HENLEY'S WORKABLE RADIO RECEIVERS

Simple Crystal ~ Two Stage Amplifier
Simple Audion ~ Three Tube Regenerative
Four Tube Radio Frequency Amplifier
Two Tube Reflex ~ Five Tube Neutrodyne
Eight Tube Super Heterodyne ~

by
John E. Anderson
Elmer H. Lewis

The Norman W. Henley Publishing Co.
2 West 45th St., New York

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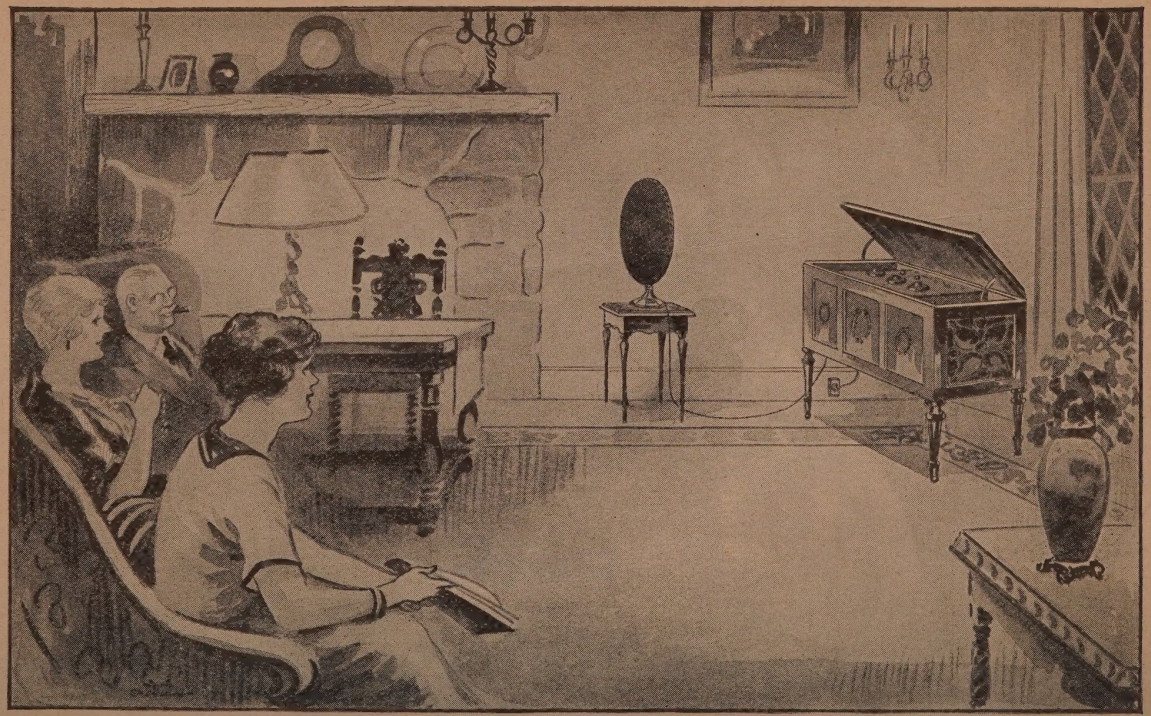

Radio Reception de Luxe in 1925

Up-to-date Loud Speaker—Super-Heterodyne Receiver—Current from Lighting Circuit

HENLEY'S

Workable Radio Receivers

THEIR DESIGN AND CONSTRUCTION

SIMPLE CRYSTAL—SIMPLE AUDION—TWO STAGE AMPLIFIER — DOUBLE CIRCUIT REGENERATIVE — RADIO FREQUENCY AMPLIFIER—REFLEX—NEUTRODYNE—SUPER-HETERODYNE—ULTIMATE RECEIVING SYSTEM—LOW LOSS SHORT WAVE RECEIVER

CONTAINS EXPLICIT INSTRUCTIONS FOR CONSTRUCTION AND OPERATION OF EACH OF THE ABOVE TYPES TOGETHER WITH CIRCUIT DIAGRAMS, PANEL LAYOUTS, APPARATUS ARRANGEMENT AND OTHER NECESSARY INFORMATION EACH TYPE IS THOROUGHLY PRACTICAL AND OPERATIVE

INCLUDING

INSTRUCTIONS ON HOW TO READ CIRCUIT DIAGRAMS, ILLUSTRATIONS OF AND INFORMATION ON MODERN FACTORY BUILT RECEIVERS, IN WHICH SUGGESTIONS MAY BE FOUND FOR AMATEUR CONSTRUCTION, AND A CHAPTER ON THE EFFECT OF LOCATION UPON RADIO RECEPTION

BY

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ELMER H. LEWIS, Assoc. I.R.E., Radio Instructor East Side Y. M. C. A., New York. Author of "A B C of Vacuum Tubes"

Authors of "Henley's 222 Radio Circuit Designs"

Fully Illustrated by Entirely New and Original Engravings

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PREFACE

With the hundreds of new circuits that appear every month in the daily press and magazines it is becoming more and more difficult for the novice to select the type of circuit which is best suited to his needs. It is with the object of offering a receiver to most every type of requirement from the least to the most expensive, and from the simplest selective crystal set to the most sensitive and most selective vacuum tube receiver, that this book is prepared.

The receivers described in this book represent the best of each type in use today. With first-class materials and careful workmanship each one should equal in results any commercial receiver of the same type.

For those who are living in the immediate vicinity of a high power broadcasting station and who desire to use headphones alone for reception it is not necessary to use an expensive or elaborate set; a double circuit tuner with a crystal detector, such as is described will suffice.

If it is desired to advance a step further with the idea of adding an amplifier at a later date for the reception of the local programs on a loud speaker and to eliminate the uncertainty of the adjustment of the crystal, the simple vacuum tube receiver is suggested.

Most people, after having had their radio enthusiasm aroused by listening to local broadcast programs for awhile, like to "reach out" and "pick up" more distant stations. One of the most satisfactory receivers for this purpose is a double circuit regenerative set of the type described in this book. It is sufficiently powerful to operate a loud speaker on local stations and even on stations 1,500 miles away under good receiving conditions, provided a good antenna is used. It is selective enough to tune out the local stations when receiving distant stations operating on frequencies differing by 20 to 30 kilocycles from the local stations. Although this circuit is regen-

erative it is not a serious radiator because it has double circuit tuning with loose coupling. As a means of preventing all radiation from a circuit of this type the "silencer" tube circuit described herein may be used. The proper method of using this is also explained.

Two receivers which have about the same reception range as the double circuit regenerative set are described. The first is a radio frequency amplifier consisting of two stages of radio frequency amplification, a detector and one stage of audio frequency amplification. The second is a two-tube reflex circuit, which is effectively the same as one stage of radio frequency amplification, a detector, and one stage of audio frequency amplification.

For long distance reception through the interference of local stations a sensitive and very selective set is necessary. A neutrodyne type of receiver meets these requiremnts quite satisfactorily. This receiver is ordinarily considerably more sensitive than the circuits previously described and also more selective. A stage of power amplification is added to this circuit in order that a loud speaker may be used for the distant stations.

When the utmost in selectivity and sensitivity is desired without unduly complicating the operation of the set, a superheterodyne receiver is the most satisfactory. Such a receiver is also described.

An outline is given of what might be called the ultimate set. This comprises an eight-tube super-heterodyne receiver, a loud speaker, a storage battery with its charger, a plate current supply set, and a filter for smoothing out the current ripples in the plate supply, all enclosed in a single cabinet and arranged so that the only connection to the set is the antenna and a plug to the alternating current lighting mains.

The construction of a short wave, low loss regenerative receiver which has an untuned antenna or primary circuit is described very completely so that there should be no trouble whatever in building and getting results with it.

A chapter is devoted to the description and illustration of commercial types of receivers so that the best practices in construction and design may be made available to the experimenter. He may embody the best features in the set he is constructing from the directions given. The effect of location on radio reception is discussed to make it clear that location as well as distance from a broadcasting station affect the reception.

Each type of receiver described in this book is based upon the soundest principles of radio design. The directions for construction and operation are explicit and may be successfully followed by any one.

It is the hope of the authors that the variety of receivers described in this book will effectively meet the requirements of all classes of broadcast listeners and experimenters.

THE AUTHORS

OCTOBER, 1924

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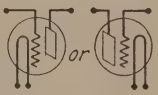
Audion or Three Element Vacuum Tube -- 

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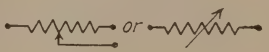
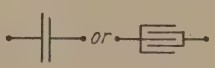
Variable Resistance (or Rheostat) 

Fixed Condenser ..... 

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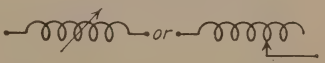
Variable Inductance Coil ..... 

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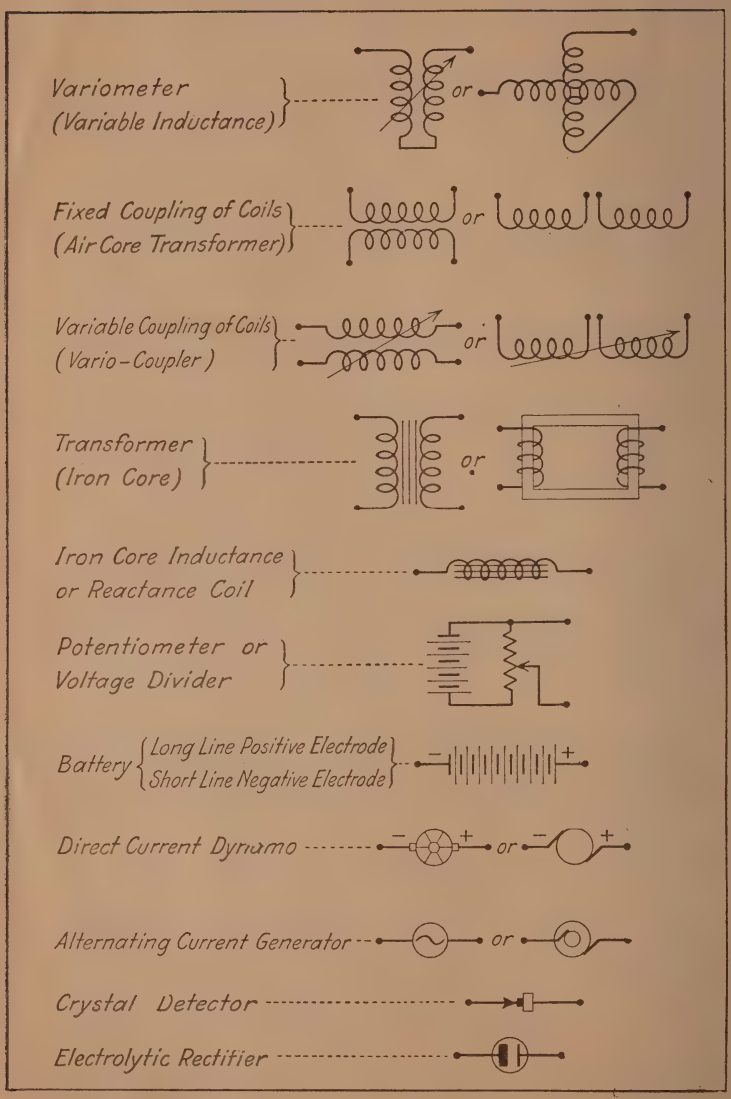

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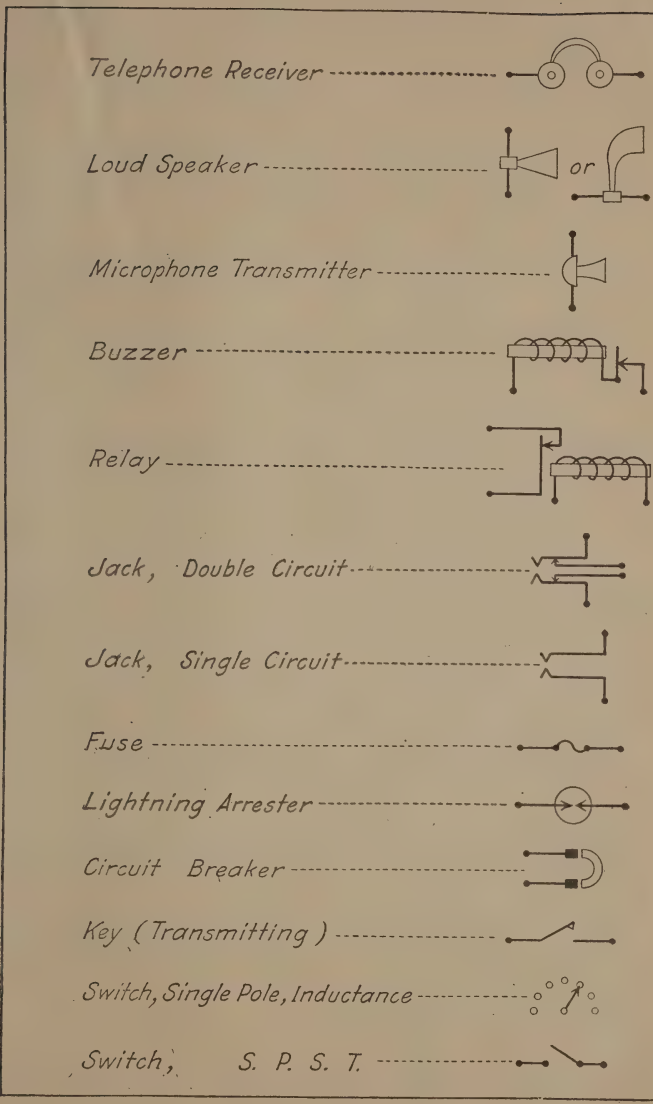

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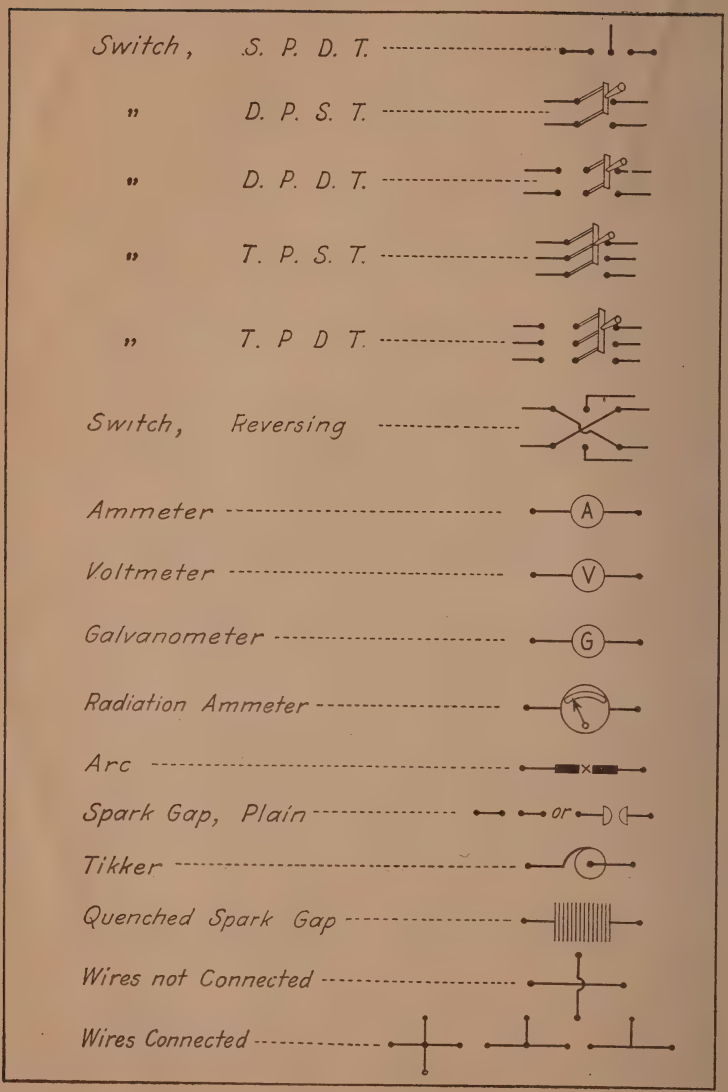


INTERNATIONAL RADIOTELEGRAPHIC CONVENTION

LIST OF ABBREVIATIONS TO BE USED IN RADIO COMMUNICATION

ABBREVIATION	QUESTION.	ANSWER OR NOTICE.
PRB	Do you wish to communicate by means of the International Signal Code?	I wish to communicate by means of the International Signal Code.
QRA	What ship or coast station is that?	This is .....
QRB	What is your distance?	My distance is .....
QRC	What is your true bearing?	My true bearing is.....degrees.
QRD	Where are you bound for?	I am bound for .....
QRF	Where are you bound from?	I am bound from.....
QRG	What line do you belong to?	I belong to the..... Line.
QRH	What is your wave length in meters?	My wave length is..... meters.
QRJ	How many words have you to send?	I have..... words to send.
QRK	How do you receive me?	I am receiving well.
QRL	Are you receiving badly? Shall I send 20? . . . . — . for adjustment?	I am receiving badly. Please send 20. . . . . — . for adjustment.
QRM	Are you being interfered with?	I am being interfered with.
QRN	Are the atmospherics strong?	Atmospherics are very strong.
QRO	Shall I increase power?	Increase power.
QRP	Shall I decrease power?	Decrease power.
QRQ	Shall I send faster?	Send faster.
QRS	Shall I send slower?	Send slower.
QRT	Shall I stop sending?	Stop sending.
QRU		I have nothing for you.
QRV	Are you ready?	I am ready. All right now.
QRW	Are you busy?	I am busy (or: I am busy with.....). Please do not interfere.
QRX	Shall I stand by?	Stand by. I will call you when required.
QRY	When will be my turn?	Your turn will be No. .....
QRZ	Are my signals weak?	Your signals are weak.
QSA	Are my signals strong?	Your signals are strong.
QSB	Is my tone bad? Is my spark bad?	The tone is bad. The spark is bad.
QSC	Is my spacing bad?	Your spacing is bad.
QSD	What is your time?	My time is.....
QSF	Is transmission to be in alternate order or in series?	Transmission will be in alternate order.
QSG		Transmission will be in series of 5 messages.
QSH		Transmission will be in series of 10 messages.
QSJ	What rate shall I collect for.....	Collect.....
QSK	Is the last radiogram canceled?	The last radiogram is canceled.
QSL	Did you get my receipt?	Please acknowledge.
QSM	What is your true course?	My true course is..... degrees.
QSN	Are you in communication with land?	I am not in communication with land.
QSO	Are you in communication with any ship or station (or: with.....)?	I am in communication with.....(through .....).
QSP	Shall I inform.....that you are calling him?	Inform.....that I am calling him.
QSQ	Is.....calling me?	You are being called by .....
QSR	Will you forward the radiogram?	I will forward the radiogram.
QST	Have you received the general call?	General call to all stations.
QSU	Please call me when you have finished (or: at ....o'clock)?	Will call when I have finished.
*QSV	Is public correspondence being handled?	Public correspondence is being handled. Please do not interfere.
QSW	Shall I increase my spark frequency?	Increase your spark frequency.
QSX	Shall I decrease my spark frequency?	Decrease your spark frequency.
QSY	Shall I send on a wave length of.....meters?	Let us change to the wave length of..... meters.
QSZ		Send each word twice. I have difficulty in receiving you.
QTA		Repeat the last radiogram.
QTC	Have you anything to transmit?	I have something to transmit.
QTE	What is my true bearing?	Your true bearing is.....degrees from.....
QTF	What is my position?	Your position is.....latitude..... longitude.

*Public correspondence is any radio work, official or private, handled on commercial wave lengths.

When an abbreviation is followed by a mark of interrogation, it refers to the question indicated for that abbreviation.

INTERNATIONAL MORSE CODE AND CONVENTIONAL SIGNALS

TO BE USED FOR ALL GENERAL PUBLIC SERVICE RADIO COMMUNICATION

1. A dash is equal to three dots.
2. The space between parts of the same letter is equal to one dot.
3. The space between two letters is equal to three dots
4. The space between two words is equal to five dots.

Henley's Workable Radio Receivers

CHAPTER I

INTRODUCTION

Characteristics of Vacuum Tubes—How to Read Circuit Diagrams—Construction of Proper Receiving Antennas—The Reduction of Lightning and Fire Hazards by Proper Protection—To Help the Beginner, a Description of Parts from Which the Set May Be Built Is Given

The designs of the various circuits described in this book are based on the characteristics of the particular vacuum tubes recommended for use in these circuits. If it is desired to use other tubes having different characteristics, it may be necessary to make changes in the designs.

The factors that usually vary are the filament battery voltage, the filament terminal voltage, the plate voltage, and the grid biasing voltage. In order to facilitate the changes that may be necessary due to the use of tubes other than those specified, tables I and II have been included.

It will be observed that the Radio Corporation UV series of tubes are identical with the Cunningham C series of tubes, and hence these may be used interchangeably without altering the design; but if the circuit has been designed for use with WD12 tubes, and it is desired to change to UV201A, it will be necessary to make a change in the filament battery voltage, as the former requires only 1.5 volts, while the latter requires 6 volts. No other changes will be necessary.

If the circuit has been designed for WD12 tubes, and it is desired to use UV199, it will be necessary not only to change the filament battery voltage but also the resistance of the rheostats. The voltage of the battery required for UV199 is from 3 to 4.5 volts, and the resistance in the filament rheostat is about 30 ohms when a single tube is used. The method of

calculating the correct resistance of the rheostats for one or more tubes will be shown below.

The column of Table I which gives the grid bias voltage when the tube is used as an amplifier gives the limiting values corresponding to the plate voltages given in the column just preceding. To get a rough approximation of the correct value of the grid bias voltage for any other plate voltage consider that the best effective value of the plate to filament potential is from 40 to 45 volts. Subtract this value from the actual plate potential applied, and divide by the amplification constant of the tube. For instance, what grid biasing voltage would be required on a UV201A tube when the plate voltage is 120? Subtracting 45 from 120, leaves 75, and then dividing by 8 (the amplification constant of that tube), gives 9. Hence, the proper grid bias is approximately 9 volts.

TABLE I

CHARACTERISTICS OF COMMERCIAL VACUUM TUBES

	Filament Terminal Voltage	Filament Battery Voltage	Filament Current Amps.	Resistance Filament Rheostat Ohms	Plate Voltage		Grid Voltage Amplifier	Amplification Constant
					Det.	Ampl.		
UV 199 C 299	3.0	4.5	0.06	30	20–40.0	45–90	0.5–4.5	6.25
UV 200 C 300	5.0	6.0	1.00	6 vernier	15–22.5			7.0
UV 201 C 301	5.0	6.0	1.00	4–6	40.0	45–90	0.5–6.0	7.0
UV 201A C 301A	5.0	6.0	0.25	6–10	40.0	45–120	0.5–9.0	8.0
WE "N" 215A	1.1	1.5	0.25	4–6	22.5–40.0	45–60	0.5–3.0	6.5
WD 11 } WD 12 }	1.1	1.5	0.25	4–6	22.5–40.0	45–90	0.5–3.0	6.5
VT 1	2.75	4.0	1.1	4	22.5–40.0	45–90	0.5–3.0	6.0
216A	5.5	6.0	1.0	None	22.5–40	45–150	.5–9	6.0

Table II gives the grid biasing voltages for various plate voltages for UV201A, UV199 and WD12 and similar tubes.

TABLE II

GRID BIAS VOLTAGE FOR BEST AMPLIFICATION

Plate Voltage	*Grid Voltage*
UV201A AND C201A	
40	.5 to 1.0
60	1.0 to 3
80	3 to 4.5
100	4.5 to 6
120	6 to 9
150	9 to 13.5
UV199	
40	.5 to 1
60	1 to 3
80-90	4.5 to 6
WD 11 AND 12	
45	0
60	1.5
80-90	3 volts

The proper amount of resistance in the filament rheostat may be obtained from the data given in the second and third columns of Table I. The second column gives the filament terminal voltage and the third the filament battery voltage. The difference between these two is the voltage drop in the resistance of the rheostat. By Ohm's law this is equal to the product of the current flowing through the rheostat and the resistance, or the resistance is equal to the voltage drop in the rheostat divided by the current. For example, consider a UV199 tube. The filament terminal voltage as found in the second column is 3 volts and the filament battery voltage as found in the second column may be 4.5 volts. The difference between these two is 1.5 volts, which is the drop in the rheostat. The current flowing through the rheostat is found in column four to be .06 ampere. Hence the resistance in the rheostat must be $\frac{1.5}{.06} = 25$ ohms. A resistance of

about 30 ohms should be specified, in order that there may be a factor of safety. If two of these tubes are used in parallel with a common rheostat, then the total current flowing through the rheostat is .12 ampere. The required resistance then is $\frac{1.5}{.12} = 12.5$ ohms. A resistance of from 15 to 20 ohms should be specified.

When selecting a rheostat, it is important to make sure that its current carrying capacity is sufficient to carry the current which is to pass through it without undue heating.

How to Read Circuit Diagrams

Since the receivers described must be constructed from directions given in the text and sketches and circuit diagrams, possibly a word or two about how to read circuit diagrams would not be amiss.

The radio novice often finds it difficult to read circuit diagrams even though he understands the meaning of the symbols used. He is unable to visualize the various constituent parts of a circuit from their symbols on the diagram, and therefore he finds it necessary to request a list of parts from those who have had more experience in the subject than he. Sometimes he makes this request because he does not understand the circuit or the symbols involved and sometimes because he lacks confidence in himself, and merely makes the request as a verification of his own conclusions. However, it is a needless waste of time that may easily be avoided.

