 degrees behind current flow. These two effects tend to neutralize each other when the proper amount of inductance and capacity are connected in series in a circuit and when they are just equal, no electromotive force other than the impressed is left to act on the circuit, the resultant and impressed electromotive forces are identical and there is no phase displacement. This is said to be a *resonant* (q.v.) circuit. (See *Lead, Lag*, also *Inductive Rise*.)

LEADS—Wires conveying or "leading" current from one point to another in a circuit. The conductors in any system of electrical distribution are referred to as *leads*. Sometimes the term *lead* is applied to the flexible wire or cable conveying current to or from a piece of apparatus.

LEAK—See *Grid Leak*.

LEAKAGE LINES—Also termed *leakage flux*—That part of the total magnetic flux in a magnet, transformer, generator, etc., which fails to complete the closed magnetic circuit and hence is dissipated or wasted. (See *Keeper*.)

LEAKAGE, SURFACE—The flow of electricity across the surface of insulators. Its amount depends on the material and preparation of the surface and the humidity of the atmosphere and is recorded by measuring the surface *resistivity* (q.v.). Several methods are employed to reduce *surface leakage*. Porcelain *insulators* for outdoor use are often of the *petticoat* type so that a portion of the surface of the insulator remains dry during a rain or snowstorm. Another method very generally used in radio work to reduce surface leakage, is the use of corrugated surfaces on insulators. This method increases the length and hence the resistance of the surface across which leakage is likely to take place.

LENGTH OF AERIAL—The distance from the aerial binding post at the instrument to the farthest point of the antenna system, measured to any of its extremities. Only one component wire of a system is taken into consideration even if two, three or four are used. In a *T aerial* only half of the horizontal span must be added to the length of the down lead. In the *umbrella* type, the length of one radial lead is added to the down lead.