In this book the various symbols on a circuit diagram are captioned, and the values of the various coils, condensers, and resistances are usually given. If these values are omitted from the diagram they are either understood or else they are given in the text pertaining to the particular receiver.

Suppose we have decided to build the crystal receiver described in this book (Circuit Fig. 27), assuming that the antenna and ground circuits have already been installed. In the

first place, it is seen that there are two symbols for variable condensers—a 43 plate and—a 23 plate condenser. Hence, one of each is needed. Then there is a symbol for a fixed phone condenser of .001 mfd. capacity. Hence we add one of these to the list of parts. There are also two symbols for inductance switches, each having 3 points. Therefore we need 2 inductance switch arms, 6 points, and 4 switch stops. It is also seen that the coupling between the primary coil L_1 and the secondary coil L_2 is variable. Hence, the two coils cannot be wound on the same form. A vario-coupler of some kind is needed. If one can be found on the market that has the proper number of taps and turns on the primary and secondary, it is best to buy it complete. Otherwise, it must be made at home. For this a tube of the proper length and diameter is needed for the primary, and another for the secondary. There is also a symbol for a crystal detector and one for a telephone headset. Hence, one of each of these is included in the list of needed parts.

If it is desired to mount the circuit in a cabinet, additional parts needed will be a panel, a box, four binding posts, three dials, various screws, nuts and some wire.

Hence, the list of parts will be:

1 43 plate condenser	3 dials
1 23 plate condenser	1 crystal detector
1 .001 mica condenser	1 headset
2 switch arms	4 binding posts
6 switch points	1 panel (about 7″ x 10″)
4 switch stops	1 cabinet (about 7″ x 10″ x 8″)
1 vario-coupler (properly tapped)	Various screws, nuts and some wire

It is beyond the scope of this book to discuss the care and use of batteries, the meaning of wave length and frequency, etc. The reader is referred to *Henley's 222 Radio Circuit Designs for further information in regard to these points and for circuit diagrams of all types of receivers and transmitters.

* Published by The Norman W. Henley Publishing Company, 2 West 45th Street, New York City. Price $1.00.

Antennas

It must be remembered in the construction of a radio receiver that the better the antenna, the better the signals for a given type of set will be. It is of more importance to have a good antenna for a simple set than it is for one more complex, as its operation is dependent only on the energy it

Fig. 1. Simple Antenna System (Receiving)

receives from the antenna. In the case of the more complex sets, a slight increase in the amplification often compensates for a poor antenna.

There are many types of antennas in use in radio reception, each of which has its special field of usefulness depending on local conditions.

By far the most common and most satisfactory form is the outdoor, open circuit type. Of this there are several variations, namely the vertical wire, the inverted L, the T, and the umbrella. The vertical wire is the simplest form and is a very satisfactory antenna. It is held up by a wooden mast or other support and very carefully insulated. The inverted L, illustrated in Fig. 1, is the most common form. It consists of a vertical wire, or lead-in, and a horizontal portion. The

total length of this antenna, when used for the reception of broadcast wave lengths from 220 to 550 meters, should not exceed 180 feet. This includes the horizontal top, the lead-in, and the ground wire. The T type of antenna is similar to the inverted L except that the lead-in is taken off the middle of the horizontal portion.

Each of these antennas may consist of single wires or of groups of wires. For instance the vertical wire type may consist of several wires in parallel, either arranged side by side, or in the form of a cylinder. The separate wires are usually spaced 2 feet apart. The horizontal portion of the other types may be made in a similar manner. Not much, if anything is gained by using more than a single wire.

In any of these antennas the strength of the received signals is proportional to the effective height of the antenna. The

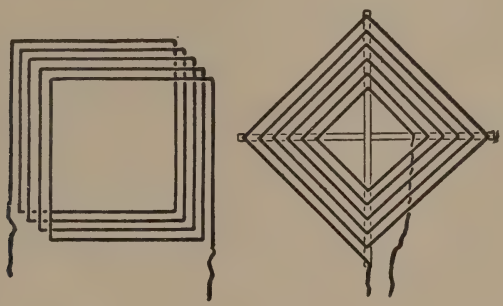


Fig. 2. Loop Antennas

effective height of an antenna is never equal to the actual physical height, but is always less than that. For a given physical height of antenna, the effective height may be increased by lengthening the horizontal portion, although the gain is not rapid.

Another convenient form of antenna is the closed circuit or loop, two forms of which are shown in Fig. 2. Ordinarily this is more selective than any of the other types, and in

addition it is directive; that is, it receives signals from certain directions better than those coming from another. The loop antenna is not as effective as the outdoor antenna, and therefore requires more sensitive receiving equipment. The size of the loop may vary from a few inches to 10 or 15 feet across, the number of wires depending on the cross section. The usual size, however, for broadcast reception is from 2 to 4 feet. The number of turns then may vary from 14 for the smaller size to 6 for the larger. Loop antennas cannot be used to advantage inside steel buildings or in places where the loop would be shielded from the transmitting station by a metallic screen.

When erecting an outdoor antenna it should be placed as high as possible and as far away from walls of buildings,

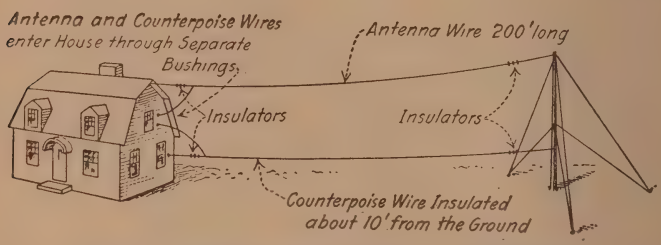


Fig. 3. Antenna System Using Counterpoise

branches of trees, and electric wires of every kind as is practicable. It should be securely fastened to prevent excessive swinging and it should be thoroughly insulated at every contact with its supports.

In some cases, it is desirable to construct a counterpoise beneath the antenna, insulated from the ground and made up of a number of wires—say 10 to 30—having a length at least equal to that of the antenna and a width about half of its length. In Fig. 3 is shown a single wire counterpoise in connection with a single wire antenna. The counterpoise reduces the effective resistance of the antenna circuit and in-

creases the signal strength and selectivity. It has been found in practice by amateurs who are operating experimental stations that the use of a counterpoise has increased their range many times.

The Reduction of Lightning and Fire Hazard

When erecting an outdoor antenna certain precautionary measures should be observed in order that the danger from lightning and fire may be reduced to a minimum. The antenna should not be erected too close to a high tension electric wires, or in such a manner that it will come in contact with such wires if either those wires or the antenna should fall.

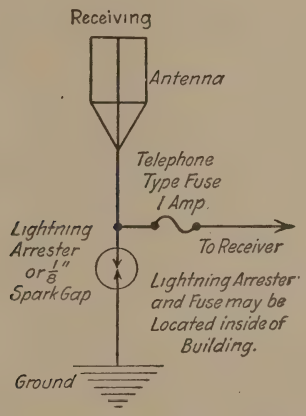


Fig. 4. Lightning Arrester Connections

The receiving antenna should have a lightning arrester connected directly between the antenna terminal and ground, as shown in Fig. 4. A fuse may also be connected in series with the antenna-receiver lead.

Further details on the reduction of fire and lightning hazard will be found in the Regulations of the National Board of Fire Underwriters in this chapter.

NATIONAL FIRE PROTECTION ASSOCIATION

AVAILABLE FOR RELEASE, APRIL 29, 1922

Electrical Committee

DANA PIERCE, Chairman

REPORT OF STANDING COMMITTEE ON SIGNAL SYSTEMS, WIRELESS AND LIGHTNING

COMMITTEE

WILLIAM S. BOYD, CHAIRMAN
175 West Jackson Boulevard, Chicago, Ill.

J. M. CURTIN — F. A. RAYMOND
C. W. MITCHELL — RALPH SWEETLAND

To Electrical Inspectors:

The following report of the Technical Sub-Committee on Radio Equipment (National Electrical Code, Rule 86) has been approved by the Standing Committee on Signal Systems, Wireless and Lightning, and in co-operation with Mr. Dana Pierce, Chairman of the Electrical Committee, is promulgated in order to produce field experience to substantiate the wisdom of the proposed rules before final submission to the Electrical Committee for incorporation into the 1923 edition of the National Electrical Code. Neither the Standing Committee nor the Electrical Committee has authority to suspend or replace the present Rule 86 of the National Electrical Code, but this report is issued by the authority granted to the Chairman of the Standing Committee and the Chairman of the Electrical Committee for the information of inspection departments having jurisdiction over the application of the Code.

Suggestions for improvements in these proposed rules should be sent to Mr. William S. Boyd, Chairman, 175 W. Jackson Boulevard, Chicago, not later than September 1, 1922.

(Signed) DANA PIERCE, Chairman,
Electrical Committee, N. F. P. A.

(Signed) WILLIAM S. BOYD, *Chairman,*
Standing Committee on Signal Systems, Wireless and Lightning.

CORRECTED FINAL REPORT

The following requirements are submitted as proposed revisions of Rule 86, National Electrical Code:

RULE 86, RADIO EQUIPMENT

NOTE: These rules do not apply to Radio Equipment installed on ship-board.

In setting up radio equipment all wiring pertaining thereto must conform to the general requirements of this code for the class of work installed and the following additional specifications:

FOR RECEIVING STATIONS ONLY

ANTENNA

a. Antennas outside of buildings shall not cross over or under electric light or power wires of any circuit of more than six hundred (600) volts or railway trolley or feeder wires nor shall it be so located that a failure of either antenna or of the above-mentioned electric light or power wires can result in a contact between the antenna and such electric light or power wires.

Antennas shall be constructed and installed in a strong and durable manner and shall be so located as to prevent accidental contact with light and power wires by sagging or swinging.

Splices and joints in the antenna span, unless made with approved clamps or splicing devices, shall be soldered.

Antennas installed inside of buildings are not covered by the above specifications.

LEAD-IN WIRES

b. Lead-in wires shall be of copper, approved copper-clad steel or other approved metal which will not corrode excessively

and in no case shall they be smaller than No. 14 B. & S. gauge except that approved copper-clad steel not less than No. 17 B. & S. gauge may be used.

Lead-in wires on the outside of buildings shall not come nearer than four (4) inches to electric light and power wires unless separated therefrom by a continuous and firmly fixed non-conductor that will maintain permanent separation. The non-conductor shall be in addition to any insulation on the wire.

Lead-in wires shall enter building through a non-combustible, non-absorptive insulating bushing.

PROTECTIVE DEVICE

c. Each lead-in wire shall be provided with an approved protective device properly connected and located (inside or outside the building) as near as practicable to the point where the wire enters the building. The protector shall not be placed in the immediate vicinity of easily ignitible stuff, or where exposed to inflammable gases or dust or flyings of combustible materials.

The protective device shall be an approved lightning arrester which will operate at a potential of five hundred (500) volts or less.

The use of an antenna grounding switch is desirable, but does not obviate the necessity for the approved protective device required in this section. The antenna grounding switch if installed shall, in its closed position, form a shunt around the protective device.

PROTECTIVE GROUND WIRE

d. The ground wire may be bare or insulated and shall be of copper or approved copper-clad steel. If of copper the ground wire shall be not smaller than No. 14 B. & S. gauge, and if of approved copper-clad steel it shall not be smaller than No. 17 B. & S. gauge. The ground wire shall be run in as straight a line as possible to a good permanent ground. Prefer-

ence shall be given to water piping. Gas piping shall not be used for grounding protective devices. Other permissible grounds are grounded steel frames of buildings or other grounded metallic work in the building and artificial grounds such as driven pipes, plates, cones, etc.

The ground wire shall be protected against mechanical injury. An approved ground clamp shall be used wherever the ground wire is connected to pipes or piping.

WIRES INSIDE BUILDINGS

e. Wires inside buildings shall be securely fastened in a workmanlike manner and shall not come nearer than two (2) inches to any electric light or power wire unless separated therefrom by some continuous and firmly fixed non-conductor making a permanent separation. This non-conductor shall be in addition to any regular insulation on the wire. Porcelain tubing or approved flexible tubing may be used for encasing wires to comply with this rule.

RECEIVING EQUIPMENT GROUND WIRE

f. The ground conductor may be bare or insulated and shall be of copper, approved copper-clad steel or other approved metal which will not corrode excessively under existing conditions, and in no case shall the ground wire be less than No. 14 B. & S. gauge except that approved copper-clad steel not less than No. 17 B. & S. gauge may be used.

The ground wire may be run inside or outside of building. When receiving equipment ground wire is run in full compliance with rules for Protective Ground Wire, in Section *d*, it may be used as the ground conductor for the protective device.

FOR TRANSMITTING STATIONS

ANTENNA

g. Antennas outside of buildings shall not cross over or under electric light or power wires of any circuit of more than

six hundred (600) volts or railway trolley, or feeder wires nor shall it be so located that a failure of either the antenna or of the above-mentioned electric light or power wires can result in a contact between the antenna and such electric light or power wires.

Antennas shall be constructed and installed in a strong and durable manner and shall be so located as to prevent accidental contact with light and power wires by sagging or swinging.

Splices and joints in the antenna span shall, unless made with approved clamps or splicing devices, be soldered.

LEAD-IN WIRES

h. Lead-in wires shall be of copper, approved copper-clad steel or other metal which will not corrode excessively and in no case shall they be smaller than No. 14 B. & S. gauge.

Antenna and counterpoise conductors and wires leading therefrom to ground switch, where attached to buildings, must be firmly mounted five (5) inches clear of the surface of the building, on non-absorptive insulating supports such as treated wood pins or brackets equipped with insulators having not less than five (5) inch creepage and air gap distance to inflammable or conducting material. Where desired approved suspension type insulators may be used.

i. In passing the antenna or counterpoise lead-in into the building a tube or bushing of non-absorptive insulating material shall be used and shall be installed so as to have a creepage and air-gap distance of at least five (5) inches to any extraneous body. If porcelain or other fragile material is used it shall be installed so as to be protected from mechanical injury. A drilled window pane may be used in place of bushing provided five (5) inch creepage and air-gap distance is maintained.

PROTECTIVE GROUNDING SWITCH

j. A double-throw knife switch having a break distance of four (4) inches and a blade not less than one-eighth (⅛) inch by one-half (½) inch shall be used to join the antenna and counterpoise lead-ins to the ground conductor. The switch may be located inside or outside the building. The base of the switch shall be of non-absorptive insulating material. Slate base switches are not recommended. This switch must be so mounted that its current-carrying parts will be at least five (5) inches clear of the building wall or other conductors and located preferably in the most direct line between the lead-in conductors and the point where ground connection is made. The conductor from grounding switch to ground connection must be securely supported.

PROTECTIVE GROUND WIRE

k. Antenna and counterpoise conductors must be effectively and permanently grounded at all times when station is not in actual operation (unattended) by a conductor at least as large as the lead-in, and in no case shall it be smaller than No. 14 B. & S. gauge copper or approved copper-clad steel. This ground wire need not be insulated or mounted on insulating supports. The ground wire shall be run in as straight a line as possible to a good permanent ground. Preference shall be given to water piping. Gas piping shall not be used for the ground connection. Other permissible grounds are the grounded steel frames of buildings and other grounded metal work in buildings and artificial grounding devices such as driven pipes, plates, cones, etc. The ground wire shall be protected against mechanical injury. An approved ground clamp shall be used wherever the ground wire is connected to pipes or piping.

OPERATING GROUND WIRE

l. The radio operating ground conductor shall be of copper strip not less than three-eighths (⅜) inch wire by one-sixty-

fourth (1-64) inch thick, or of copper or approved copper-clad steel having a periphery or girth (around the outside) of at least three-quarters (¾) inch (for example, a No. 2 B. & S. gauge wire) and shall be firmly secured in place throughout its length. The radio operating ground conductor shall be protected and supported similar to the lead-in conductors.

OPERATING GROUND

m. The operating ground conductor shall be connected to a good permanent ground. Preference shall be given to water piping. Gas piping shall not be used for ground connections. Other permissible grounds are grounded steel frames of buildings or other grounded metal work in the building and artificial grounding devices such as driven pipes, plates, cones, etc.

POWER FROM STREET MAINS

n. When the current supply is obtained directly from street mains, the circuit shall be installed in approved metal conduit, armored cable or metal raceways.

If lead covered wire is used, it shall be protected throughout its length in approved metal conduit or metal raceways.

PROTECTION FROM SURGES, ETC.

o. In order to protect the supply system from high-potential surges and kick-backs there must be installed in the supply line as near as possible to each radio-transformer, rotary spark-gap, motor in generator sets and other auxiliary apparatus one of the following:

1. Two condensers, each of not less than one-half (½) microfarad capacity and capable of withstanding six hundred (600) volt test, in series across the line and mid-point between condensers grounded; across (in parallel with) each of these condensers shall be connected a shunting fixed spark-gap capable of not more than one-thirty-second (1-32) inch separation.

2. Two vacuum tube type protectors in series across the line with the mid-point grounded.

3. Non-inductively wound resistors connected across the line with mid-point grounded.

4. Electrolytic lightning arresters such as the aluminum cell type.

In no case shall the ground wire of surge and kick-back protective devices be run in parallel with the operating ground wire when within a distance of thirty (30) feet.

The ground wire of the surge and kick-back protective devices shall not be connected to the operating ground or ground wire.

SUITABLE DEVICES

p. Transformers, voltage reducers, keys and other devices employed shall be of types suitable for radio operation.

Parts from Which Your Set May Be Built

Coils, Condensers and Accessories

Types of Coils and Condensers Used in Radio Equipment; What to Avoid in the Construction or Purchase of Coils and Condensers

A detailed discussion of the many types of coils and condensers that are used in radio circuits is beyond the scope of this book. Hence only a few typical examples of these essentials are illustrated, and this is done with the view of giving the novice and experimenter a concrete representation of the various parts used in the circuits discussed. A few

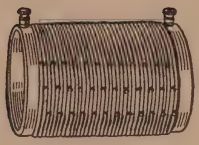


Fig. 5. Solenoidal Inductance Coil

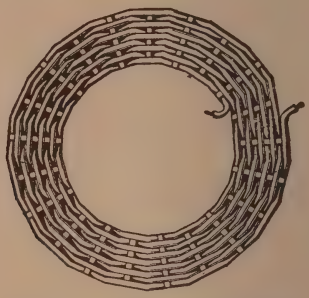


Fig. 6. Spider Web Coil

suggestions regarding their good and undesirable qualities are also made in order that the novice may have a general guide in the construction or purchase of them. For the same reasons a few other pieces of radio apparatus are iluustrated in this chapter.

Coils

Figure 5 represents a single layer, air core solenoidal inductance coil. This type of coil is most frequently used for the shorter and broadcasting wave lengths, and it is ordinarily considered to be the most efficient within this range.

FIGURE 6 shows the so-called spider-web, or stagger-wound coil—a type which is useful in circuits where a flat coil is desirable. It is an efficient type of coil, perhaps not so good as the solenoidal coil, but on account of the staggered winding

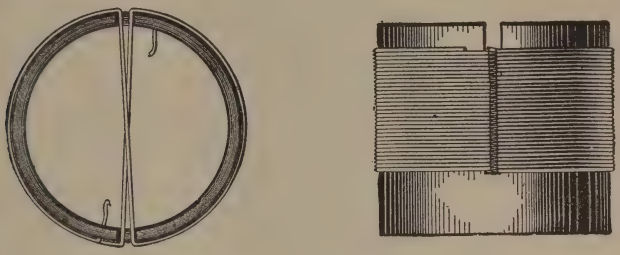


Fig. 7. Figure of Eight Coil

it has a very low distributed capacity and this is an advantage at high frequencies (i.e. short waves).

FIGURE 7 illustrates the Figure of Eight coil (sometimes called a D coil). The advantage of this coil is that its external magnetic field is very small, and it may therefore be used where it is desirable to reduce to a minimum stray magnetic coupling with other coils. Two of these coils, placed end to end, and mounted so that one may be revolved about their common axis, form a very convenient vario-coupler. The coupling may be varied from minimum to maximum by merely turning one of the coils through an angle of 90°. If two of these coils are connected in series, and mounted in a similar manner, they form a very convenient variometer, the inductance of which may be varied from minimum to maximum by turning one of the coils through an angle of 180°.

FIGURE 8 shows a cross section of two bank-wound coils, illustrating the method of putting on the successive turns. One is a two-layer bank-wound coil, and the other a three-layer bank-wound coil. The advantage of banked winding in coils is that a comparatively large inductance may be obtained with a minimum of distributed capacity.

FIGURES 9 and 10 show duo-lateral and honeycomb coils, which are convenient to use where compact inductances are desired,

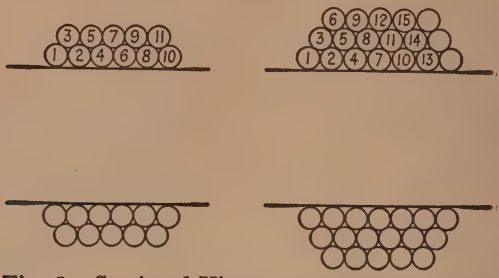


Fig. 8. Sectional View of Bank Wound Coils

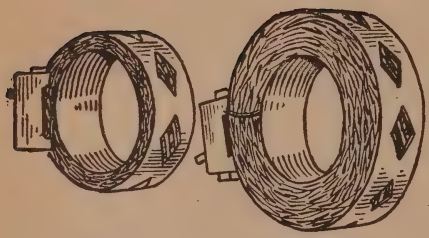


Fig. 9. Honeycomb Coils

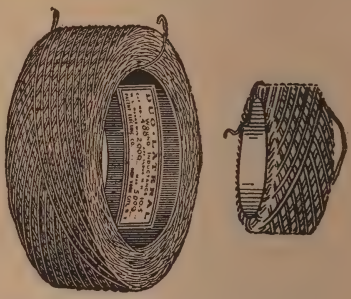


Fig. 10. Duo-Lateral Coils

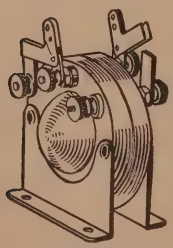


Fig. 11. Radio Frequency Transformer

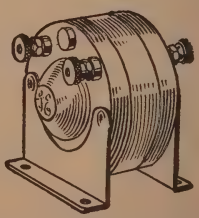


Fig. 12. Radio Frequency Transformer

such as in medium wave radio tuners, and radio-frequency choke coils. The advantage of these types of winding is a very low distributed capacity.

FIGURES 11 and 12 show typical radio-frequency transformers for short and medium wave purposes. Fig. 13 illustrates a typical audio-frequency transformer.

Fig. 13. Typical Audio Frequency Transformer

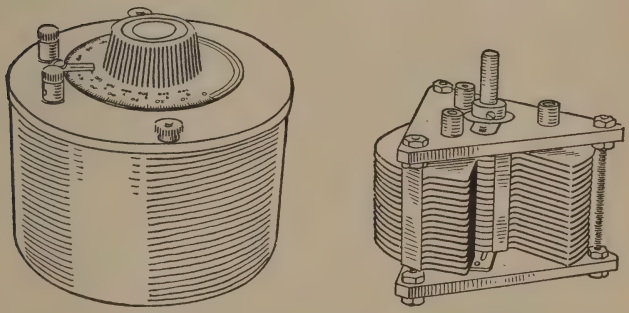


Fig. 14. Variable Air Condenser

Condensers

FIGURE 14 illustrates one of the best variable air condensers that may be obtained on the market. The figure to the right shows a panel mounting type as used in radio receiving sets, while the figure to the left illustrates the same condenser enclosed in a case as it is used for laboratory work and measurement purposes.

FIGURE 15 illustrates a self-balanced variable air condenser which is adapted for use in radio circuits.

FIGURE 16 illustrates a more common type of variable air condenser.

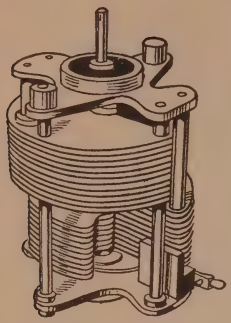


Fig. 15. Balanced Variable Air Condenser

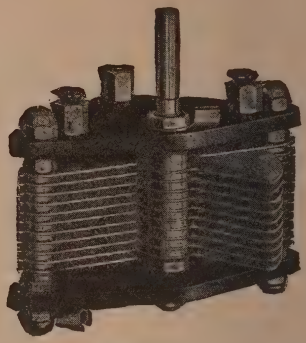
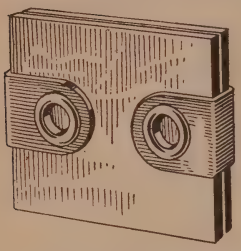


Fig. 16. Typical Variable Air Condenser



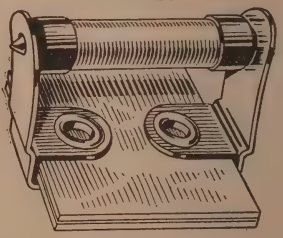


Fig. 17. Postage Stamp Type Condensers and Grid Leak

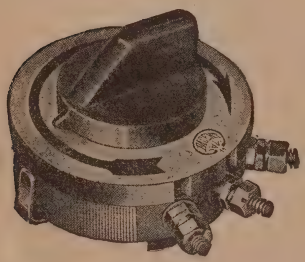


Fig. 18. Potentiometer or Rheostat

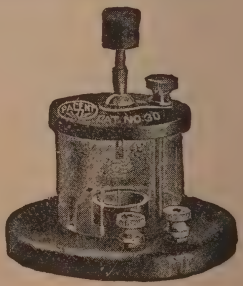


Fig. 19. Crystal Detector Mounting

FIGURE 17 is a type of fixed condenser which is used in radio circuits for stopping and by-pass purposes.

Other Radio Essentials

FIGURE 18 illustrates a typical potentiometer or rheostat. This particular instrument is so arranged that when it is used as a rheostat the connections may be so made that the current

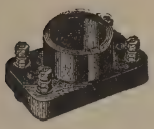


Fig. 20. Small Vacuum Tube Socket (For UV199 Tube)

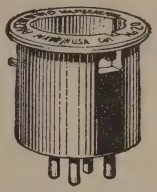


Fig. 21. Vacuum Tube Socket Adapter

Fig. 22. Telephone Plug

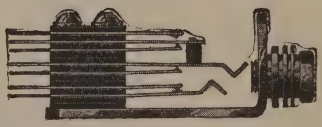


Fig. 23. Jack for Multi-Circuit Filament Control, etc.

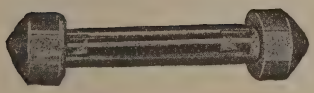


Fig. 24. Grid Leak Resistance

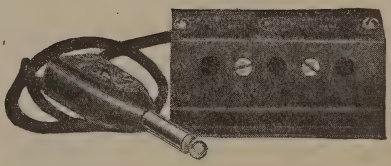


Fig. 25. Multi-jack and Plug

increases as the rheostat is turned toward the right, either when it is mounted on a board or on a panel.

FIGURE 19 is a good type of crystal detector mounting.

FIGURE 20 shows a socket adapted for the small UV199 vacuum tubes.

FIGURE 21 shows a vacuum tube socket adapter which makes it possible to use small tubes in a standard socket.

FIGURE 22 illustrates a telephone plug.

FIGURE 23 illustrates a jack. This particular jack is a double circuit filament control jack.

Fig. 26. Telephone Receiver Headset

FIGURE 24 is a typical tubular grid leak. The resistance unit of this leak is enclosed in a moisture-proof glass tube to prevent any variations in the value of the resistance.

FIGURE 25 shows a telephone plug with the multi-jack.

FIGURE 26 is a typical headset.

CHAPTER II

Simple Crystal Receiver

Description of a Simple Crystal Receiver of the Best Type Is Given, Together with Lists of Apparatus Needed and the Necessary Drawings for Its Construction—A Few Paragraphs Are Devoted Also to the Operation of the Set

There are thousands of people who desire to avail themselves of the benefits to be derived from the possession of a radio receiving set, but who hesitate to purchase one on account of the expense involved. If one lives in the immediate vicinity of a powerful radio broadcasting station the question of expense need not worry him, as a very satisfactory crystal receiver may be constructed at home from parts purchased at a reasonable price. Such a receiver may be made sufficiently selective to tune in the desired local station to the satisfactory exclusion of all others operating within the reception radius of the set, unless a very powerful station is located within a mile or two. In this case, an inexpensive wave trap may be used to exclude this station when it is desired to receive one of the more distant ones.

A good wave trap may be made by connecting a 100 microhenry inductance coil across an ordinary 43 plate variable condenser. This inductance may be obtained approximately by winding 40 turns of No. 18 double cotton covered wire on a cardboard or composition tube 3 inches in diameter. The wave trap should be connected in series with the antenna lead; that is, the antenna lead should be connected to one side of the wave trap coil and condenser, and the antenna binding post on the receiver to the other side. To eliminate a disturbing station this wave trap is tuned exactly to the wave length of that station. Tuning should be done carefully as it is

extremely sharp. If the set is then retuned it will be possible to receive weaker and more distant stations without interference from the local station. It may be well to bring out taps on the wave trap coil at about the 25th and 20th turns, and use these for the shorter wave lengths because a wave trap connected in this manner will work best when the inductance of the coil is small, and the capacity of the condenser large.

The wave trap may also be inductively coupled to the antenna and this method is often preferred. In this case a small coupling coil of about 12 turns of wire on a tube which just fits inside the wave trap coil of 40 turns, metioned above, is employed. Instead of connecting the antenna lead to one side of the 40 turn coil and condenser it is connected to one end of the small 12 turn coil. Taps should be brought out from the 12 turn coil at the 4th and 8th turns. The antenna binding post on the receiver is then connected to the contact arm or lever of the tap switch instead of to the other end of the 40 turn coil and condenser. The 12 turn coil is then in series with the antenna and antenna post on the receiver and the coupling of this coil to the 40 turn coil (or wave trap coil) is varied by adjusting the tap switch. Maximum coupling is had when the switch includes all of the 12 turn coil in the antenna circuit and minimum coupling is had when only 4 turns are included. When the coupling is maximum the wave trap will blank out signals which are too strong, to be blanked out with minimum or medium coupling.

Description of Receiver

The Circuit. The circuit diagram of a satisfactory and selective crystal receiver is shown in Fig. 27. It is a double circuit tuner in which both the primary or antenna circuit and the secondary are tuned. Approximate tuning of the primary is obtained by varying the inductance of the primary coil L_1 and fine tuning by varying the capacity of condenser C_1. Tuning of the secondary circuit is done with condenser C_2.

Most crystal detector circuits are not selective, due to the effect of the crystal and telephones on the tuned circuit. There are many ways of improving the selectivity. In Fig. 27, one method is shown. A switch which is connected to one side of the telephone is used to connect the crystal and phones across

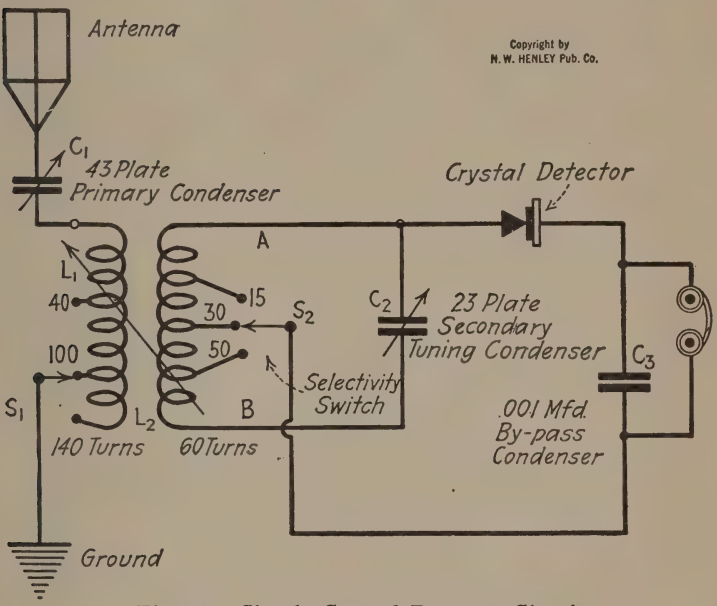


Fig. 27. Simple Crystal Detector Circuit

a portion only of the secondary coil. The fewer the number of turns included in the detector-telephone circuit, the more selective the receiver will be. Thus, when the switch is on the 15 turn tap the circuit is most selective, when on the 30 turn tap less so, and when on the 50 turn tap, it is only slightly more selective than if it were connected across the entire coil. The increased selectivity is gained only at a sacrifice in volume of signal.

Condenser C_1 is of the ordinary 43 plate size, and C_2 of the 23 plate size. Condenser C_3 is a by-pass or telephone shunting

condenser. Its capacity should be about .001 microfarad. This condenser is desirable but not absolutely necessary.

Inductance coil L_1 may be wound on a tube 3½ inches in diameter with about 140 turns of No. 24 or No. 26 double cotton covered wire. Taps should be taken out at the 40th and 100th turns. The secondary coil L_2 should be wound on a tube 2½ inches in diameter with approximately 60 turns of No. 24 or No. 26 double cotton covered wire. Taps should be brought out at the 15th, 30th and 50th turns.

The telephones used with this circuit should have a resistance of at least 2000 ohms. This is necessary in order to get maximum energy out of the crystal detector circuit into the telephone receiver.

The crystal detector consists essentially of a cup or receptacle to hold the crystal, and an adjustable arm with a small

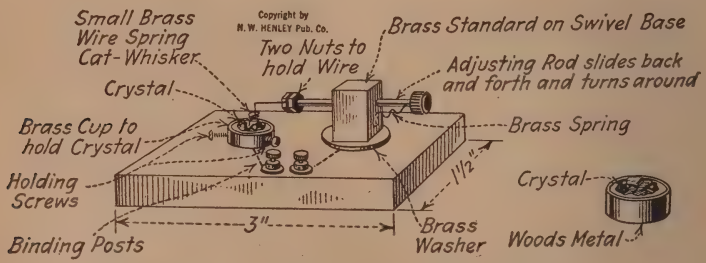


Fig. 28. Crystal Detector Mounting

flexible wire (or "catwhisker") which may be placed in contact with any portion of the crystal with any degree of pressure. In adjusting the crystal, a great deal of skill is required but fortunately this is acquired very rapidly. Fig. 28 illustrates one of many types of crystal detector stands. This detector stand is so made that the rough crystals, or crystals which have been mounted in Woods Metal (a metal which melts in boiling water) may be used.

There are numerous kinds of crystals that may be used satisfactorily. Galena is probably the most sensitive on weak signals, but it is difficult to adjust for greatest response and

very difficult to maintain in adjustment, especially where there is any vibration. Iron pyrite is a sensitive and reliable crystal, and it is not difficult to adjust. Chalcopyrite, when used with a zincite crystal instead of a catwhisker of the ordinary type, is a sensitive as well as a stable combination. In the old days it used to be called the "Perikon" detector and sold for $110.00.

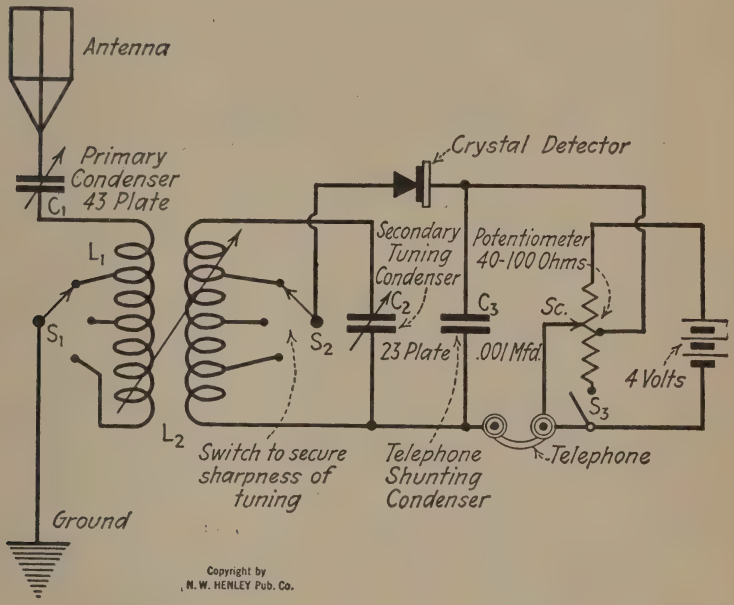


Fig. 29. Carborundum Detector Circuit

For very loud signals and in places where there is much vibration, a carborundum crystal is the most satisfactory. It is easy to adjust, and it does not easily get out of adjustment. This crystal, however, requires a local polarizing battery for greatest sensitivity. A 400 to 1000 ohm potentiometer is connected across a 4 volt polarizing battery. One side of the crystal is connected to one side or the middle of this potentiometer, and one of the telephone leads to the sliding contact S_c. The switch S_3 is closed, and the contact S_c is moved until

the signals are loudest. If the crystal lead is connected to one side, it may be necessary to reverse the battery before the proper adjustment may be obtained. If the crystal lead is connected to the middle, as shown in Fig. 29 this is not neces-

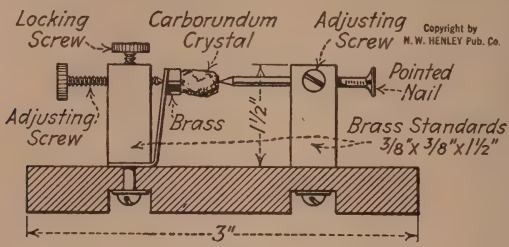


Fig. 30. Carborundum Detector

sary as the best point will be found on one side of the middle or the other. To connect the crystal lead to the middle of the potentiometer simply solder this lead to the resistance wire at the middle of the resister unit.

The carborundum detector may take the form as shown in Fig. 30. The nail may be adjusted roughly, and additional pressure may be applied by means of the adjusting screw. The best pieces of carborundum have a rough flat surface on one edge and sharp crystalline surface on the other. The rough edge should be faced to the pointed nail.

The Set. To construct this set, the following materials and apparatus are required:

1 primary condenser, 43 plate (.001 mfd.)
1 secondary condenser, 23 plate (.0005 mfd.)
1 telephone shunting condenser (.001 mfd.)
1 primary coil (140 turns No. 24 or No. 26 dcc wire on a 3½ inch tube about 4 inches long)
1 secondary coil (60 turns No. 24 or No. 26 dcc wire on a 2½ inch tube about 2½ inches long), or a vario-coupler
2 inductance switch arms
6 switch points
4 switch stops
1 crystal detector
1 pair of telephone receivers
1 baseboard, 11" x 6" x ½"

It is first necessary to purchase and assemble these pieces of apparatus. After this is done it is necessary to decide

whether the open type of mounting, or the cabinet type is desired. If the latter is decided upon, additional parts will be needed:

1 panel, 7″ x 12″ x 3/16″
1 cabinet, 7″ x 12″ x 7″
4 binding posts
3 dials
Various screws, nuts and some wire

If a carborundum crystal is used the following materials will be needed in addition:

1 400-1000 ohm potentiometer
1 flashlight battery of 4.5 volts
1 single pole, single throw switch

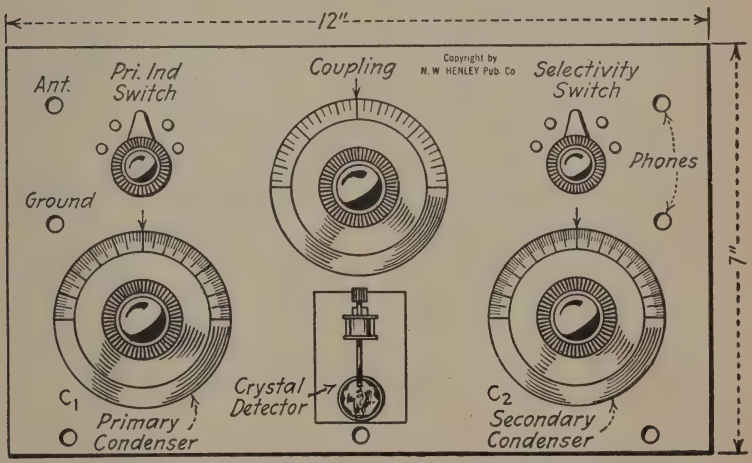


Fig. 31. Front View of Simple Crystal Receiver

If a wave trap is to be constructed in connection with the set, the following will be the material needed for that purpose:

1 cardboard, or composition tube 3 inches long and 3 inches in diameter
1 variable condenser (43 plate, .001 mfd.)
50 feet No. 18 double cotton covered wire

If the set is intended for experimental purposes and as a stepping stone to some more complicated receiver, it is recommended that the set be mounted open on a board. No suggestions as to the arrangement of the parts need be given for this form of set, but if the receiver is desired solely for the enjoyment of broadcast programs, the set will not only be much more satisfactory if it is mounted on a panel and enclosed in a cabinet, but it will also present a much neater appearance.

In Fig. 31 is given the size and layout of a possible panel suitable for this circuit. This is only suggestive, and need not

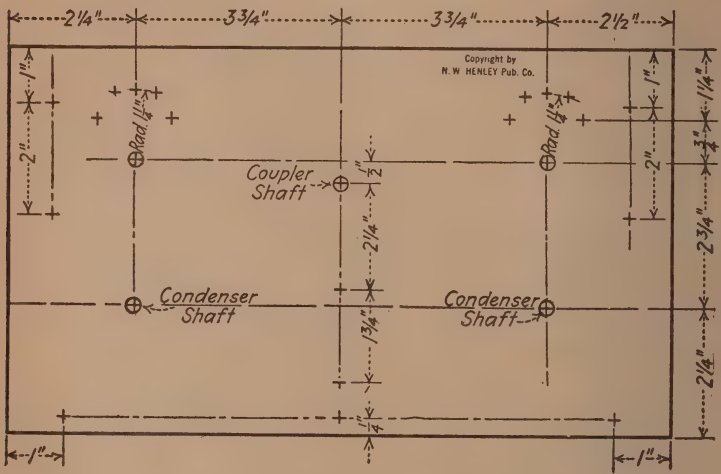


Fig. 32. Details of Panel Drilling

be followed. Accurate dimensions cannot be given because the sizes of various parts now on the market have not been standardized, and any one type of apparatus may not be obtainable everywhere. It is best to collect the parts first and then measure the coils, condenser, and other apparatus, to determine the size of panel and cabinet needed. It is well to get a panel which is too large, rather than one which just fits the parts when they are crowded together.

After the panel has been purchased the location of the various units should be determined accurately by measurement, and the panel then drilled. Be sure to allow plenty of room for mounting purposes and for binding posts.

It is best to lay the panel out symmetrically whenever possible and practicable. Although it is ordinarily desirable to make all leads as short as possible, it will do no serious harm to make them a little longer for the sake of obtaining a well-balanced layout.

FIGURE 32 gives the dimension for a panel template with locations of holes for the various pieces of apparatus to be mounted on the panel. Most of the holes are to fit 6/32 or 8/32 machine screws, and therefore No. 26 and No. 18 drills, respectively, should be used. Where the holes are to be larger the centers have been enclosed within two concentric circles. For a ¼ inch shaft, a 5/16 inch drill should be used. The switch arm bearings usually require larger holes. All sizes, however, can best be determined after all the parts have been obtained.

FIGURE 33 is a perspective of the rear of the set showing wiring in accordance with diagram Fig. 27.

After the equipment has been assembled, it should be wired up in accordance with the circuit diagram or the perspective (Fig. 33), care being taken to solder all joints carefully. As has already been pointed out under the paragraph on antennas it is most essential to have a good antenna for use with a crystal detector set. No reasonable effort should be spared to make the antenna as efficient as possible.

The Wave Length Range. The tuning range of a set depends upon the coils and condensers used in the antenna and secondary circuits. The primary circuit as specified in this receiver, when used with any ordinary antenna, has a range sufficiently wide to include all the broadcasting wave lengths, and it will tune to longer waves than those used in broadcasting. The secondary circuit will tune to wave lengths from about 250 to 650 meters.

Reception Range. The reliable receiving range of this re-

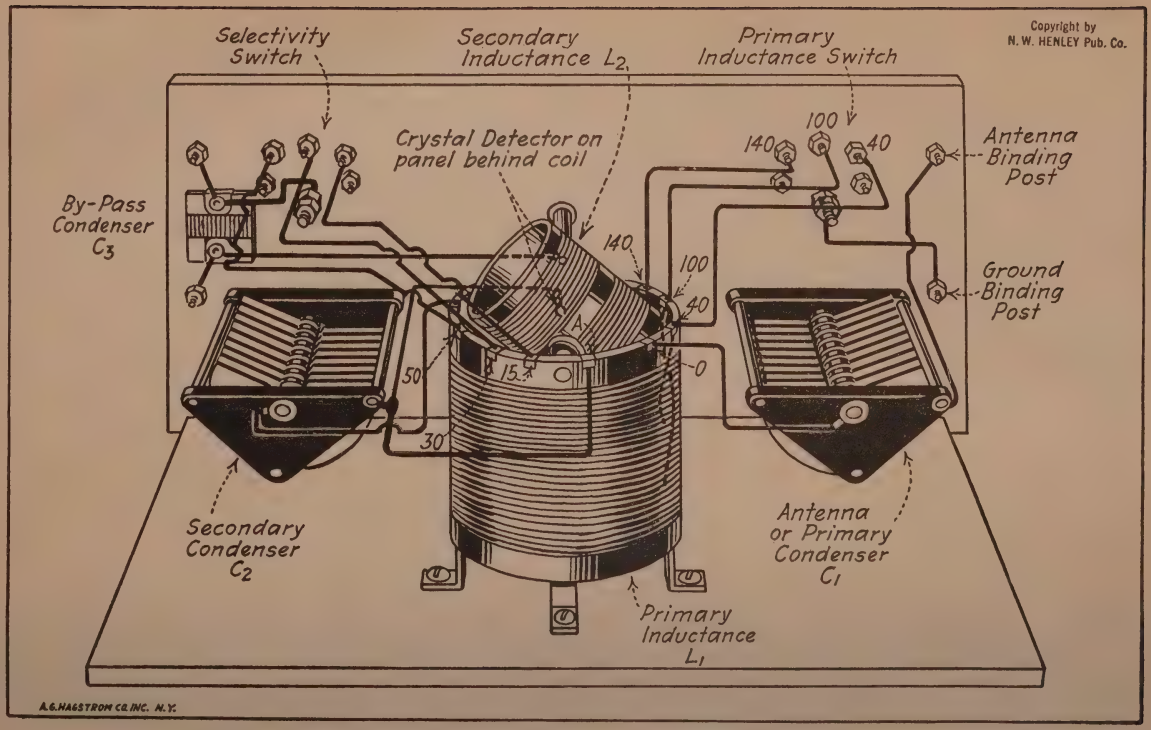


Fig. 33. Rear View of Simple Crystal Receiver

ceiver is from 10 to 20 miles. Under exceptional conditions it may reach 50 miles and even more.

Of course, in large cities it is very often the case that the signal strength 20 miles from a station is the same as that only 3 to 4 miles away in another direction, due to the effect of the high buildings. This is a very important factor to consider when deciding what type of set to build to receive from the local broadcasting stations.

When tuning in with this receiver, set the antenna condenser C_1 at maximum, the antenna switch at the 40th turn tap, the coupling dial at about 50, and the selectivity switch at the 50th turn tap. Then place the catwhisker against the crystal and tune with condenser C_2. If no signal is heard, as the dial of C_2 is turned from 0 to 100 adjust the crystal again and repeat. As soon as a signal is heard adjust the condenser until this signal is loudest. Then adjust the catwhisker against the crystal until the signal becomes as loud as possible. Then tune with condenser C_1 until the signals are a maximum. If there is no maximum include more turns and try for a maximum again. When found, re-adjust condenser C_2 a little. Now, if there is an interfering signal which also comes in, it is necessary to increase the selectivity of the set. This is done by setting switch S_2 on points 30 or 15, and by reducing the coupling.

Every time the switch S_2 and the dial of the coupler are changed, condenser C_2 must be readjusted and of course, every time S_1 is changed C_1 must be readjusted. C_1 is not so greatly affected by the setting of the coupler. If the interfering station cannot be tuned out, the wave trap, as already described, must be used.

When a particular station has been tuned in exactly, its call letters and wave length, together with the settings of condenser and coupler dials and tap switches should be recorded for future reference. This should be done for every station tuned in. Finally, it will not be necessary to go through the tuning process every time but merely set the dials and switches in

accordance with the calibration data in order to get any desired station or wave length within the limits of the receiver.

It may be added that the capacity of a variable condenser is maximum when the rotary (or moveable plates) are all in mesh with the stationary plates and minimum when they are all out. The coupling between any two coils is maximum when they are closest together and minimum when they are as far apart as possible. If the coils, as in a vario-coupler, are so arranged that one turns on its axis then maximum coupling is had when the coils are parallel with each other and minimum when they are at right angles.

CHAPTER III

Simple Vacuum Tube Receiver

The Simple Vacuum Tube Receiver Is Described—Both the Grid Bias and Grid Leak Method of Detection Are Considered. Specific Information on the Coils, Condensers, etc., Are Given Together with Picture Diagrams, Panel Layouts and Sufficient Text So That the Receiver May Be Made by the Beginner

While the simple vacuum tube receiver is not much more sensitive than a crystal receiver employing the same type of tuner, it is much more stable in operation and obviates the necessity of continually adjusting the crystal. It is therefore not advisable to build a simple, single bulb vacuum tube receiver unless it is intended to add amplification or to make it regenerative at an after date. Many people, however, prefer to start with a single tube set and gradually extend it as they gain in experience and enthusiasm until they have one of the more complex sets. For this reason a receiver employing a single tube is described below.

The tuner, consisting of the primary and secondary condensers, the primary and secondary inductance coils employed in this circuit is similar to that described in the previous chapter. Both the antenna and the secondary circuits are tuned, and the coupling between the primary and the secondary is variable so that loose coupling may be used. The special feature for increasing selectivity used in the crystal receiver is also used in this circuit because the tube exerts a similar effect on the selectivity as the crystal, although not to the same extent. If this feature together with the double tuning and loose coupling does not give sufficiently high selectivity to eliminate the signals from some high power station, recourse must be taken to a wave trap as in the case of the crystal receiver. The wave trap described in the preceding chapter will also serve in this circuit.

The circuit diagram of the receiver is shown in Fig. 34. C_1 is the primary tuning condenser with which fine tuning of the primary circuit is obtained. It should be a 43 plate. C_2 is the secondary tuning condenser which may also be a 43 plate condenser, but a 23 plate condenser will probably give better

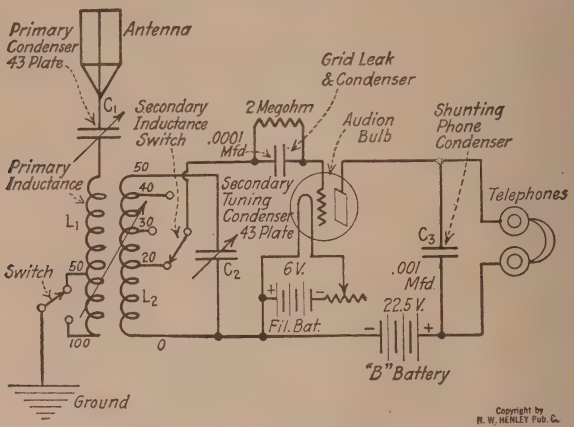


Fig. 34. Circuit Diagram of Simple Vacuum Tube Receiver

results. The grid blocking condenser may have any value from .0001 to .00025 microfarad and it should be a good mica dielectric condenser. C_3 is a by-pass condenser across the telephones. Its value should be about .001 mfd., and should preferably be a mica dielectric condenser.

The primary inductance coil L_1 should contain about 140 turns of No. 26 double cotton covered wire wound on a tube 3½" in diameter. It should have taps at the 50th and the 100th turns. The secondary inductance coil L_2 should contain 60 turns of No. 24 or 22 double cotton covered wire on a tube 2½" in diameter. This coil should be tapped at the 20th, 30th and 40th turns. Coils L_1 and L_2 may be the stator and rotor, respectively, of a good vario-coupler if one having the proper number of turns and taps can be found on the market.

The grid leak resistance should be about 2 megohms and should be of the type in which the resistance unit is sealed in

a moisture proof container. The rheostat should have a resistance of 10 ohms, unless a UV199 tube is to be used, when it should have a resistance of 30 ohms.

The circuit shown in Fig. 34 employs the grid condenser and grid leak method of detection. This is especially sensitive when weak signals are to be received; but when the signals become very strong this arrangement becomes unstable and distorts

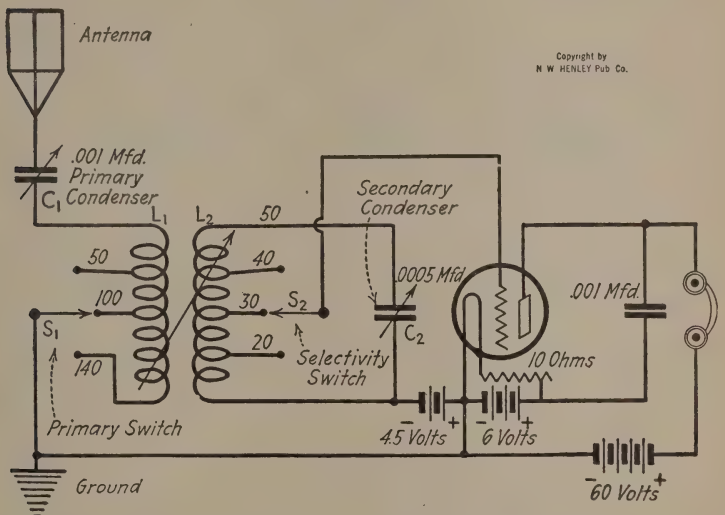


Fig. 35. Circuit Diagram of Simple Vacuum Tube Receiver Using Negative Grid Bias Detector

the signals. A more satisfactory method of detecting very strong signals is by the use of a negative grid biasing battery. Fig. 35 is a circuit diagram of the proper connections of the receiver when a grid battery is used for detection. The only change in the receiver is the substitution of the grid battery for the grid condenser and leak and the increase of the plate voltage to 60 volts.

There are two inductance switches in this receiver. The first is in the antenna to ground circuit and is used to vary the primary inductance, while the second is in the secondary

circuit and is used to vary the degree of selectivity of the circuit.

Since this receiver is intended for use with a headset, the dry cell tubes will give entire satisfaction. Any of the tubes now on the market such as the UV199, WD12, and UV201A

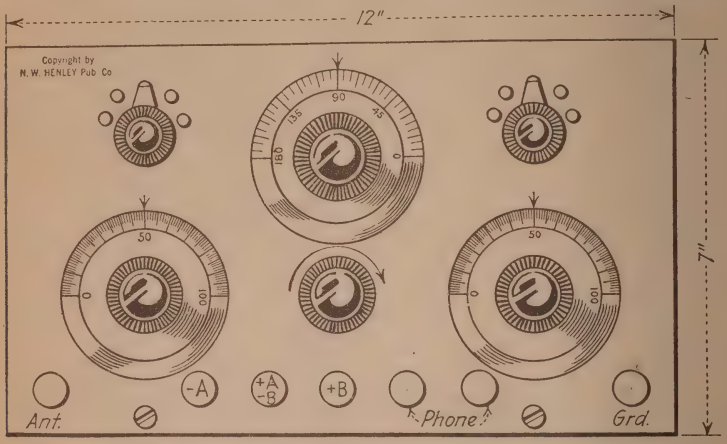


Fig. 36. Front View of Simple Vacuum Tube Receiver

may be used. The first of these requires a 4.5 volt battery, the second a single 1.5 volt dry cell, and the last a 6 volt battery which may be made up of 4 dry cells connected in series. The plate voltage for these tubes may have any value from 22.5 to 45 volts if the grid condenser and leak method of detection is used. If the grid battery method of detection is used the voltage may be much higher. A voltage of 60 with 4.5 volts on the grid is suggested.

The Set. The arrangement of the various parts of this receiver necessarily depends on the size of the apparatus purchased and on the tastes of the individual builder. Hence the following is merely suggested as a general guide.

FIGURE 36 shows the panel layout of the receiver. The dial of the primary tuning condenser is shown in the lower left corner, and directly above it is the antenna inductance switch. The dial of the secondary condenser is shown in the lower

right hand corner and directly above it is the selectivity switch. The filament rheostat is shown between the two condenser dials, while the dial of the coupler is shown between the two inductance switches. All of the binding posts are shown at the bottom of the panel. Fig. 37 gives the dimensions for a panel template for drilling the panel in accordance with the suggested layout of Fig. 36. Fig. 38 shows the connections of the units as viewed from the rear of the set.

The following apparatus should be purchased before laying out the set as it may possibly be that some apparatus unit is so large that it will determine the size of the panel and box:

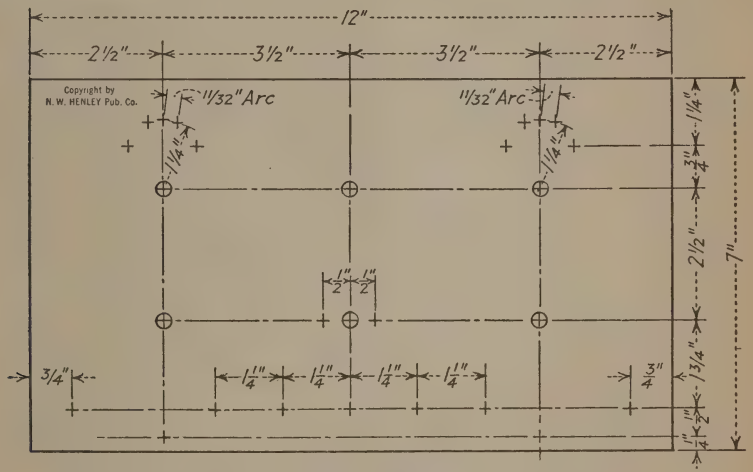


Fig. 37. Details of Panel Drilling

1 primary condenser (43 plate .001 mfd.)
1 secondary condenser (23 plate .0005 mfd. or 43 plate .001 mfd.)
2 switches
6 switch points and 4 stops
1 grid condenser and grid leak (.0001 mfd. 2 megohms)
1 tube socket (Standard or UV 199 type)
1 filament rheostat (10 or 20 or 30 ohms)
1 shunting condenser (.001 mfd.)
1 pair telephone receivers (2000 to 3000 ohms)
1 "B" battery 22½ volts
1 "A" battery, 1.5, 4.5 or 6 volts
7 binding posts
3 dials, 3" diameter
Some nuts, screws, soldering lugs, and bare copper wire.

Additional parts needed

1 panel
1 cabinet
Antenna and ground equipment

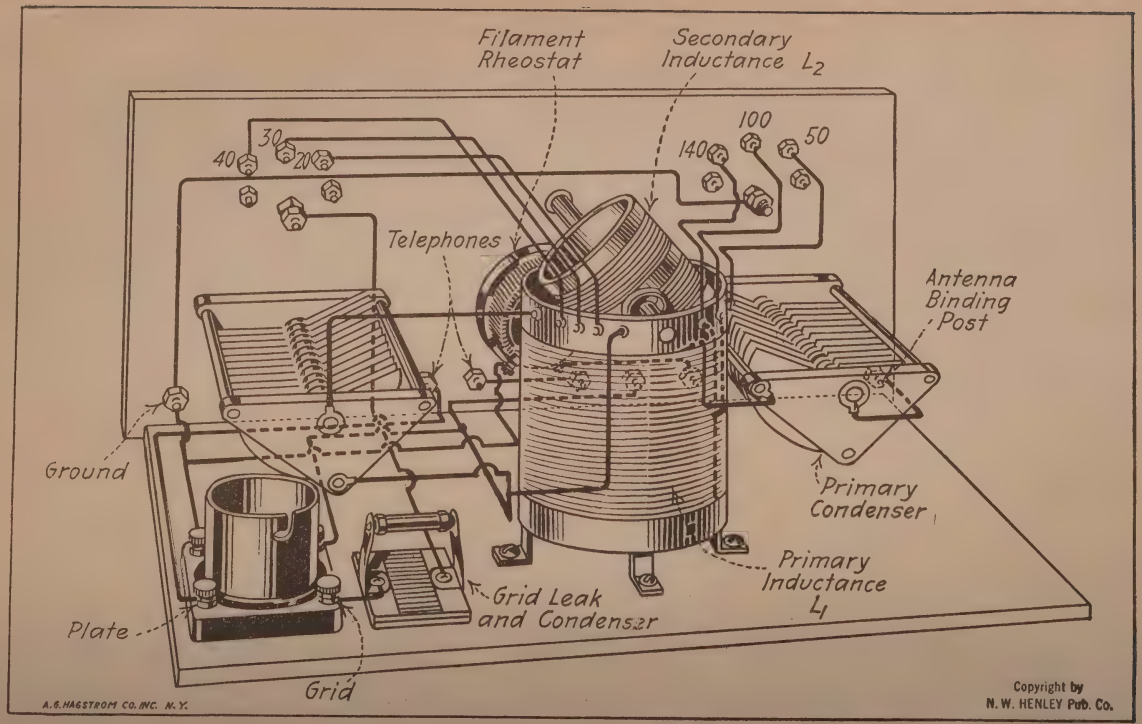


Fig. 38. Rear View of Simple Vacuum Tube Receiver

The first step in the construction of the set is to prepare the panel. Obtain all the essential dimensions of the instruments that are to be mounted on the panel. Lay these out very accurately on a piece of bristol board or heavy manila paper of exactly the same size as the panel, and mark the locations of all holes. Check the measurements to make sure that they are correct and that they have been correctly transferred to the template. Then clamp the paper template to the panel proper, and with a sharp-pointed instrument mark the panel through the paper. Remove the template from the panel and check the measurements again. If correct, go over all marks with a center punch and make a hole large enough to prevent the drill from slipping. Then clamp the panel to the work bench and drill the proper size holes. In drilling, the drill must be held at right angles to the panel. Countersink all holes which are to take flat-head screws. When this has been done mount the instruments on the panel temporarily to see if they will fit. If they do, remove them and put a tin or copper-foil shield back of the panel. Be sure to cut holes in the shield large enough so that the shield does not touch the condensers or other instruments on the panel. This may be fastened with shellac or similar material. Then the instruments may be mounted permanently on the panel. Now attach the panel temporarily on the baseboard and arrange the various pieces of apparatus in accordance with Fig. 38, or in the best suitable manner, mark their location with a pencil, remove the panel and fasten the various parts on the baseboard. Now put soldering lugs under all terminals and binding posts, and wire the set as far as possible before the panel is mounted, following either the schematic diagram Fig. 34 or 35, or the picture drawing Fig. 38 which follows diagram Fig. 34. Then mount the panel and complete the wiring.

The receiver is now ready to be tested. If a buzzer is available this is the most convenient for use in testing to see that all connections are properly made, and that there are no short circuits. Then connect the filament battery to the "B" battery terminals. If the tubes light the plate circuit is incorrect and

this should be corrected before further test. Then connect the filament battery to the positive and negative "A" battery connections and if the tubes light this circuit is probably correct. Then connect the plate battery to its proper terminal.

After this preliminary test has been completed, the receiver should be tested on an incoming radio signal. Connect up all batteries and the antenna and ground leads, and tune the receiver. Set the primary inductance switch L_1 on the 50th turn tap, the primary condenser C_1 and the coupling on maximum, and the selectivity switch on the 40th turn tap. Then tune with C_2 until the desired signal is maximum. If no signal is heard, and there is a broadcasting station transmitting within the reception range of the set, check over the connections again, especially those of the antenna and ground circuit. When a signal has been picked up and tuned in with C_2 its strength may be increased by tuning the primary circuit with condenser C_1. In order to secure maximum signal strength in this way it may be necessary to change the primary inductance switch to the 100th or 140th turns.

Now if two or more stations can be heard at the same time, it will be necessary to increase the selectivity of the receiver. This is done by loosening the coupling between the primary and the secondary coils, and by setting the selectivity switch on either the 30th or 20th turn taps. It will be necessary to retune both the primary condenser C_1 and the secondary C_2 every time either the coupling or the selectivity switch is changed.

To obviate the necessity of tuning the receiver every time a calibration chart should be prepared. If this is done it will only be necessary to tune the circuit once for each wave length. After it has once been tuned, it is only necessary to refer to the chart and set the dials according to the calibration data. The first column of this chart should contain the call letters, the second the frequency in kilocycles, the third the wave length in meters, the fourth the setting of C_1, the fifth the setting of C_2, the sixth the setting of the primary inductance switch and the seventh the coupling.

CHAPTER IV

Two Stage Audio Frequency Amplifier

A Simple Two-Stage Audio Frequency Amplifier Is Described In Detail and Its Design So Clearly Pictured That It Is Easily Constructed. This Amplifier Is Intended for Use with the Receivers Described In Chapters II and III

Many people who own a simple detector circuit similar to either of those previously described like to increase the signal strength by adding amplification. For this purpose the following amplifier is described. When this amplifier is connected to the output of either the crystal detector circuit or the similar vacuum tube circuit, the signals from local stations will be sufficiently loud to operate a loud speaker satisfactorily. It consists of two stages, and it is so arranged that the telephones or loud speaker may be plugged into either of the two. There is also a volume control so that the signal distortion due to the overloading of the tubes, or the sound producing mechanism, may be prevented. The schematic diagram of the amplifier is shown in Fig. 39. T_1 and T_2 are the two audio-frequency transformers. Both of these should have a turns ratio of 1 to 4 or less and a very high primary impedance. The inductance of the primary on open secondary should not be less than 10 henrys. Much better quality would be obtained if the primary inductance were as high as 35 henrys when the transformer is working between ordinary vacuum tubes having a tube impedance of 20,000 ohms or less.

The best tubes to use in this circuit are UV201A or 216A, or tubes having the same characteristics. Smaller tubes than these are likely to become overloaded, and give a distorted signal. A good combination is to use a UV201A in the first stage, and a 216A in the second.

Only one rheostat, R_2, is used in the circuit to control the filaments of both tubes. If two tubes of the same type are

used in both stages, the connections may be as shown in the diagram, but if UV201A is used in the first stage and a 216A in the second stage, then the filament of the latter should be connected directly across the battery; that is, the positive return lead from that tube should be connected on the other side of the rheostat. The 216A tube will work satisfactorily when it is connected directly across a 6 volt battery, whereas

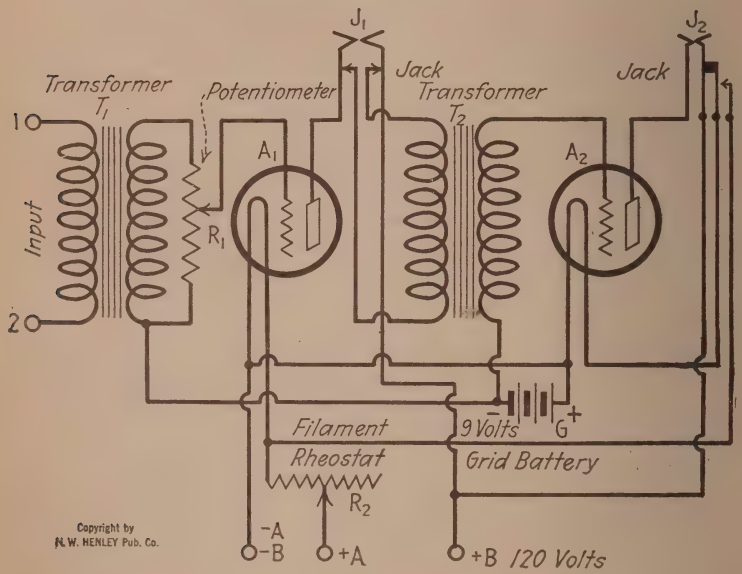


Fig. 39. Circuit Diagram of Two-Stage Amplifier

a UV201A requires only 5 volts. If the two filaments, when the two tubes are different, were connected as shown, the filament of the first would not be safe when the second tube is turned off, due to the rise in the filament current of the first.

The details of the potentiometer used for volume control are shown in Fig. 40. The potentiometer is made up of two 48,000 ohm and four 100,000 ohm resistance units with the necessary switch points and contact lever.

The two jacks J_1 and J_2 are provided so that the telephones may be plugged into either the first or second stages. J_1 is a double circuit jack, while J_2 is a single circuit automatic filament control jack. The latter type of jack is used so that the second filament is lighted only when the telephones are

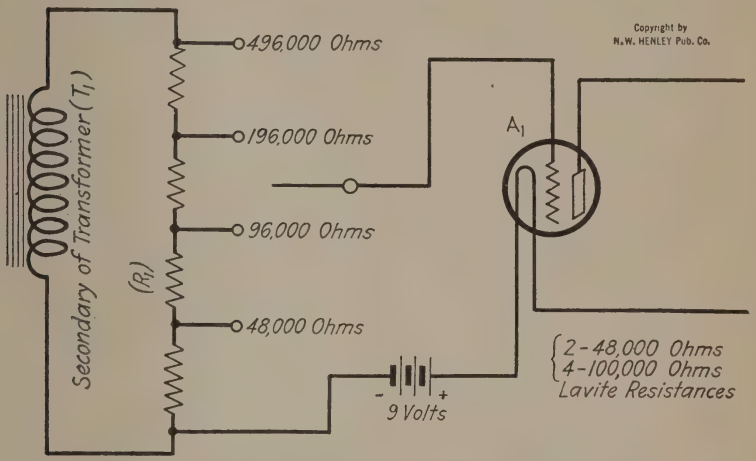


Fig. 40. Potentiometer in Two Stage Amplifier

plugged into the plate circuit of that tube. The finer variation of amplification (or volume of sound) is obtained by means of the volume control, potentiometer R_1, which is inserted in parallel with the secondary of the first transformer. (Fig. 40.) This volume control device is placed in the input of the first stage in order that the current level in the amplifier may be as low as possible, as then the distortion in the amplifier will be the least.

In order that the tubes may operate under the best conditions, a high plate voltage is employed, as well as a negative grid bias. A suitable value for the plate potential on either of the tubes is 120 volts, and the corresponding grid bias potential 9 volts. The latter is being supplied by the battery G. If the amplifier is only to be used for headset reception, the plate

voltage may be only 60 volts, provided the biasing voltage be reduced to 3 or 4½ volts.

Description of the Set. The following pieces of apparatus will be needed for the construction of this amplifier:

2 audio frequency transformers
2 standard tube sockets
1 double circuit jack
1 single circuit, automatic filament jack
1 10 ohm rheostat
1 switch arm
4 switch points, 2 stops
5 binding posts
1 grid battery (9 volts, or 3-4½ volts)
1 potentiometer as per Fig. 40
1 7″ x 7″ x 3/16″ panel
1 board, 8″ x 6″ x ½″
1 cabinet, 7″ x 7″ x 8″
2 vacuum tubes
1 telephone plug
Screws, nuts, wire, soldering lugs, and solder

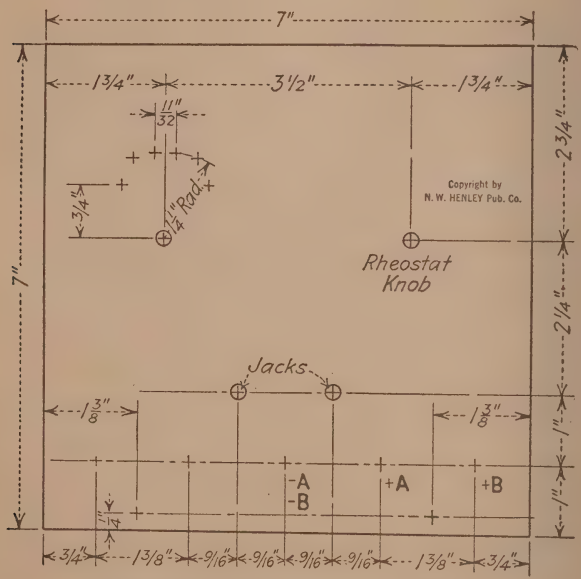


Fig. 41. Details of Panel Drilling

When the parts have been purchased the set may be constructed as shown in Fig. 41, which shows the panel drilling. Fig. 42 shows the floor plan of the same amplifier. These are placed on a panel of 7″ x 7″, and a cabinet 7″ x 7″ x 8″.

The volume control R_1 appears to the left of the panel, and the rheostat knob to the right. The two jacks are shown in the middle of the panel, below the median line, and all the binding posts are shown near the bottom of the panel.

Preparation of the Panel. In preparing the panel, first decide on the layout, giving due consideration to the dimensions of the various parts purchased. Then lay them out in a manner

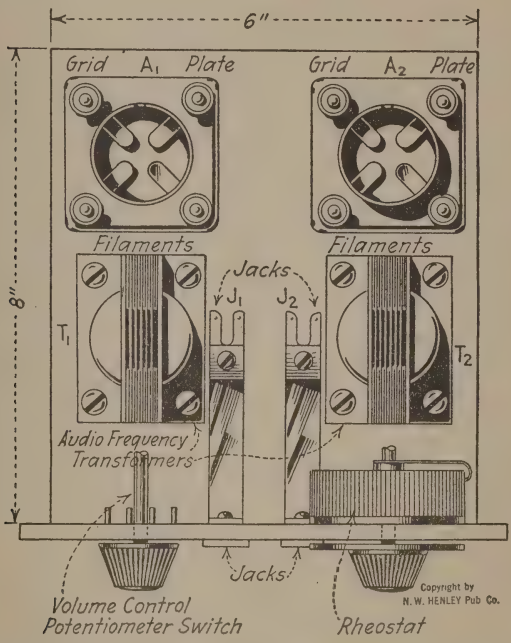


Fig. 42. Layout of Apparatus on Baseboard

similar to that suggested in Fig. 41. First make an accurate template on a piece of bristol board or heavy manila paper. Check the various dimensions, and if correct, clamp the template to the panel, mark the centers with a sharp-pointed instrument. Remove the template and check all dimensions

again very carefully. If the locations of all the centers are found to be correct, go over all with a center punch and make holes to prevent the drill from slipping. Clamp the panel to the work bench and drill with the proper size drill. All holes larger than 3/16″ should first be drilled with a smaller drill to make sure that the center will be in the right place, and then enlarge to the correct size with the proper drill. Countersink all holes which are to have flat head screws. If it is desired to give the panel a dull finish, this may be done by rubbing with a piece of fine emery cloth and oil.

When the panel has been prepared mount all the apparatus on it and then temporarily attach the panel to the baseboard. Then arrange the sockets, transformers and grid battery on the baseboard in the best suitable manner, so that none of the instruments on the baseboard interfere with any of the instruments on the panel. Fig. 42 is suggested. The two audio-frequency transformers should be placed as far apart in the cabinet as possible. If they are not shielded, the cores should be placed at right angles, or they should be placed in such a manner that the stray coupling does not feed back energy in such a way as to cause howling. It should be remarked here that the design of some audio-frequency transformers is such that when the cores are apparently placed at right angles, the magnetic fields are not at right angles, because they are symmetrical about a vertical line. When that is the case, it would do no good to place the cores at right angles. When the instruments on the baseboard have been properly placed, mark their location with a pencil, remove the panel from the baseboard, and mount the instruments on the baseboard. Now put soldering lugs under all terminals and binding posts of both the panel and the baseboard, and wire both as far as possible before they are put together. In wiring, the circuit diagram of Fig. 39 or the picture diagram of Fig. 43 should be followed. Then the panel should be attached permanently to the baseboard and the wiring completed. It is best to use No. 14 bare tinned-copper wire, or 1/16 inch square copper bus wire. The

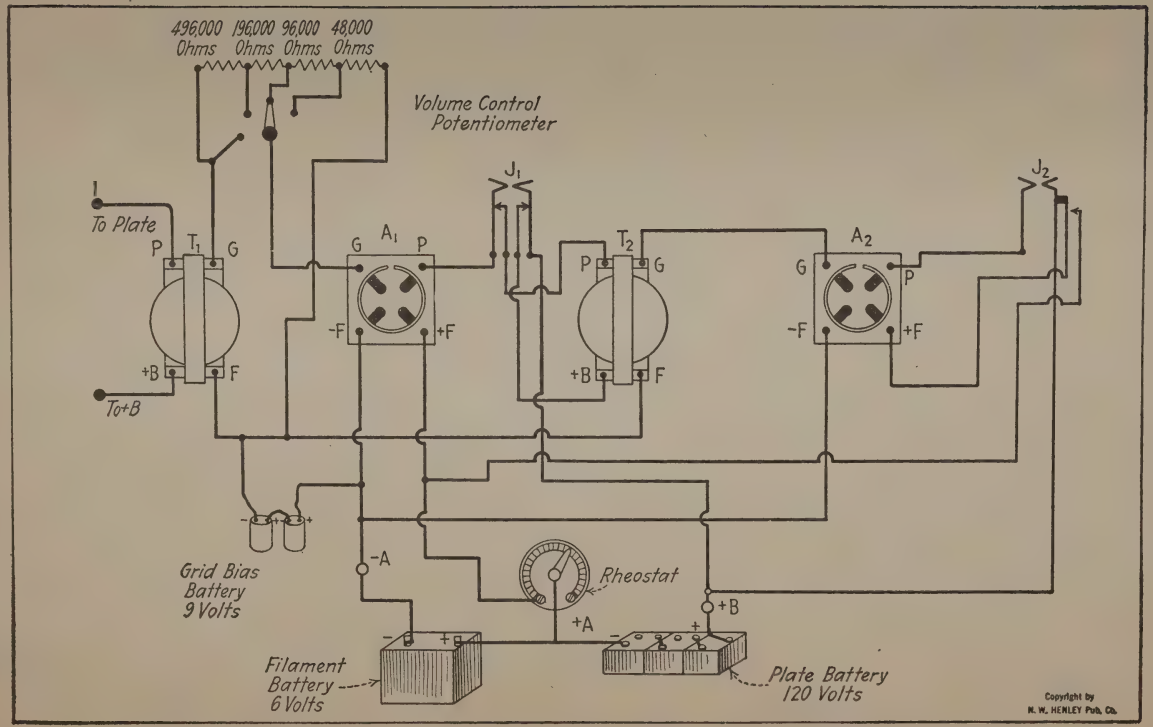


Fig. 43. Wiring Diagram of Two-Stage Amplifier Showing Battery Connections

use of "spaghetti" is only necessary where there is any danger of short circuiting.

Testing the Set. When the wiring has been completed, the set is ready to be tested. Place the tubes in their sockets and connect the "A" battery to the "B" battery binding posts. If either of the tubes light the plate circuit of that tube or tubes is incorrect and the wiring should be checked up with the circuit diagram. If this is O.K. the "A" battery may be connected to the "A" battery binding posts to see if the tubes light. If they do the filament circuits are probably correct. When this has been done, connect the binding post marked "Input, 1 and 2" (see diagram Fig. 39) to the output terminals of a detector in a receiving set. These detector output terminals are those to which a pair of telephone receivers are normally connected when the receiver only is in use. Tune the receiver and see if signals are heard in the telephone receivers which have been plugged into the jack, J_2 (see Fig. 39). If no signals come through, connect the telephone receivers to the telephone or output terminals of the receiving set to see if signals can be heard. If they can, then it will be necessary to check over all the wiring for faulty connections. Use the diagram of Fig. 39 as a guide. Very little difficulty should be experienced with a simple circuit of this type.

When this amplifier is connected to any of the detector circuits previously described, the signals should be loud enough to operate a loud speaker with sufficient volume to be heard in a good-sized room.

CHAPTER V

Three Tube Double Circuit Regenerative Receiver

The Three Tube Double Circuit Regenerative Receiver Is Described Because It Is the Best of the Regenerative Receivers. A Circuit Is Given for the Complete Elimination of Radiation from a Regenerative Receiver. Complete Details Are Given So That Such a Receiver May Be Constructed and Operated from the Information Contained in This Chapter

When the entire family circle desires to listen in on a radio program, a loud speaker and a receiver capable of operating it are necessary. Such a receiver should be sufficiently sensitive to pick up signals from broadcasting stations located 1000 to 1500 miles away and amplify them so that they may be heard easily on a loud speaker in a good-sized room. It should also be sufficiently selective to exclude the signals from the high power local broadcasting and other stations while receiving a distant station whose frequency differs only by 20 to 30 kilocycles from the frequencies of the closer stations. It is not always necessary to eliminate the interfering signals completely, but to a sufficient extent that they do not disturb the desired program to an objectionable degree.

Description of Receiver

The Circuit. A very simple and satisfactory circuit which meets the above requirements is the double circuit, two variometer regenerative receiver to which two stages of audio frequency amplification have been added (shown in Fig. 44). This circuit is very sensitive, quite selective, and comparatively simple to operate. For these reasons it has gained considerable popularity with radio enthusiasts.

The primary or antenna circuit of this receiver is tuned with condenser C_1 and with the variable inductance coil L. The secondary circuit is tuned by the variometer V_1. Selectivity is obtained by keeping the coupling between the antenna coil

L and the coupling coil L_2 loose and by carefully tuning both the primary and the secondary circuits.

Regeneration is obtained in this receiver by means of tuning the plate circuit of the tube with variometer V_2. When the plate circuit is in tune with the grid circuit for a given frequency there is sufficient feed-back through the grid to plate capacity of the tube to cause the circuit to oscillate at that frequency. If this frequency exactly coincides with the frequency of an incoming signal which is impressed on the grid, the receiver is extremely sensitive to that frequency. Ordinarily it is not practical to use this method of reception because of the instability of the two frequencies. The slightest change in either of the two will cause audible beats; and if the receiver oscillates too violently, the signals will be weak or they will entirely disappear. The proper method of using the regenerative feature is to tune the plate circuit with the variometer until the receiver is on the verge of oscillation. The signals are then very strong and comparatively free from distortion. The tube then acts as a highly sensitive relay which is controlled solely by the signals which are impressed on the grid circuit.

A regenerative set of this type will unavoidably break into oscillation at times no matter how carefully the operator handles the circuit while tuning, and whenever this occurs it radiates energy from the antenna and this causes interference with all other receiving sets in the neighborhood. This trouble may be minimized by keeping the coupling between coils L and L_2 as loose as will give satisfactory results. But even when the coupling is very loose there will be some radiation, and this may best be prevented by inserting a "silencer" tube or radio frequency amplifier in front of the regenerative detector tube. How this may be done without changing to any great extent the panel layout or the interior arrangement of parts is shown in Fig. 45.

In this modified form of the receiver the silencer tube is connected directly across the antenna inductance coil L. If

the primary condenser C_1 is small and the inductance L large the input voltage (the voltage between grid and filament) will be large and hence the signals will be strong. The power output of the silencer tube is coupled to the input of the detector (grid filament circuit) by means of L_1 which is in inductive relation with the coupling coil L_2. The latter coil may be the same as that in Fig. 44. Although the coupling between coils L_1 and L_2 is shown to be variable, this is not absolutely necessary since sufficient selectivity may be obtained with the coupling fixed and rather close. However, the use of fixed coupling would entail a departure from the panel layout, as will be described for the first circuit. The ratio of turns of L_1 to L_2 may be as high as 1 to 4.

In the circuit as shown in Fig. 44 rheostat R_2 is used for the detector alone, while in Fig. 45 it is also used for the silencer tube. In other respects the modified circuit does not differ in any way from the three tube circuit. Since the owner of the three tube circuit will very likely be highly unpopular with his radio neighbors, it is recommended that the four tube circuit be used whenever possible.

The antenna condenser C_1 may be either a 43 or 23 plate variable air condenser. This is the only variable condenser in the circuit. It is used to obtain fine tuning in the antenna circuit. C_2 is the ordinary grid blocking condenser, and it may have any value from .0001 to .00025 microfarad. C_3 is a by-pass for the high frequency currents across the primary of the first audio frequency transformer T_1 and across the plate battery. Both C_2 and C_3 should be good mica dielectric condensers.

The antenna inductance coil L should have at least 140 turns of No. 26 double cotton covered wire on a tube 3″ in diameter, and it should have at least two taps, which may be taken out at the 50th and the 100th turns. L_2 may contain from 15 to 20 turns on a tube which will turn inside the tube of coil L. Coils L and L_2 may constitute the primary and secondary, respectively, of a good vario-coupler which may be purchased.

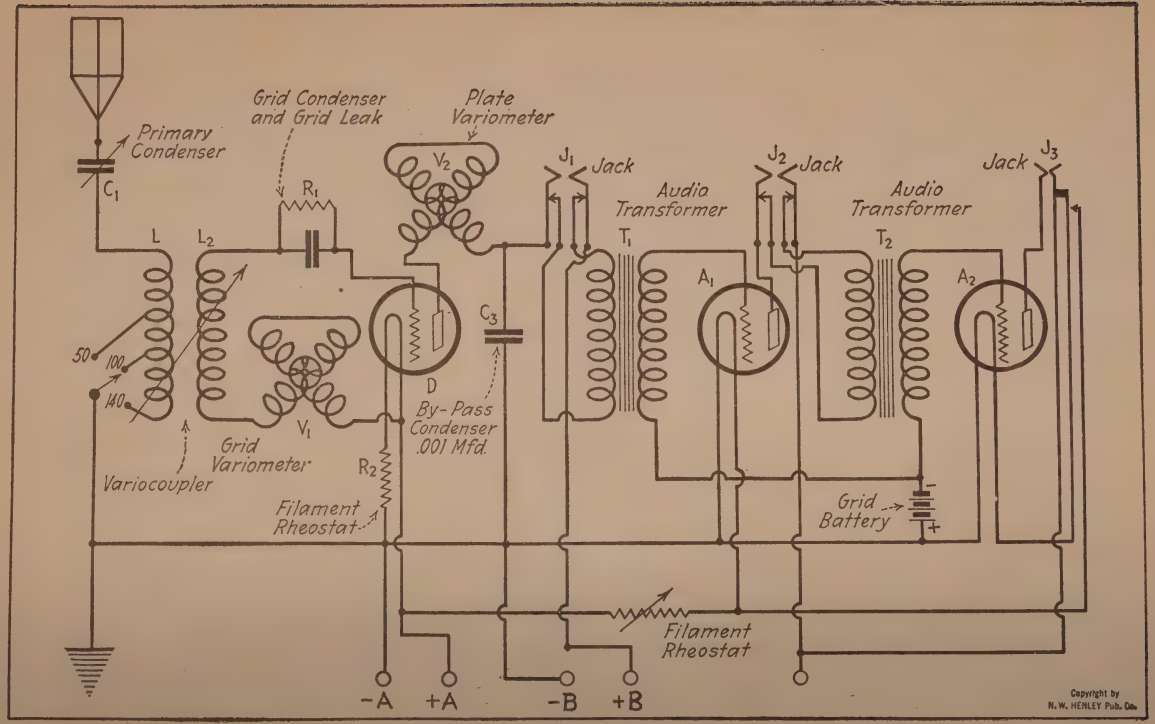


Fig. 44. Circuit Diagram of Three Tube Regenerative Receiver

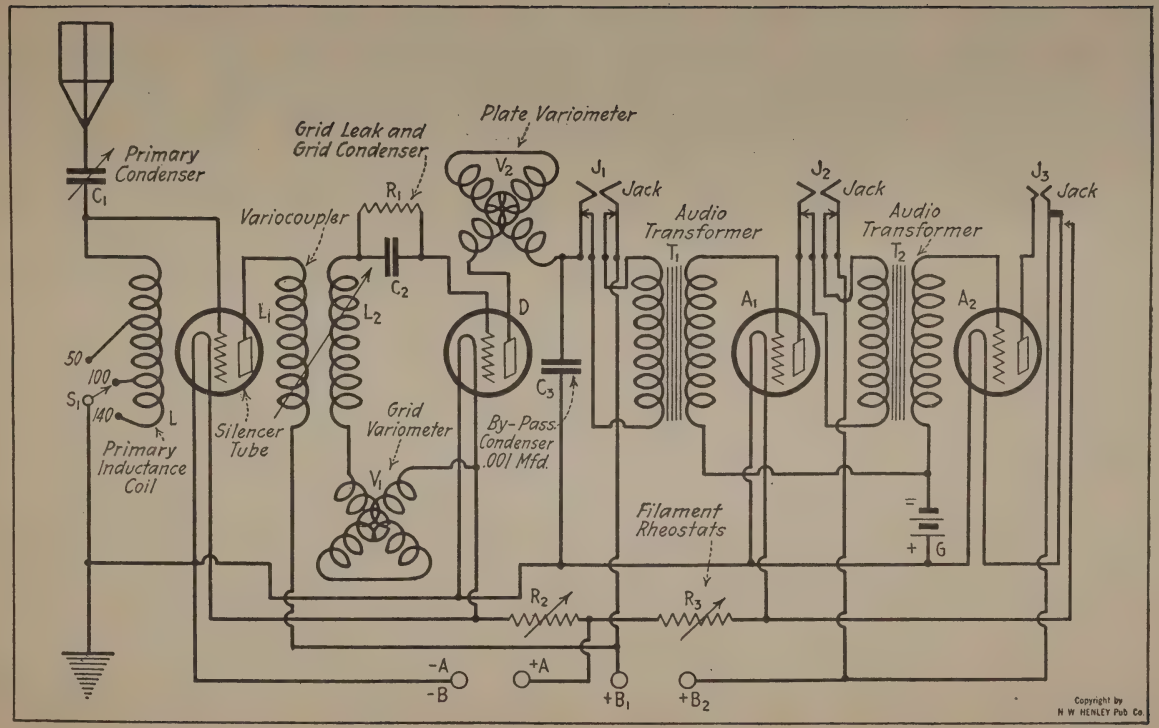


Fig. 45. Circuit Diagram of Three Tube Regenerating Receiver with Muffler or Silencer Tube

Variometers V_1 and V_2 should be of the medium size obtainable on the market. This also applies to the vario-coupler LL_2.

The two audio frequency transformers T_1 and T_2 may be any good instruments having a turns ratio of about 1 to 4 or less and a high primary impedance. It is of greater importance that the audio frequency transformers have a high primary impedance than a high turns ratio.

Jacks J_1 and J_2 are ordinary double circuit jacks but J_3 is of a special type. It is so arranged that when the telephone plug is inserted in it the filament circuit of the last tube is automatically closed. Pacent 65 or a similar jack may be used for this purpose.

The grid leak resistance R_1 depends somewhat on the kind of detector tube which is used. For a UV200 it should be about 500,000 ohms while for other tubes it may vary from one to five megohms. The two rheostats R_2 and R_3 should each have a resistance of about 10 ohms for all tubes suitable for loud speaker operation. Since tubes A_1 and A_2 are both on rheostat R_3 the current in the filaments will drop below normal when the telephone is plugged into J_3. It is therefore necessary to reduce the resistance in the rheostat in order to bring the current up to the proper level. When the plug is withdrawn again, the current in the filament of tube A_1 will increase above normal. Hence, before withdrawing the plug, the resistance should be increased in order to protect the filament of that tube from overheating. However, the difference is only 10% and there is no danger of the tube burning out if this precaution is momentarily neglected.

When listening in on the detector alone both tubes A_1 and A_2 may be turned out with the rheostat R_3.

It is recommended that standard tube sockets be used in this circuit, so that UV201A tubes may be used. Smaller tubes than these are not satisfactory for loud speaker operation.

Batteries. When UV201A tubes are used a 6 volt storage battery is required.

The plate voltage on the detector tube should be about 40 volts, while on the amplifier tubes it may range from 60 to 120. The value of the grid battery G depends on the plate voltage used on the amplifier tubes. The voltage specified by the manufacturers and furnished with the tubes should be used, or see Table II Chapter I.

List of Parts. The parts and material needed for the construction of this receiver will be:

1 grid condenser, .0001 to .00025 mfd.
1 by-pass condenser, .001 mfd.
1 43 plate variable condenser
1 vario-coupler
2 variometers
1 grid leak, 2 megohms
2 rheostats, 10 ohms
3 standard tube sockets
2 double circuit jacks
1 single circuit, open automatic filament jack
2 audio frequency transformers
1 filament battery, 6 volt storage
1 plate battery, 60 to 120 volts
1 grid battery
4 dials
1 inductance switch
3 switch points and 2 stops
6 binding posts
1 sheet, tin or copper foil, 6″ by 23″
1 panel, 3/16″ x 7″ x 24″
1 baseboard, 7″ x 23″ x ½″
1 cabinet, 7″ x 8″ x 24″
1 telephone plug
1 headset or loud speaker
3 vacuum tubes

Assembling the Set. The first step in building the set after all the necessary parts have been obtained is to prepare the panel. First decide upon the panel layout. When doing this due consideration must be given to the dimension of the various parts. The layout given in Fig. 46 is suggested as suitable. This not only makes the panel arrangement symmetrical, but it also allows ample room for the various parts. Fig. 47 gives dimensions for a drilling template for the layout suggested in Fig. 46 and Fig. 48 is a perspective of the rear of the receiver showing arrangement of parts.

When the panel layout has been decided upon make an accurate template of bristol board or heavy manila paper. Clamp this template to the panel and make a mark on the panel through the template with a sharp pointed instrument. Then remove the template and check the locations of the center marks against the dimensions of the various parts that are to be mounted. When they have been verified go over the

marks with a center punch, making holes deep enough to prevent the drill from slipping. Then clamp the panel to a board and drill the holes to required size. Countersink to proper depth all holes which are to take flat head screws.

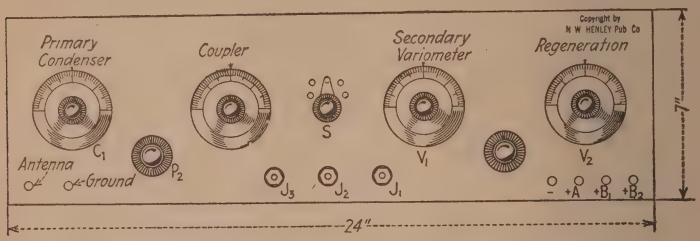


Fig. 46. Front View of the Receiver Panel

After the panel has been drilled and the true location of holes checked by actual test, prepare the shield and mount it on the panel. Be sure to cut holes in shield large enough to prevent any of the instruments on the panel from touching it. It may be fastened with glue or shellac. When this has dried mount the instruments on the panel and attach the panel to

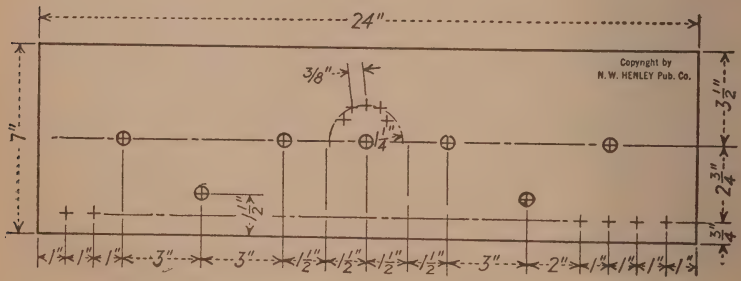


Fig. 47. Panel Drilling Dimensions

the baseboard. Arrange the parts on the baseboard in accordance with Fig. 48 and mark with a pencil. Then remove the panel and fasten the various instruments to the baseboard.

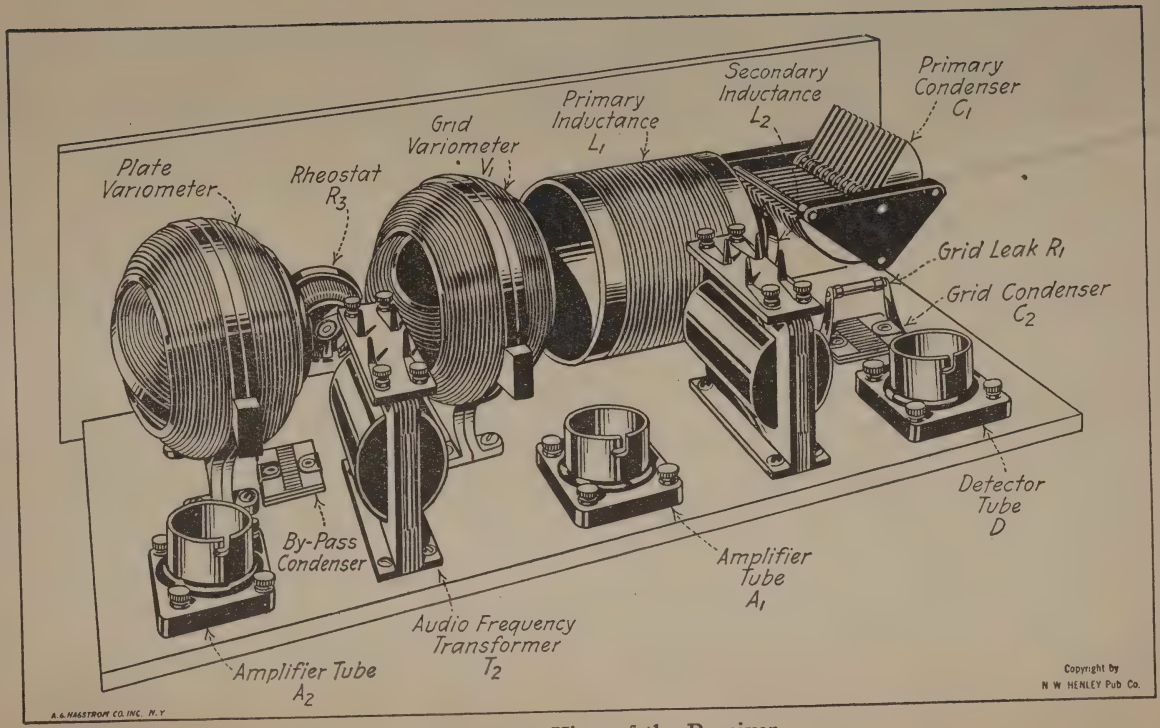


Fig. 48. Rear View of the Receiver

The set is now ready to be wired. Put well-tinned soldering lugs under all terminals and binding posts to facilitate the wiring and soldering. Wire as much as possible while the panel assembly and baseboard assembly are in separate units. Then attach the panel permanently to baseboard and complete the wiring. Use either No. 14 tinned copper wire or tinned copper bus bar, and follow the schematic diagram in Fig. 44 or the picture diagram of Fig. 48.

Testing. Test the receiver before putting the circuit in the cabinet. Place the tubes in the sockets and first connect the filament battery. If the filaments light the filament circuit is probably correct. Then connect the plate battery, first using a very low voltage as a precaution against a faulty connection. If it is all right for about 16 volts it is probably safe to use the high voltage. Ascertain whether the high voltage reaches the plate terminals on the tube sockets. If not, there is an open circuit which must be completed. Then go over the rest of the wiring with a buzzer, if one is available. If none is available, an ordinary headset with a 1.5 volt cell in series may be used to test whether the connections are continuous. When the testing with the buzzer has been completed connect up the set for a test on a signal.

The Operation of the Set. When first tuning in this circuit, set the inductance switch S at minimum, the condenser C_1 at maximum, and the coupling between L and L_2 also at maximum. Then using the variometer V_1 tune the circuit until the desired signals can be heard with a maximum strength. Then tune this circuit with condenser C_1 until the signal is a maximum. In order to obtain this condition, it may be necessary to change the setting of the switch S to one of the other points, depending on the wavelength of the signal in question. Now if it is desired to increase the strength of the signals still further, this may be done by tuning the plate circuit with the variometer V_2. A point will be found at which the signals will be maximum, and beyond which the circuit will oscillate. The final setting of the variometer V_2 should be considerably below

the point at which oscillations begin. Now if sufficient selectivity cannot be obtained, the coupling between L and L_2 should be reduced and the primary and secondary circuits retuned.

Calibration of the Set

In order to obviate the necessity of tuning the receiver each time a certain station is wanted, the set should be calibrated so that it will only be necessary to refer to the calibration data. In the first column of the chart made, the call letters of the stations should be recorded, in the second and third, the frequency in kilocycles and the wave length in meters and in the fourth the setting of the variometer V_1. These should be recorded for the best settings of the coupling and the variometer V_2.

CHAPTER VI

Radio Frequency Amplifier Receiver

The Tuned Radio Frequency Amplifier Receiver Is Described in Detail. The Necessary Circuit Drawings and Panel Layout Sketches Showing Arrangement of Apparatus Are Given for the Construction of This Set. The Operation of the Set Is Described So That the Set May Be Properly Operated After It Is Constructed

One of the most reliable of radio frequency receivers, and at the same time the simplest to operate, is one in which radio frequency transformers are used to couple the succesive stages of amplification. Such a receiver, however, is not so sensitive for a given number of tubes as receivers using tuned coupling transformers, but it is much more stable in operation, and it is not so liable to cause interference by radiation. The efficiency of the receiver is largely dependent on the efficiency of the radio frequency transformers over the frequency band it is intended to receive.

In order that such a transformer may be effective over the broadcasting frequency range (from 1350 to 550 kilocycles), its effective tuning should be very broad with its maximum near the middle of the band, or about 850 kc (350 meters).

Due to the fact that the received signals are amplified at radio frequency, this type of receiver is quite selective, but not nearly so selective as a receiver having tuned coupling transformers.

Description of Receiver

In Fig. 49 is shown a typical receiver in which radio frequency transformers are used to couple the successive stages. It is a four tube circuit, divided into two stages of radio frequency amplification, a detector, and one stage of audio frequency amplification. The tuner of this receiver is of the double circuit type with loose coupling which makes it possible to obtain satisfactory selectivity.

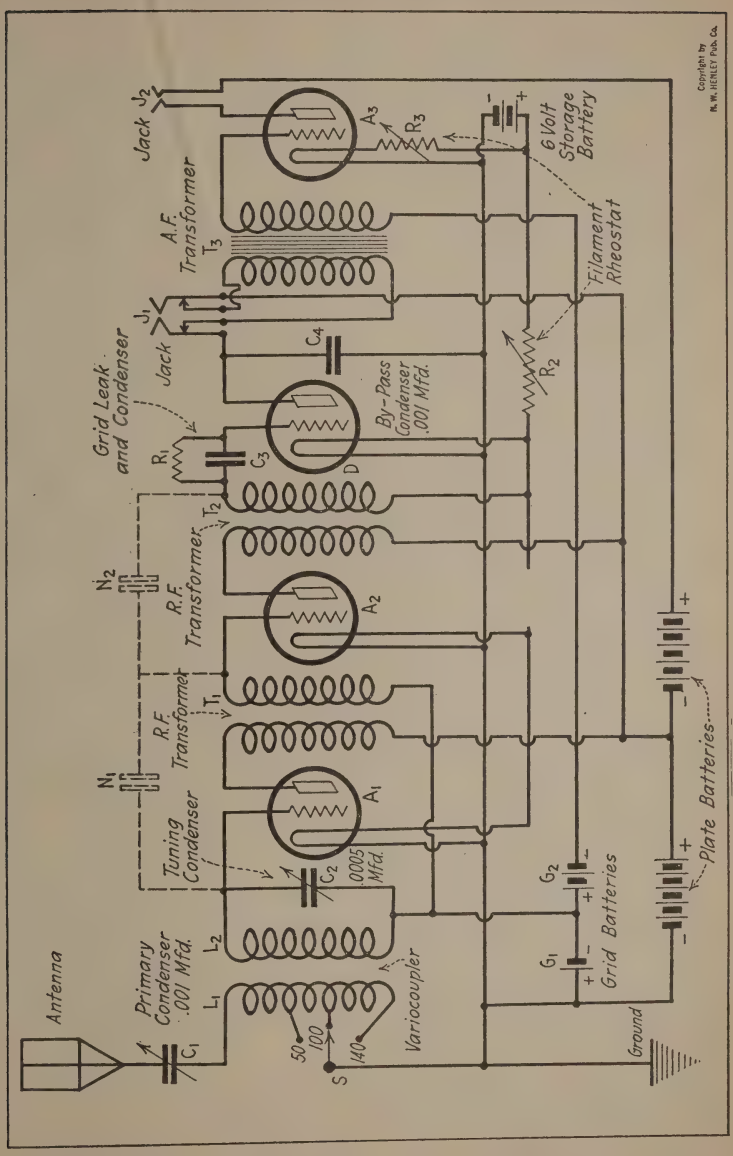


Fig. 49. Circuit Diagram of the Radio Frequency Amplification Receiver

The primary condenser C_1, which is used to obtain final tuning of the antenna circuit, should be of the 43-plate size. Condenser C_2, the secondary tuning condenser, should be of the 23-plate size, and it should preferably be equipped with a vernier adjustment. C_3 is the grid blocking condenser in the input circuit of the detector. Its value may be anything from .0001 to .00025 microfarad. Condenser C_4 is a radio frequency by-pass in the output circuit of the detector. Its value should be about .001 microfarad.

The primary inductance coil L_1 and the secondary tuning coil L_2 may be the stator and rotor respectively of a good vario-coupler, which may either be purchased or made at home. L_1 should contain about 140 turns of No. 24 or No. 26 double cotton covered copper wire wound on a cardboard or composition tube 3″ in diameter. This coil should be tapped at the 50th and 100th turns. L_2 should contain about 60 turns of the same kind of wire wound on a tube 2½″ in diameter. It should be mounted inside the primary coil in such a manner that it may be turned through an angle of 90°.

The transformers T_1 and T_2 may be any two good radio frequency transformers having an effective frequency band of 1350 to 550 kc (220 to 550 meters), T_3 is an audio frequency transformer. Its turns ratio should be 1 to 4 or less and its primary should have a very high impedance. This is necessary in order to get natural reproduction of voice and music.

The grid leak resistance R_1 should be about 2 megohms. R_2 is a rheostat which is used for the filaments of the radio frequency portion of the circuit. If UV201A tubes are used the resistance of this rheostat may be from 6 to 20 ohms. R_3 is the filament control rheostat for the audio frequency amplifier tube. If a 216A tube is used as audio amplifier, this rheostat may be omitted. Otherwise it may be of the same resistance as R_2.

Jack J_1 is a double circuit jack for the output of the detector tube, while J_2 is a single circuit open type for the output of the audio amplifier.

The most satisfactory filament supply is a 6 volt storage battery, unless the small dry cell tubes are used throughout, when a 1.5 or a 4.5 volt dry cell battery may be used to advantage, depending on the type of tube used. The plate voltage on the two radio frequency tubes and the detector should be about 40 volts, and the voltage on the audio frequency amplifier from 60 to 150 volts. The grid voltage on the two radio frequency amplifiers should be about 1.5 volts when the plate voltage is 40 volts. The grid biasing voltage on the audio frequency amplifier tube should vary from 3 volts for 60 volts on the plate to 9 volts for 150 volts on the plate. G_1 is the grid bias battery on the radio frequency amplifiers, and G_1 and G_2 the grid bias battery on the audio frequency amplifier.

In radio frequency amplifier circuits of this type, it has been customary to connect the grid return leads to the sliding contact of a potentiometer connected across the filament for the purpose of preventing self-oscillations in the tubes. This is merely a makeshift, which reduces the amplification to a point where the circuit will not oscillate. A grid battery is not used in that case. A much better method of preventing oscillations is to use the neutralizing condensers N_1 and N_2, which are connected in the circuit as is shown by the dotted lines. When these are used, the grid battery may be used and added amplification secured. The principle of the neutralizing condensers, and the method of constructing and adjusting them, are discussed under the neutrodyne circuit in Chapter VIII.

List of Parts. The following parts and materials will be required for the construction and operation of this receiver:

1 43-plate condenser (.001 mfd.)
1 23-plate condenser (vernier, .0005 mfd.)
1 grid condenser (.0001 to .00025 mfd.)
1 by-pass condenser (.001 mfd.)
2 neutralizing condensers
1 vario-coupler
2 radio frequency transformers
1 audio frequency transformer
1 double circuit jack
1 single circuit jack
1 grid leak—2 megohms
2 rheostats
4 vacuum tube sockets
1 6 volt storage battery
1 120 volt plate battery
1 9 volt grid battery

4 UV 201A vacuum tubes
1 headset
1 telephone plug
1 inductance switch
3 switch points
2 switch stops
1 base board 7″ x 17″ x ½″
1 panel 7″ x 18″ x 3/16″
1 cabinet 7″ x 8″ x 18″
3 dials
6 binding posts
A good antenna and ground, bus wire, machine and wood screws, nuts and some solder

The first step in building a receiver is to collect the various parts and materials that are to go into the set. The size of the panel, baseboard, and cabinet necessarily depends on the amount and size of the various parts, and since these have not been standardized, it would not be practicable to specify

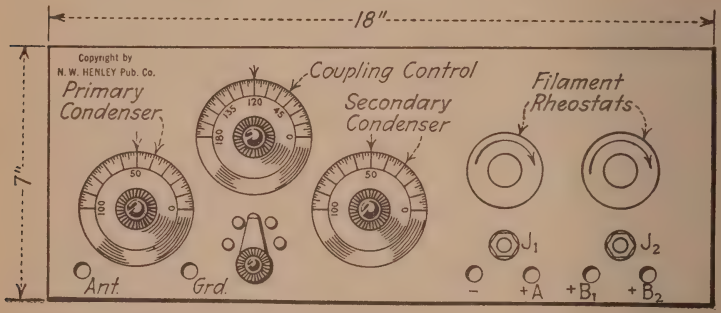


Fig. 50. View of the Front of the Panel

them absolutely. Some builders may prefer a large, roomy set, while others may prefer a neat, compact assembly. Generally, less trouble will be experienced, both mechanically and electrically, if the panel and cabinet are too large rather than just large enough. Figs. 50 and 51 give the panel layout and dimensions for a drilling template, based on a standard panel 7″ x 18″. This is merely suggested as a general guide, and may, of course, be deviated from in either direction to suit the varying tastes of the individual constructors.

It will be observed that a certain measure of symmetry has been secured in the panel layout. The antenna and ground bindings posts are on the extreme left, while the battery

binding posts are opposite. The tuning and coupling elements are placed on the left of the panel, while the jacks and the rheostats are on the right. The rheostats are placed half way up the panel, and the jacks directly under them, and over the battery binding posts.

The first step in preparing the panel is to decide upon the layout. This can only be done after all the parts have been collected. When a satisfactory layout has been decided upon,

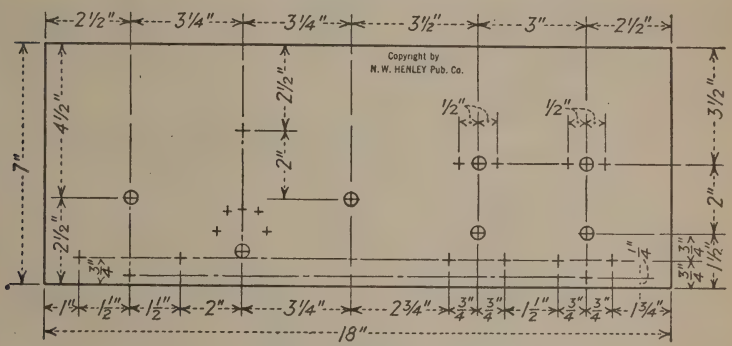


Fig. 51. Panel Drilling Dimensions

obtain all essential measurements of the parts which are to be mounted on the panel. Lay these out on a template made of bristol board or heavy manila paper of the exact dimensions of the panel. This must be done very carefully. Check all the measurements and see that they have been transferred correctly to the template. When sure that the template is correct, clamp it to the panel and mark all holes with a sharp pointed instrument such as a mechanics scriber. Remove template and re-check the location of the centers. If correct, go over all with a center punch, making a hole deep enough to prevent the drill from slipping. Then clamp the panel to the work bench and drill all holes with the proper size drill. For holes larger than about 3/16″ it is well to drill a small hole first and then enlarge to proper size because it is difficult to place a large hole in the right place without first centering it with a

small drill. While drilling it is necessary that the drill be held at right angles to the panel otherwise the holes will not be in the right place on the opposite side of the panel. After all the holes have been made, countersink to proper depth all holes which are to take flathened screws.

When these operations have been completed, mount the parts on the panel and attach the panel temporarily to the baseboard. Then arrange the parts that go on the baseboard in the most suitable manner. Mark their locations with a pencil, remove panel, and mount the parts on the baseboard. Fig. 52 will serve as a guide in mounting the instruments on the baseboard.

If a shield is to go on the panel, it should be prepared and mounted on the back of the panel before any of the parts are mounted on it.

The set is now ready to be wired. Put well-tinned soldering lugs under all binding posts and terminals, both on the panel and on the baseboard, in order that the final wiring and soldering may be simplified. Much trouble will be avoided if as much of the wiring as possible is done before the panel is mounted on the baseboard. In soldering, use a hot, clean and well-tinned copper with a non-corrosive flux. The rosin core solder obtainable in radio stores is suitable.

In wiring the set follow either the circuit diagram Fig. 49 and the perspective drawing of the rear of the set showing the location of the apparatus, Fig. 52.

The reception range of this receiver, using a headset, may be 1000 to 2000 miles or more. High power stations within a radius of possibly 25 to 200 miles may be received on a loud speaker.

Operation of the Set. In operating this set, plug the headset into the detector jack J_1, first making sure that rheostat R_2 is off. Insert the tubes and turn the filament current on gradually until the tubes have the proper brilliancy. Then to tune in a station set condenser C_1 at maximum, the switch S at minimum, and the coupling between L_1 and L_2 near maximum. Then

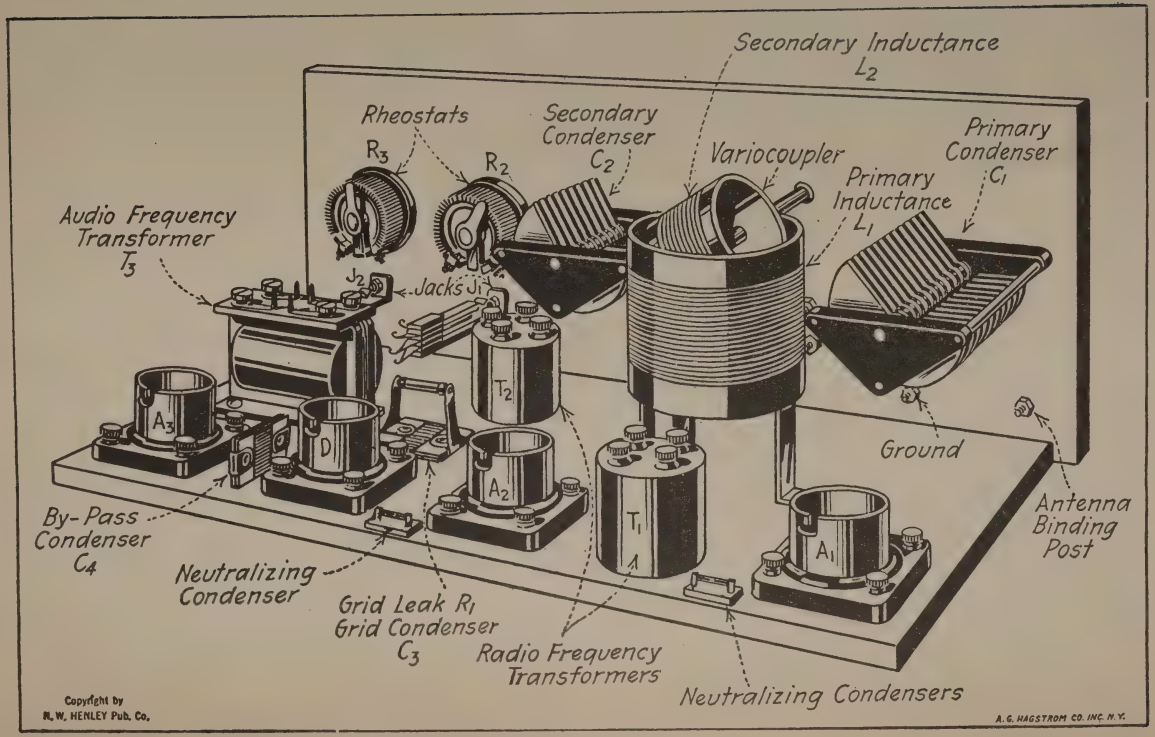


Fig. 52. Rear View of the Receiver

turn the dial of C_2 until the desired signal is heard, and leave it at the point where the signals are a maximum. Now reduce the coupling and retune C_2 to make sure that the signals are at maximum.

It is well to record the values of the two condenser settings as well as the coupling where a given signal is heard best, in order to simplify subsequent tuning operations. This should be done for signals of all wave lengths that are picked up.

CHAPTER VII

Two Tube Reflex Receiver

A Very Satisfactory Type of Reflex Set Is Described in Detail and All the Necessary Information, Including List of Parts, Circuits, Panel and Apparatus Layouts, etc., Is Given for Its Construction

The object of using a regenerative circuit is to obtain the greatest possible volume with the least number of tubes. The same result, however, may be obtained with a reflex circuit in which one or more of the tubes are used twice to amplify the signals—first at radio frequency, and then at audio frequency. Thus, a two tube circuit without regeneration may be made the equivalent of a two tube regenerative circuit or to a three tube non-regenerative circuit composed of one stage of radio frequency amplification, a detector, and one stage of audio frequency amplification. A circuit of this type with tuned coupling is probably also as good as the four tube radio frequency amplifier circuit described in Chapter VI in which radio frequency transformers are used.

The circuit shown in Fig. 53 is an example of a two tube reflex circuit. The first tube is used both as a radio and audio amplifier, while the second is an ordinary detector. The signals are first impressed on the grid circuit of the first tube and amplified at radio frequency. Then they are impressed on the grid circuit of the second or detector tube by means of the tuned coupling transformer. The audio frequency output of the detector is returned to the first tube and impressed on its grid circuit by means of the audio frequency transformer. The amplified audio frequency signal in the plate circuit of the first tube is then passed to the telephone headset or loud speaker.

The selectivity of this circuit is quite satisfactory since the coupling between the antenna and the secondary may be made loose, and there are three tuned circuits to filter out undesired

wave lengths. The radio frequency amplification of the first tube also increases the selectivity.

Condenser C_1 should be an ordinary 43 plate and C_2 should be a 23 plate or smaller variable air condenser. C_3 and C_6 are high frequency by-pass condensers and may each have a value

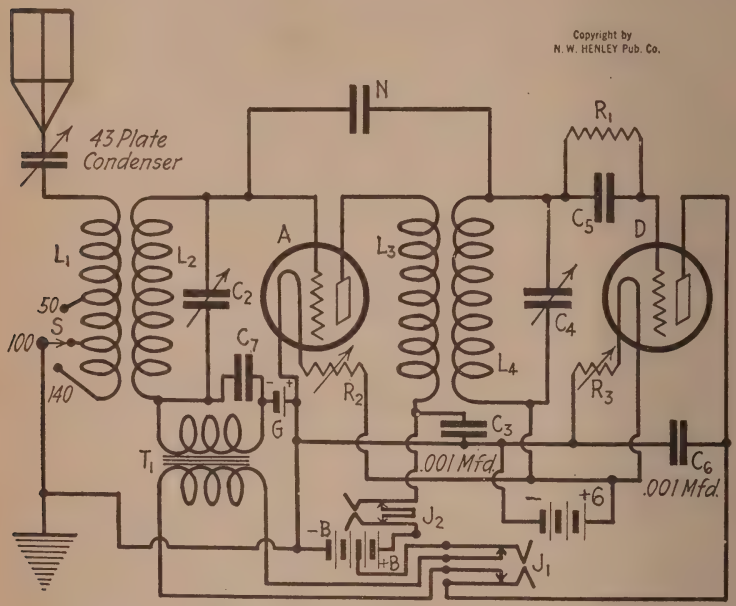


Fig. 53. Circuit of Two Tube Reflex Receiver

of about .001 microfarad. C_4 is a variable air condenser of the same size as C_2. C_5 may have any value from .0001 to .00025 microfarad. The grid leak resistance may vary from ½ to 5 megohms depending on the kind of tube used for detector and the intensity of the signals. For a UV200 it should be about ½ megohm, and for other tubes above 1 megohm. C_7 may be either a .0005 or a .001 microfarad condenser.

For the value of the neutralizing condenser N, its connection and construction, the reader is referred to the description of

the Neutrodyne circuit in Chapter VIII. The purpose of this condenser is to prevent self-oscillation in the first tube.

The best tubes to use in this circuit are the UV201A and 216A types. Smaller tubes should not be used because they would quickly become overloaded by the high voltages impressed, and distortion and singing would result. A good combination of tubes would be a 216A in the first stage, and a UV201A in the second. A WD12 may also used as detector, provided the filament circuit is properly changed.

The primary coil L_1 and the secondary coil L_2 may be the stator and rotor respectively of a good vario-coupler. L_1 should have about 140 turns of No. 24 or No. 26 double cotton covered wire wound on a tube 3 inches in diameter. Taps should be brought out from this coil at the 50th and 100th turns. The secondary L_2 may be wound with 60 turns of the same size wire as the primary on a tube $2\frac{1}{2}''$ in diameter, which will just turn inside the primary provided it is not over $2\frac{1}{4}''$ long. The coupling between the first and the second tube may be an arrangement like the tuned radio frequency transformers used in the neutrodyne type of receiver or L_3 may be wound with about 20 turns of No. 26 or No. 24 double cotton covered wire on a tube $2\frac{3}{4}''$ in diameter, and L_4 with about 45 turns of the same kind of wire on a tube $3''$ in diameter.

It is not desirable to make the coupling between L_3 and L_4 variable because it unnecessarily complicates the tuning of the receiver.

The proper amount of resistance in the rheostats R_2 and R_3 depends on the filament voltage, and the type of tube used. The reader is referred to the discussion on tube characteristics in Chapter I.

Jack J_1 is for the output of the detector tube, and it should be a double circuit jack. J_2 is for the output of the amplifier, and should be a double circuit jack, connected as indicated.

The best plate voltage for the detector is from 22.5 to 45 volts. This is not at all critical except for the UV200 tube, for

which it should be about 22.5. The plate voltage on the amplifier tube may vary from 40 to 120 volts, depending on the tube used. Greater volume is obtainable with the higher plate voltages.

The correct value of the grid battery G depends mainly on the plate voltage used. This information is usually furnished with the tube or see Table II, Chapter I. It varies from ½ volt at 40 volts on the plate to about 9 for 120 volts on the plate.

In many reflex circuits of this type trouble may be experienced from oscillations in the first tube due mostly to electrostatic feed back from plate to grid. The trouble in many cases is minimized when the parts are spread out in a long cabinet, such as is specified for this circuit and following the design described. It may be completely eliminated by the use of a neutralizing condenser, for details of which the reader is referred to the neutrodyne circuit, described in Chapter VIII.

The wave length range of the tuners in this circuit is about 200 to 600 meters. If it is desired to shift this range up or down the wave length scale, it is only necessary to add or subtract a few turns of wire from the tuning coils, L_1, L_2 and L_4.

The reception range of this circuit under good conditions may be 1500 miles or more on a headset. The local stations and even some distant stations may be received on a loud speaker.

Reflex Circuit

List of Parts

1 variable condenser .001 mfd.
2 variable condensers .0005 mfd.
2 mica by-pass condensers .001 mfd.
1 mica by-pass condenser .0005 mfd.
1 grid condenser .0002 mfd.
1 grid leak about 1 megohm
2 rheostats about 10 ohm
1 fixed coupler or tuned radio frequency transformer
1 vario-coupler
1 inductance switch
3 switch points
2 switch stops
2 tube sockets
1 audio frequency transformer
2 double circuit jacks
2 vacuum tubes
1 7″ x 24″ x 3/16″ panel
1 7″ x 24″ cabinet
7 binding posts

4 dials
1 filament battery
1 plate battery
1 grid battery
1 base board 23″ x 7″ x ½″
1 strip of copper foil 3″ x 24″
Antenna wire 150 ft. No. 14
Ground wire 50 ft. No. 14
1 ground clamp
2 antenna insulators
2 nailed porcelain knobs
1 porcelain lead in tubes
1 headset (2200 ohm)
1 telephone plug
Copper bus wire about 25 ft.
machine and wood screws

Description of Set. In Fig. 54 is shown a possible arrangement of the tuning controls on the panel. This is based on a 7″ x 24″ panel, which is recommended although a smaller one may be used. The primary tuning condenser C_1 appears at the extreme left, and the coupling control to the right of this condenser. One of the rheostats is between and below these controls. The primary inductance switch S appears in the middle of the panel, and above the median line. The two secondary tuning condensers C_2 and C_4 are placed on the right half of the panel and centered along the median line. The second rheostat is placed between and below these two con-

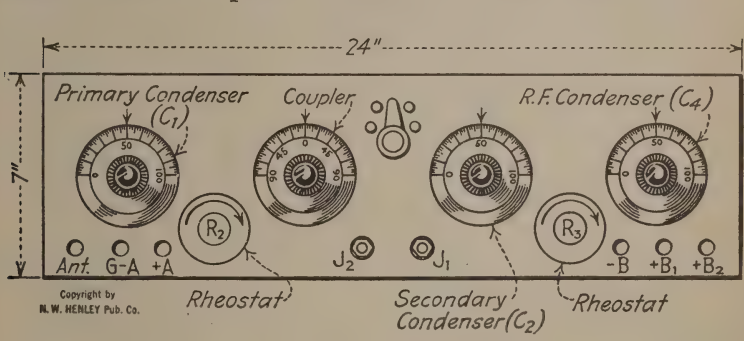


Fig. 54. View of the Front Panel

trols. Half of the six binding posts are placed on the left and half on the right, and the two jacks are placed in the middle. Thus, the layout is perfectly symmetrical. The appearance of the panel may be improved by putting the six binding posts on a sub-panel at the rear.

FIGURE 55 gives dimensions for a template for drilling the panel shown in Fig. 54 and Fig. 56 the floor plan of the re-

ceiver based on a 7″ x 24″ panel, and 7″ x 23″ baseboard.

Before drilling the panel prepare a template of bristol board or heavy manila paper. Measure all the necessary dimensions on the parts that have been obtained for the set, and lay these out accurately on the template. Then clamp the template

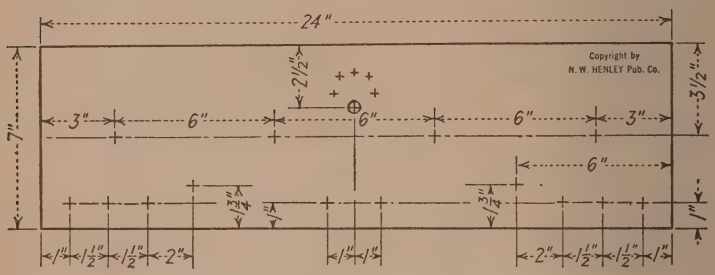


Fig. 55. Panel Drilling Dimensions

to the panel and mark centers with a sharp pointed instrument. Remove template and check locations of centers again to make sure that all holes are in the proper places. Then go over the

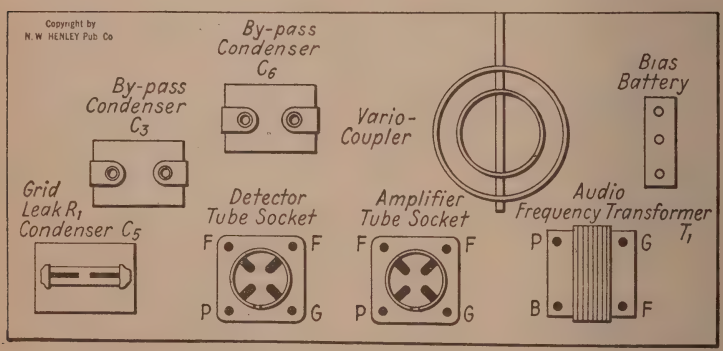


Fig. 56. Layout of Apparatus

panel with a center punch and make a hole deep enough to prevent the drill from slipping. For holes larger than 3/16″ use a small drill first and then enlarge to proper size. It is easier to place a small hole in the exact location than a large

one. After drilling, countersink to the proper depth all holes that are to take flathead screws.

The next step is to mount a good shield on the panel to prevent "body capacity" from affecting the tuning units. This shield should preferably be made of 1/16" copper or brass sheeting, but if this is not available, or if the builder does not have the proper tools to work it, ordinary tinfoil or copperfoil may be used. This may be cut with a pair of scissors and mounted with shellac. Now mount all the instruments on the panel and attach the panel temporarily to the baseboard. Then arrange the parts that go on the baseboard in accordance with Fig. 56, or some other suitable way, being careful to see that none of the instruments on the panel interfere with any on the baseboard. Mark the locations on the baseboard with a pencil. Remove panel and mount instruments on the baseboard permanently. Now put well-tinned soldering lugs on all terminals, and wire as much of the set as possible, following the circuit diagram of Fig. 53 and the perspective of rear of set showing location of apparatus (Fig. 57). Attach the panel to the baseboard and finish the wiring. Use tinned No. 14 copper wire, or tinned bus wire. The use of "spaghetti" or similar insulator is only necessary where there is danger of a short circuit.

Now the set is ready for testing. First go over the wiring with a buzzer to ascertain that everything is correct. Then insert the tubes in the sockets and connect the filament battery. If the tubes light the filament circuit is probably correct. Then connect the plate battery and test whether the high potential reaches the plate terminals. If this also is found correct, the set is ready to be tested for signal reception. Connect the antenna and ground to the proper terminals, and tune in.

Set the primary condenser C_1 on 100, the primary inductance switch on the 50 turn tap, and the secondary condenser C_4 on zero. Then turn the dial of condenser C_2 back and forth, and listen. If a strong signal is within the tuning range of the set, it should be heard. If one is picked up, leave condenser

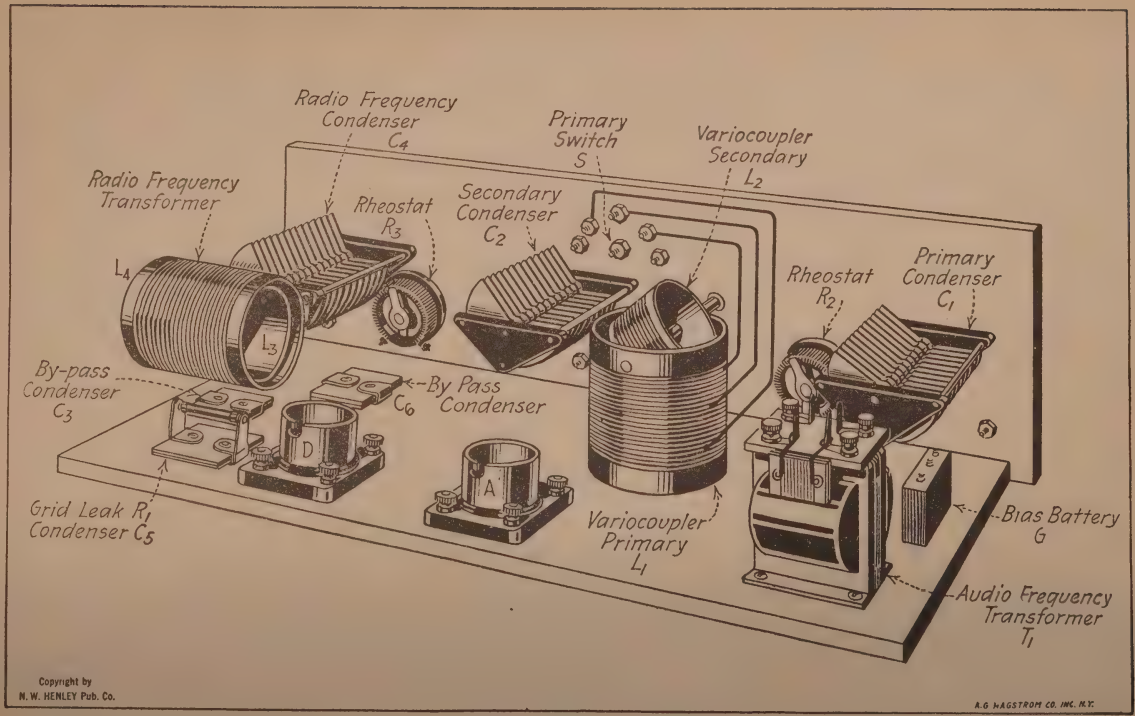


Fig. 57. Rear View of Receiver

C_2 where the signal is loudest, and tune with condenser C_1 to see if a point can be found at which the signals again are loudest. It may be necessary to change the switch S to another tap to find this point. When it has been found retune C_2. Then go to condenser C_4 and tune that for maximum signal strength. Now reduce the coupling to 25 or less, and retune condensers C_1 and C_2. If more than one station can be heard the coupling should be reduced still further. The strength of the desired signal will probably be so great that the coupling may be made very loose. The same process is necessary for all the different wave lengths.

In order to avoid the necessity of going through this tuning process every time a station is desired, the set should be calibrated; that is, the settings of the three tuning condensers and the inductance switch for a given value of the coupling should be recorded. This value of coupling should be low since for close coupling between L_1 and L_2 the tuning of the primary condenser C_1 and the secondary C_2 depends to a great degree on the coupling. The setting of C_4 is practically unaffected by the coupling between these coils.

If there is any trouble from singing and self-oscillation in the circuit the neutralizing condenser N should be used. To adjust this condenser, open the filament of the first tube by means of the rheostat, or by inserting a bit of paper under one of the prongs of the tube. This prevents the signal from passing the tube in the regular way: i.e., through the electron stream. If any of the signal reaches the telephones when they are connected in the output of the detector, or in the jack J_1, it crosses the first tube through stray coupling. It is this that causes oscillations, and it must be eliminated. Adjust the value of the condenser N until no signal is heard or until it is minimum. The neutralization is then complete. A strong signal should be used while adjusting, and all the tuned circuits should be accurately adjusted to the wave lengths of this signal.

If there is also some inductive coupling between L_2 and L_4

the neutralization will only be complete for the frequency at which the adjustment is made. To correct this a small negative tickler coil may be used. The capacity and inductive coupling should be neutralized separately in order that the circuit may be balanced for all frequencies. If the coils L_2 and L_4 are properly placed, the stray inductive coupling should be negligible and tickler unnecessary.

CHAPTER VIII

Neutrodyne Type Receiver

For Distant Reception Through Local Stations the Neutrodyne Type Receiver Is Very Satisfactory and in This Chapter the Details, Including Necessary Circuits, Layouts and Picture Diagrams Are Given for Its Construction. Under "Adjustment of Receiver," the Use of the Calibration Table Is Explained

One of the most satisfactory of all receivers is the five-tube neutrodyne, which comprises two stages of neutralized radio frequency amplification, a detector, and two stages of audio frequency amplification. Since it uses three tuned coupling transformers with a step-up ratio between the tubes, it is very selective and at the same time very sensitive. It will pick up the signals from a 500 watt transmitter 1500 miles away under good weather conditions and deliver sufficient volume to operate a loud speaker without much interference from an equally powerful broadcasting station located a few miles away and operating on a wave length differing by only 5 per cent. Under exceptionally good conditions, signals from stations even 3000 miles away may be received.

Although the receiver has three tuned circuits in tandem, all of which must be in exact resonance with the desired wave, the set is relatively simple to operate. This is because the absence of variable couplings make it possible and practicable to calibrate the tuned circuits so that when a particular station has once been received it may be tuned in again by merely referring to and following the calibration data.

The principle of operation of the neutrodyne circuit may be explained briefly by referring to Fig. 58. There exists a certain amount of electrostatic capacity between the plate of a tube and the grid, and also between the apparatus on the grid or input side of the tube, and the apparatus on the plate or output side. This capacity allows a certain amount of energy from the plate to reach the grid, and this energy reaches the grid in such a manner as to increase the original

input. At radio frequencies the amount of energy that returns to the grid is sufficient to start and maintain oscillations which are independent of the original input, and these oscillations either "paralyze" the tube, or produce undesirable noises.

The principle of the neutrodyne circuit is to wipe out the effect of this capacity between the output and input sides of the tube. This is done by feeding back energy to the grid in opposite phase to that reaching it through the stray capacity in sufficient amount to affect neutralization. This reverse feedback is secured by means of a small neutralizing condenser N_1 connected between the grid of the tube and some point on the output side at which the voltage is of the proper phase. Usually this point is a tap on the secondary of the tuned transformer between the tube and the next following. In order that there may be a point, however, at which the voltage is of the proper phase, the connections of the transformer must be such that there is a change of phase. If neutralization cannot be effected with a certain connection the leads of either the primary or the secondary should be reversed.

In the usual neutrodyne circuit, such as is described here, two neutralizing condensers N_1 are necessary, one for each of the radio frequency amplifier stages.

Description of Receiver

The Circuit. FIGURE 58. In the circuit there are three identical tuned radio frequency transformers, L_1L_2 of special construction. The primary L_1 contains 15 turns of No. 24 double cotton covered wire wound on a cardboard or bakelite tube 2¾″ in diameter. The secondary L_2 contains 60 turns of No. 24 double cotton covered wire wound on a tube 3″ in diameter. The primary coil is mounted inside the secondary near the ground end of tube and the terminals are brought out to four binding posts attached to the ends of the secondary coil former. A tap is made on the secondary coil at about the seventeenth turn from the terminal. When this unit is made up, it is mounted directly on a 17 plate variable air condenser

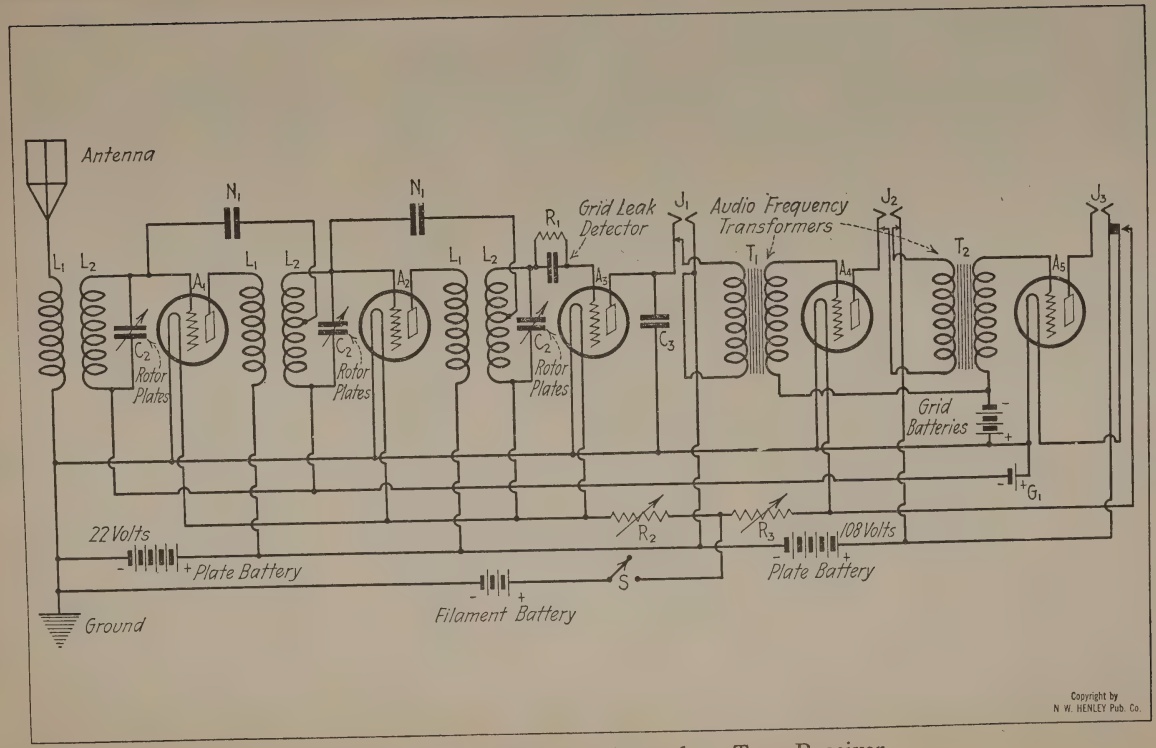


Fig. 58. Circuit Diagram of Neutrodyne Type Receiver

and the proper connections made to the secondary coil. The rotor plates of the condenser should be connected to the filament terminal of the coil secondary.

Three of these units are needed in this receiver. They may be obtained in any radio store ready for panel mounting, under the trade name of neutroformers. A much more satisfactory receiver may be constructed if these units are purchased rather than made at home.

Various forms of the neutralizing condensers N_1 may be used. Perhaps the simplest and best is that sold under the trade name of Neutrodon. It consists of two heavy copper wires W_1 and W_2 (Fig. 59) placed end to end but separated about ⅛ of an inch. These are surrounded by a brass sleeve S made of a piece of brass tubing 3/16″ in diameter and 2″ long. The sleeve is insulated from the central wires by a fibre bushing. This arrangement forms in reality two small condensers in series. To vary the capacity the sleeve is moved back and forth. The capacity is greatest when the sleeve covers just as much of one wire as the other, and least when it is entirely clear of one of them.

The grid condenser C_1 (Fig. 58) may be a .0002 microfarad

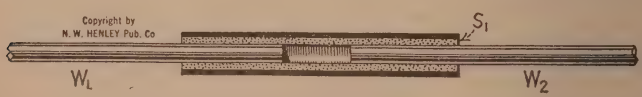


Fig. 59. Balancing Condenser

mica condenser and the by-pass C_3 may be a .001 microfarad condenser.

The grid leak resistance should be about 2 megohms. The rheostats R_2 and R_3 may each have a resistance of 10 ohms, and they should have a carrying capacity of at least one ampere.

J_1 and J_2 are double circuit jacks, while J_3 is a single circuit open automatic filament control jack.

S is a single pole single throw jack switch for turning on and off the filament battery.

T_1 and T_2 are any good audio frequency transformers having a high primary impedance and a ratio of not much more than 4 to 1.

It is recommended that UV201A or similar tubes be used throughout, except that WE216A tubes may be used in the audio frequency amplifier. No changes in the circuit need be made if both the audio amplifier tubes are the same, but if A_4 is a UV201A and A_5 a WE216A, then the lead from the automatic filament switch to the positive side of the filament of tube A_4 should be moved to the other side of rheostat R_3; i.e., to the lead between the switch S and rheostat R_3. No rheostat is necessary when the 216A tube is connected to a 6 volt battery, and the filament of tube A_4 would not be safe if the 216A tube were also on rheostat R_3.

A 6 volt storage battery should be used to supply the filament current in this circuit. The plate voltage on the two radio frequency tubes and the detector should be about 40, and on the two audio tubes about 120. The grid voltage on the first two tubes should be about 1½ volts, while that on the audio frequency tubes should be about 9 volts. These voltages are given by the grid batteries G_1 and G_2. If the plate voltage on the audio tubes should be reduced, the value of the grid voltage should also be reduced,—see Table II, Chapter I.

Neutrodyne Type Receiver

List of Parts

3 17-plate variable air condensers
3 radio frequency transformers
2 neutralizing condensers
1 by-pass condenser, .001 mfd.
1 grid condenser, .0002 mfd.
1 grid leak, 2 megohms
5 tube sockets
2 double circuit jacks
1 single circuit open jack with automatic filament control
2 rheostats—10 ohms
1 6 volt storage battery
3 45 volt plate batteries
2 4½ volt grid batteries with taps
1 1½ volt dry cell
7 binding posts
1 7″ x 24″ x 3/16″ panel
1 23″ x 7″ x ½″ base board
1 7″ x 8″ x 24″ cabinet
3 4″ dials
1 head set
5 UV201A tubes
25 ft. 1/16″ tinned copper bus bar, wood and machine screws, soldering lugs, and nuts
2 telephone plugs
1 loud speaker

The Set. FIGURE 60 shows a sketch of the finished panel with knobs and dials mounted on it. If desired, all binding posts may be put on a sub-panel at the rear of the cabinet. This will greatly improve the appearance of the receiver, as it eliminates all unsightly battery leads from the front panel.

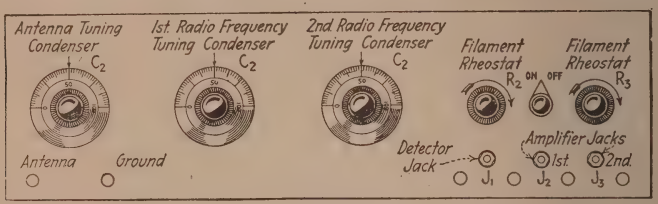


Fig. 60. View of the Front Panel

FIGURE 61 gives dimensions for a drilling template of the panel. This is merely suggestive of the general layout, as accurate figures would not be applicable to all makes of apparatus. As a preliminary step in preparing the panel all essential dimensions of the parts to be mounted on the panel should be obtained with a ruler and a pair of dividers. These

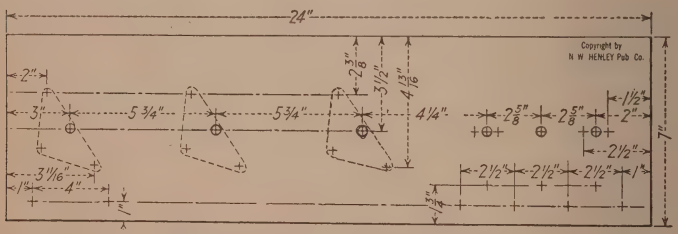


Fig. 61. Panel Drilling Details

dimensions should then be laid out on a piece of bristol board or heavy manila paper of the same dimensions as the panel. When this has been done and carefully checked for possible errors, the cardboard template should be accurately clamped to the panel. The marks should be made in the panel through the cardboard with a sharp pointed scriber. Then the template should be removed and the marks on the panel carefully

checked to make sure that all the holes are in the right place. This must be done very carefully, especially for the condensers and the two rheostats.

After the true location of all holes has been verified, all should be gone over with a center punch to make a mark large enough to prevent the drill from slipping. For holes larger than 3/16″ it is well to drill a smaller hole first, and then

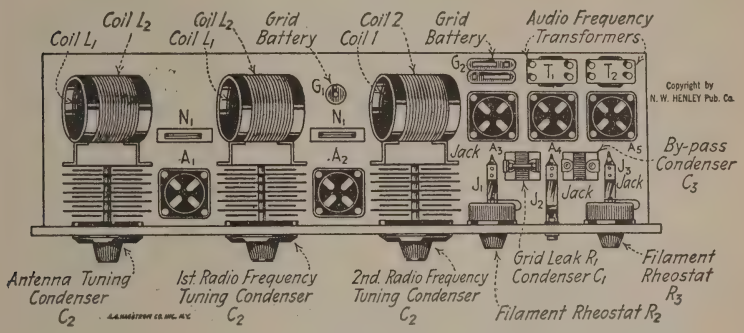


Fig. 62. Layout of Apparatus

enlarge to proper size. The size of the drill to be used for the various holes must be determined after the apparatus have been purchased. For a ¼″ shaft, which is used in most condensers, a 5/16″ drill is about right, and for a standard 6/32″ machine screw, a No. 26 B & S drill. Jacks usually require a ⅜″ or 7/16″ drill. After the panel has been drilled, carefully countersink the condenser and rheostat mounting holes until the proper size flathead machine screw will just fit without projecting above the panel surface. Then mount all the parts that are to go on the panel, and then temporarily mount the panel on the baseboard. When this has been done, arrange all sockets, transformers and grid batteries on the baseboard in accordance with the floor plan given in Fig. 62, in such a manner that the parts on the baseboard do not interfere with those on the panel. Mark the locations with a pencil, remove the panel, and mount sockets, transformers, etc. on the base-

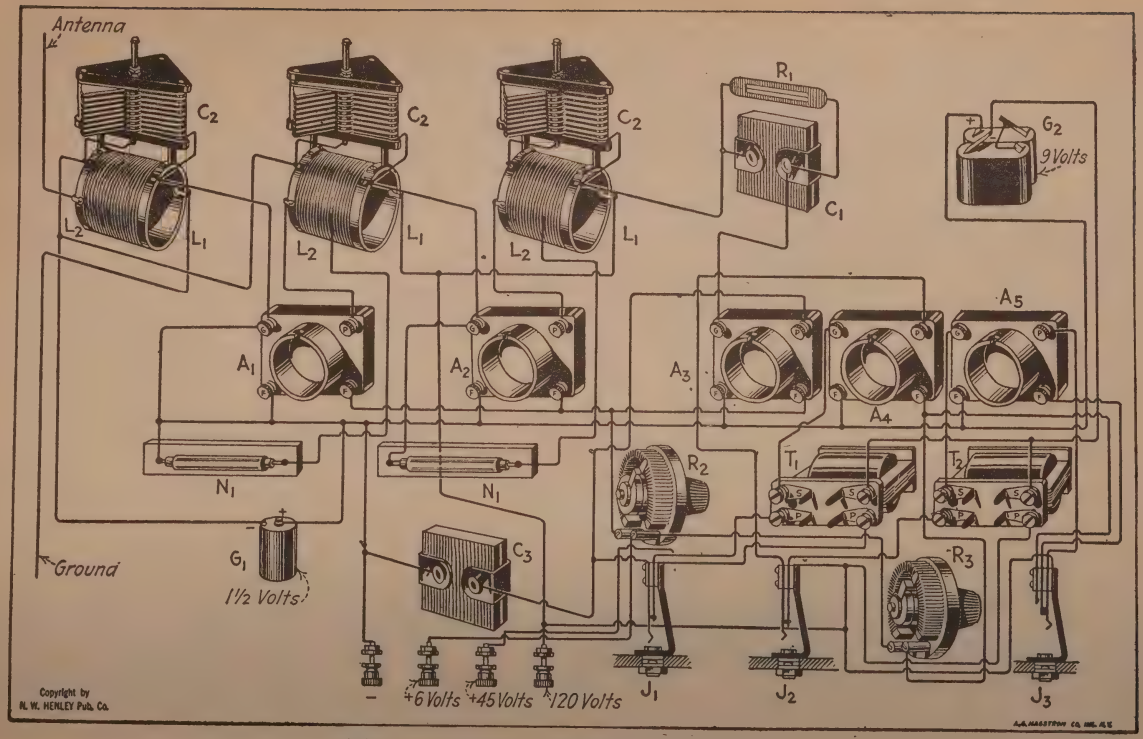


Fig. 63. Picture Diagram of Connections

board permanently. Then before attaching the panel permanently to the baseboard, put well-tinned solderings lugs on all terminals where connections are to be made. Then wire the set in accordance with the circuit diagram shown in Fig. 58 or with the picture diagram shown in Fig. 63. Either No. 14 tinned copper wire or 1/16" tinned copper bus wire may be used. The use of "spaghetti" is optional. Bare wire is entirely satisfactory if precaution is taken against short circuits. Solder all connections with a hot, clean, soldering copper, using a non-corrosive flux, such as rosin.

Adjustment of Receiver. When the wiring has been completed test the circuit with a buzzer to make sure that all connections are correct. If a buzzer is not available, an ordinary headset with a 1½ volt battery in series may be used. When certain that all connections have been made correctly, insert tubes into the sockets to see if they will light, and if the rheostats function properly. Next connect the plate battery and ascertain whether the plate voltage reaches the plate binding posts on the sockets.

The next procedure is to adjust the neutralizing condensers. If a high frequency buzzer is available this may be used in this connection; otherwise, tune in the set on the nearest broadcasting station. Tune very carefully so that all the tuned circuits are in resonance with the incoming wave. Remove the first tube from its socket and insulate one of the filament prongs with a bit of paper. Then replace tube in its socket. A weak signal will still probably be heard while listening in one of the jacks. Now adjust the first neutralizing condenser until this signal entirely disappears or until it is minimum. Then remove the insulating paper from the prong of the first tube so that it will light. Then go to the second tube and insulate that in the same way. Again a signal will probably be heard in the telephones. Adjust the second neutralizing condenser until the signal disappears or until it is minimum. This completes the adjustment of the neutralizing condensers.

The receiver is now ready for calibration. If a calibrated wave-meter, capable of transmitting any desired high frequency wave is available, this is the most convenient and rapid for calibrating the receiver. If one is not available, recourse must be taken to the various broadcasting stations.

TABLE III

CALIBRATION TABLE

Call Letters	Frequency KC.	Wave Length Meters	Settings of Condenser Dials			Call Letters
			1	2	3	
KSD	550	546	81	87	84	
KYW	560	536	77	83	80	
WOAW	570	526	74	79	76	
WCX	580	517	70	75	73	WWJ
WIP	590	509	67	72	69	WOO
WMC	600	500	64	69	66	
WEAF	610	492	61	66	63	KGW, WECO
WOC	620	484	58	64	60	
WFAA	630	476	56	61	57	WBAP
WRC	640	469	53	58	55	WCAP, KFI
WCAE	650	462	50	56	52	
WJZ	660	455	48	53	50	KDZE
WJAZ	670	448	46	51	48	WMAQ
WOS	680	441	44	49	46	
	690	434				
WSB	700	429	40	45	41	
KPO	710	423	38	43	39	
WBAH	720	417	36	41	37	WLAG
WDAF	730	411	34	39	36	WHB
WJY	740	405	32	37	34	WOR
CFUC	750	400	30	36	33	PWX, WBAK, WHAS

Prepare a table like that shown in Table III for the record of the calibration. The first column is reserved for the call letters of the broadcasting stations, the second gives the frequency of the wave, the third the corresponding wave length, the fourth, fifth and the sixth the setting on the three variable condensers and the seventh is reserved for additional stations.

To make a complete table begin with 550 kilocycles and increase the frequency by 10 kilocycles at a time up to 1350. One line should also be reserved for the 833 kilocycle frequency, which corresponds to the 360 meter wave length used by class A transmitting stations. As there is more than one station sending on any one frequency ample room should be provided in the first and seventh columns for several call letters.

The call letters, frequencies, and corresponding wave-lengths may be obtained from the list published in this book, or it may be obtained from government publications. To complete the table, tune in accurately a station, and as soon as it has been identified by its call letters record the capacity setting of all the condensers in the proper square. Do this whenever a new station is tuned in, and the calibration table will gradually be filled in. To tune in subsequently on any desired station, all that is necessary is to refer to the table, set the dials, and listen.

As many of the Canadian broadcasting stations do not fit into this table, a similar table should be made for them.

CHAPTER IX

Super-Heterodyne Receiver

The Most Sensitive and Selective Receiver—The Super-heterodyne—Is Described in Detail. The Construction of the Beat Frequency Transformers Is Explained and Methods of Testing Them and the Complete Set Are Minutely Described

The most satisfactory receiver from the points of view of sensitivity, selectivity, and simplicity of operation, is the super-heterodyne. It is capable of delivering loud speaker volume of signals from either local or distant transmitting stations in almost any locality and with a reasonably good antenna, provided atmospherics or man-made static from electrical installations is not excessive in that location. In places where an outdoor antenna is not possible, this receiver may be used with entire satisfaction on a small loop or on an open wire erected in the room. It surpasses all other types of receivers in selectivity and the only practical limit to its sensitivity is static disturbances. The quality of the signals is exceptionally good because amplification is mainly done at radio frequency.

Principle of Operation. When two musical tones of nearly equal pitch are sounded together, there is a periodic rise and fall in the intensity of the sound heard. The frequency of this rise and fall is equal to the difference between the frequencies of the two tones which are sounded together. Almost everybody is familiar with this phenomenon in accoustics, and knows it by the term "beats."

As the difference between the frequencies of the two tones is increased the beat frequency is also increased until the separate beats can no longer be heard. The beat frequency then merges into a tone, which at first is of a low disagreeable pitch, but finally becomes as pleasing as either of the two original tones.

Since musical tone frequencies are relatively low, the beat frequency between them is also low. But the principle applies equally well to air vibrations far above the musical scale, and even to vibrations whose frequencies are far above audibility, and it is not limited to air vibrations. The principle applies also to electrical vibrations or oscillations. When currents of any two frequencies are impressed on a suitable detector circuit, the two produce a beat current whose frequency is the difference between the frequencies of the two original currents. The whistling interference familiar to every radio listener is a beat frequency between two electrical vibrations of much higher frequencies. When the two original frequencies are the same, no beat can be heard, but as one is changed the beats begin to be heard, first as a tone of a low pitch, then higher and higher, until it becomes a shrill whistle, which gradually passes into the region above audibility. The beats do not cease as long as the two vibrations are maintained; they merely cease to be heard.

The principle of beats is used for the reception of continuous radio waves which have a frequency so high that they are inaudible to the human ear. To make it audible another vibration is generated at the receiving station and this is impressed on the same detecting circuit as the signal wave. The locally generated vibration is made to differ from the incoming signal frequency by an audible beat frequency and hence the signals may be heard. This method of reception is called *the heterodyne method* of receiving continuous waves.

The heterodyne or beat frequency may also be made so high that it cannot be heard by the human ear; that is, it may be a super-audible heterodyne frequency. That is the case in the super-heterodyne method of receiving continuous and modulated continuous radio waves, which is an application of the principle of beats. The high frequency oscillation carrying the signal is received on an ordinary tuner or radio frequency amplifier and is impressed on a detector or modulator. On this modulator is also impressed the output of a local high fre-

quency oscillator, whose frequency is adjusted so as to differ from the incoming oscillation by any desired super-audible beat frequency. A current of this beat frequency results. This is selected by means of a tuned circuit and amplified to any desired extent. It is then detected to make it audible in the loud speaker or telephones. Thus in the super-heterodyne method of reception the radio frequency is stepped down to another and much lower radio frequency at which it is amplified. The amplification at this frequency may be carried to a much higher level because the amplifier tubes are much more efficient and the accompanying circuits are much more stable in operation at this lower frequency.

The Circuit. In Fig. 64 is shown the circuit diagram of a satisfactory super-heterodyne receiver in which eight tubes are used. The first tube is a radio frequency amplifier and "silencer." It is connected directly across the antenna inductance in order that full advantage may be taken of the high potentials obtainable in the single circuit tuner. It is non-regenerative and it is so adjusted that no energy from the plate side of the circuit can get back to the grid side. Thus the audible beats which may be generated in the modulator due to the interaction of the locally generated oscillations, with the signal carrier frequency are prevented from reaching the antenna. This effectively prevents this super-heterodyne from radiating and thereby causing the well known "bloop"' type of interference. The second tube is the local oscillator and the third is the modulator. The incoming oscillations are impressed on the modulator by means of the tuned transformer L_1L_2, and the local oscillations are impressed on the modulator by means of the coupling coil L_4, which is in mutual relation with the oscillating coil L_3. The fourth and fifth tubes are intermediate frequency amplifiers, which are coupled by means of the tuned transformers L_5L_6. There are three of these. The last of them impresses the super-audible frequency on the sixth tube, which is a detector. The seventh and eighth tubes are ordinary audio frequency amplifiers.

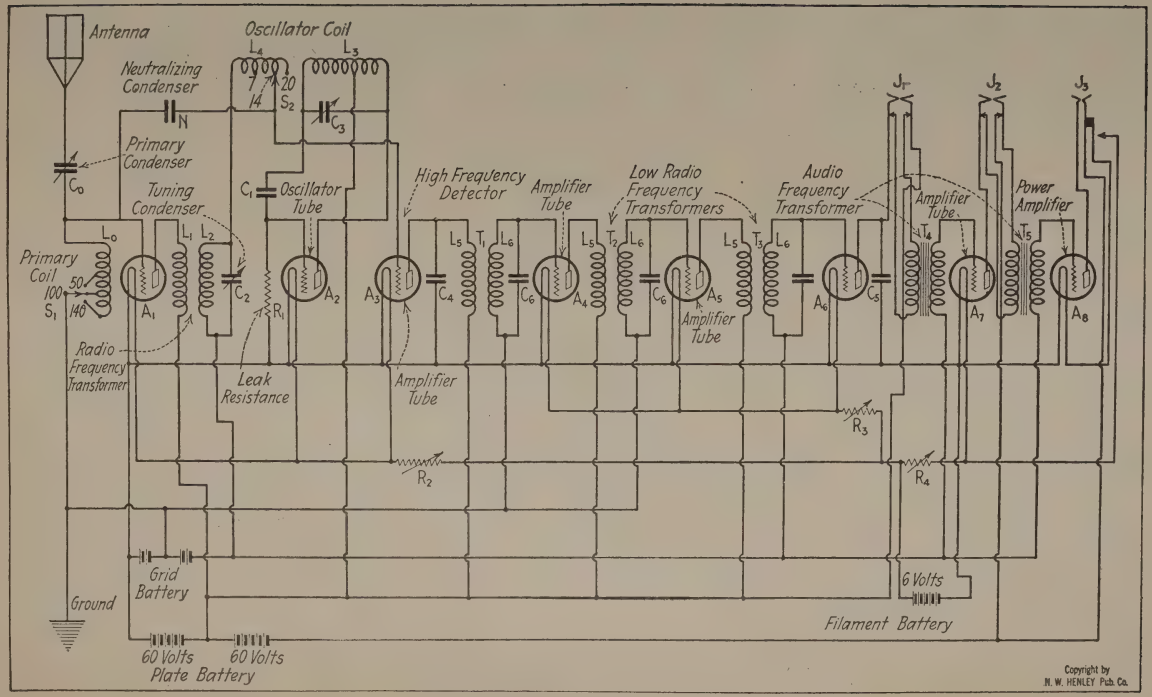


Fig. 64. Circuit Diagram of Super-Heterodyne Receiver

C_0 may be either a 43 or a 23- plate condenser of the ordinary type. C_2 and C_3 should be 23-plate variable air condensers preferably supplied with vernier adjustment. C_1 is a mica dielectric condenser having a fixed capacity of .001 microfarad. C_4 may be of the same type and size as C_1. The three condensers C_6 should be good mica dielectric condensers having a value of .0001 microfarad. C_5 should be a condenser of the same type but its capacity should be about .002 microfarad. N is a small neutralizing condenser to prevent the first tube from oscillating. Its size and method of construction may be obtained in the discussion on the neutrodyne circuit in this book.

The coil L_0 is the antenna tuning inductance. It should consist of about 140 turns of No. 26 double cotton covered wire wound on a cardboard or composition tube 3″ in diameter. This coil should be tapped at the 50th and 100th turns. L_1 may consist of 15 to 20 turns of No. 26 double cotton covered wire wound on a tube 2½″ in diameter, and L_2 may consist of 55 turns of No. 22 or No. 24 double cotton covered wire wound on a tube 3″ in diameter. L_1 should be placed inside of L_2 in order to secure the proper coupling and to conserve space. The tuned coupling transformer L_1L_2 may be made similar to those described under the neutrodyne circuit. L_3, the oscillating coil, may consist of 50 turns of No. 22 or No. 24 double cotton covered wire wound on a tube 3″ in diameter. This coil should be tapped at a point about 20 turns from the plate terminal. L_4 may contain about 20 turns of No. 26 double cotton covered wire wound on a tube 2″ in diameter with taps taken out at the 7th and the 14th turns. This coil should be mounted inside of coil L_3.

Coils L_5 and L_6 are the primary and secondary, respectively, of the coupling transformers T_1, T_2 and T_3. These transformers may be made as follows: First obtain three wooden spools 2″ in diameter and 1″ long with ⅜″ flanges. Then put on 500 turns of No. 36 double cotton covered wire as evenly as possible. Cut wire and bring out terminals. Then put on several

layers of paraffined paper. On top of this wind 250 turns of the same kind of wire as the first winding. This 250 turn winding constitutes L_5, the primary. Put on some more paraffined paper as before, and on top of that put on another 500 turns of wire. Connect the outside terminal of the first 500 turns to the inside terminal of the second 500 turns. These two windings connected in series constitute the secondary L_6. Bring the four terminals of the transformer out to binding posts which may be fastened to the wooden core. Solder connections and protect the fine wire where exposed with bees wax or similar substance. Now fasten the condensers C_6 to the secondary binding posts. The coils are now ready to be tuned. How this may be done is discussed in another section below.

If it is not desired to construct these transformers very good results may be obtained with coils sold under the name Rubicon Type SR. The Radio Receptor Company's coils may also be used. Of course, the condensers C_6 must not be used.

The oscillator grid leak resistance R_1 should be about 12,000 ohms. This is used to maintain the grid at the proper negative potential with respect to the filament. R_2 is a rheostat which controls the filament current in the first three, or radio frequency tubes. R_3 is a rheostat which controls the filament current in the three intermediate frequency tubes, and R_4 a rheostat which controls the filament current in the two audio frequency tubes. If a Western Electric 216A tube is to be used in the last stage and a UV201A the seventh (A_7), R_4 should only be used for the latter tube. The 216A tube may be connected across a 6 volt battery. If 216A tubes are to be used in both the audio frequency stages, R_4 may be omitted or it may be retained as a filament switch.

The audio frequency transformers T_4 and T_5 should have a primary impedance several times higher than the output impedance of the tubes. This is necessary in order to prevent distortion of the signals. The turns ratio for best quality should be about 4 to 1 or less.

J_1 and J_2 are double circuit jacks for the outputs of the detector and first amplifier, respectively. J_3 is a single circuit, automatic filament control jack for the output of the last amplifier.

The best tubes to use in this circuit are UV201A or tubes having the same characteristics, except in the audio frequency amplifier, where Western Electric 216A may be used to good advantage.

The filament current should be supplied by a 6 volt storage battery having a capacity of about 120 ampere-hours. When all the tubes are lighted and when 216A tubes are used in the last two stages as suggested, the total filament current will be about $3\frac{1}{2}$ ampere.

The plate potential on the two audio frequency tubes should be 120 volts and on the first six tubes it may be 60 volts. For these voltages on the plates, the grid biasing potential on the two audio frequency tubes and on the two detectors should be about 9 volts and on the other amplifier tubes it should be about 3 volts. Hence the grid biasing battery should be made up of three 3-volt units.

In both the detectors grid biasing batteries are used for detection because this method of detection is more reliable and generally more satisfactory, especially when strong signals are involved.

If the three intermediate frequency transformers T_1, T_2 and T_3 are connected into the circuit without tuning it is probable that the receiver will not be very sensitive. The three transformers will undoubtedly tune to three slightly different frequencies due to variations in the windings. Even if each one is efficient at its own natural frequency, the overall efficiency will not be high unless the three tuning peaks coincide exactly. Therefore if full advantage is to be taken of the amplification of the tubes and the step-up of the transformers it is necessary to tune them. Two ways of doing this will be shown below.

The First Method. The best way of tuning the intermediate frequency transformers is to set up a special test circuit for

this purpose. This consists of an oscillator which generates a frequency of about 50,000 cycles per second, and an amplifier which is as nearly equal to the amplifier into which the transformers finally go as is practicable. The test circuit is shown in Fig. 65.

The circuit of the oscillator should be entirely independent of the amplifier except for a small coupling transformer L_1L_2; that is, the batteries should be distinct and the oscillator as a whole should be enclosed in an iron box. This box should be

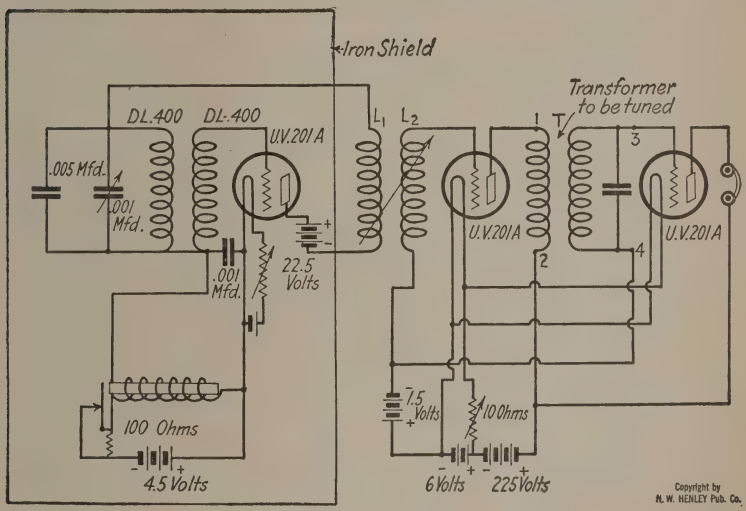


Fig. 65. Diagram of Testing Circuit

grounded and the thickness of the wall should not be less than 1/16″. The various parts of this oscillator may be mounted on a small board and Fahnestock clips may be used for terminals. The amplifier may be made similarly except that it is not necessary to shield it.

The oscillator circuit is composed of a 400 turn duo-lateral coil and two condensers, one of which is a mica condenser of .0005 microfarad capacity and the other a 43-plate variable air condenser. The oscillator coil is coupled inductively to the

grid by means of another 400 turn duo-lateral coil. The coupling between these coils should be as close as it is possible to make it. If the circuit will not oscillate, reverse the connections to one of the duo-lateral coils. The 50,000 cycle oscillations thus generated are modulated by means of a buzzer which is coupled to the grid circuit of the oscillator through a fixed condenser of .001 mfd. capacity. When the buzzer and oscillator are started, a modulated high frequency current will flow through coil L_1. This may be picked up by the amplifier circuit provided the detector is properly tuned to the frequency of the oscillator.

The transformer to be tested is placed between the two amplifier tubes UV201A. The inside terminal of the inner winding should be connected to the plate of the first tube, and the other terminal of that winding should be connected to the positive side of the plate battery. The inside terminal of the outer winding should be connected to the negative filament terminal of the second tube and the other terminal of that winding to the grid of the second tube. Now if a telephone is inserted in the plate circuit of the last tube, and the oscillator is started, the buzzer signal will be heard. If either the tuning of the secondary of transformer T or the frequency of the oscillator is varied, the strength of the signals heard in the telephones will vary. When the sound is a maximum the frequency of the oscillator is exactly in tune with the transformer.

Since there are three tuned transformers in the super-heterodyne circuit, each one of these should be placed in the test circuit and tested separately. First select the one which tunes to the highest frequency. This should be done because the others may then be tuned by removing turns rather than by adding turns, and it is much more simple to decrease the number of turns than to increase them. When the transformer that tunes to the highest frequency has been found by actual trial, use that frequency as a standard; that is, when the frequency of the oscillator has been varied until it fits exactly with the

transformer, leave the oscillator untouched and then substitute the other two transformers in turn in the test circuit, and change the number of turns in the secondary of each until the sound in the telephone is a maximum.

When all the transformers have been adjusted to the same frequency in this way, they may be connected into the intermediate frequency amplifier of the super-heterodyne circuit.

The Second Method. The following method may also be used in adjusting the intermediate transformers to the same frequency. This, however, is not as satisfactory as the preceding, but it is considerably less expensive and entails less work. In this method, the transformers are tested directly in the super-heterodyne circuit, and instead of using a separate oscillator to generate the intermediate frequency, the regular super-heterodyne frequency is used. This requires that the circuit be tuned to some incoming signal, and that the other frequency oscillator be started, so that the super-heterodyne frequency may be produced.

First remove all the intermediate transformers T_1, T_2 and T_3. Then disconnect the condenser C_4 from the plate terminal of tube A_3, and connect the plate of tube A_3 to the plate of A_5. Now connect in turn all the intermediate transformers between tubes A_5 and A_6 to determine which one tunes to the highest frequency. This may be done by listening in with the telephones in jack J_1, and by tuning the circuit to the incoming signal. Two settings of condenser C_3 will be found at which the signal will be maximum, one which is below the frequency of the incoming signal, and one above. The distance on the dial between these two points determines the intermediate frequency. The transformer which gives the widest separation between these two points on the condenser C_3 tunes to the highest frequency. This should be used as a standard, as was done in the case of the first method.

Now leave that transformer in place and remove the temporary connections between the plates of A_3 and A_5, and connect together the plates of A_3 and A_4. Now insert one of the

remaining intermediate frequency transformers between tubes A_4 and A_5, and without altering the position of condenser C_3, vary the number of turns on the secondary of transformer T_2 until the signal as heard in the telephones is again a maximum. The second transformer it then exactly in tune with the same frequency as the first.

Now insert the remaining transformers between tubes A_3 and A_4, remove the temporary connection between the plates of these tubes, and connect the by-pass condenser C_4, as shown in the diagram. Then vary the number of turns of the secondary of the transformer T_1; that is, of the remaining intermediate frequency transformer, until that also is in tune with the same frequency. This completes the adjustment of the intermediate frequency amplifier.

While this test is progressing it is absoluetly essential that the frequency of the local high frequency oscillator does not vary.

The tuning of the intermediate frequency transformers, if done by the first method, should be carried out before the set is assembled because then some of the parts which will ultimately go into the set may be used for the construction of the test set.

The following parts will be needed for the construction of this receiver:

- 3 23-plate variable condensers (.0005 mfd.)
- 1 small neutralizing condenser
- 2 mica-dielectric fixed condensers (.001 mfd.)
- 3 mica fixed condensers (.0001 mfd.)
- 1 mica fixed condenser (.002 mfd.)
- 2 inductance switches
- 6 switch points
- 4 stops
- 5 inductance coils, as described in text
- 3 intermediate frequency transformers, as described in text
- 2 audio-frequency transformers
- 2 double circuit jacks
- 1 single circuit, automatic filament control jack
- 8 vacuum tube sockets
- 1 grid leak resistance, 12,000 ohms
- 3 rheostats, 10 ohms each
- 1 6-volt, 120 ampere-hour storage battery
- 3 45 v. tapped "B" batteries
- 2 4½ v. "C" batteries
- 1 1½ v. dry cell
- 1 panel, hard rubber or bakelite, 7″ x 36″, or larger
- 1 baseboard, 7″ x 35″ x ¾″, or larger
- 1 cabinet to fit the panel
- 7 binding posts
- 1 strip bakelite 2″ x 10″, for binding posts
- 25 ft. bus wire
- 2 dozen terminal lugs
- Solder, wood screws, machine screws, etc.

1 telephone headset
2 telephone plugs
1 loud speaker for coil test circuit
7 UV201A tubes
1 216A tube
1 high frequency buzzer
1 iron box to enclose oscillator, see text
2 duo-lateral coils DL 400
1 6-ohm resistance
4 Fahnestock clips
1 43-plate condenser (.001 mfd.)
2 22½ volt "B" batteries
1 1.5 volts dry cell No. 6
1 4.5 volts "C" battery to be used for buzzer
1 fixed mica condenser, capacity .0005 mfd.
1 small coupling coil, as described in the text on the test set

Construction of the Set. The construction of the super-heterodyne receiver may be done in accordance with Figs. 64 to 69. Fig. 64 shows the schematic diagram of the receiver which may be used in wiring the set. Fig. 66 shows a suitable panel layout which may be used if desired. This is based on a panel 7" wide by 3 ft. long. In Fig. 67 are dimensions for a drilling template in accordance with the panel layout, as shown in Fig. 66.

The baseboard arrangement of the various parts is shown in Fig. 68. This figure shows the oscillator circuit in a separate shielded compartment on the extreme left of the receiver. The oscillator condenser C_3 is mounted on the panel at the extreme left and directly behind it is the oscillating coil L_3 and the small coupling coil L_4. The coupling inductance switch S_2 is also in this compartment, and is mounted between condensers C_3 and C_0. The oscillator tube is also mounted in this compartment and is placed at the rear.

The primary condenser C_0 and the primary inductance coil L_0 are mounted next. The primary tuning switch S_1 is mounted between condensers C_0 and C_2, and directly in front of the inductance coil L_0. The first radio frequency amplifier tube is mounted directly behind condenser C_0, and the modulator tube is mounted behind coil L_0. The secondary tuning condenser C_2 is mounted near the center of the panel and the tuned transformer L_1L_2 is mounted directly behind this condenser. It may be mounted in the same way as the tuned transformers in a neutrodyne circuit. It should, however, be mounted so that its axis is at right angles to the axes of both coil L_0 and L_3. It

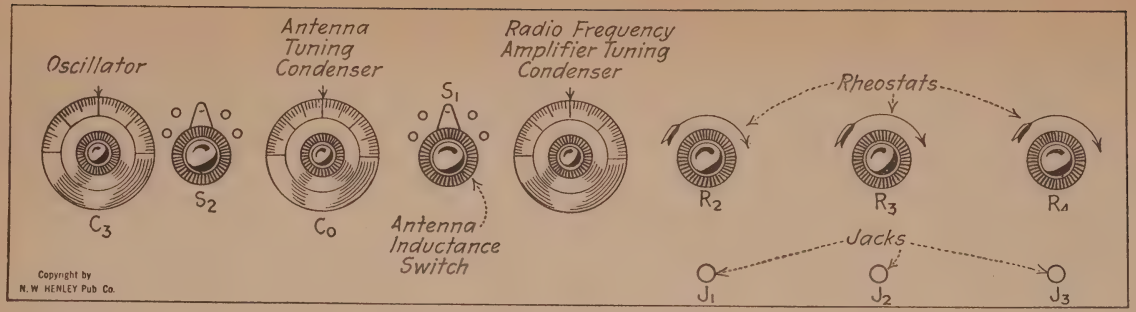


Fig. 66. Front View of Panel

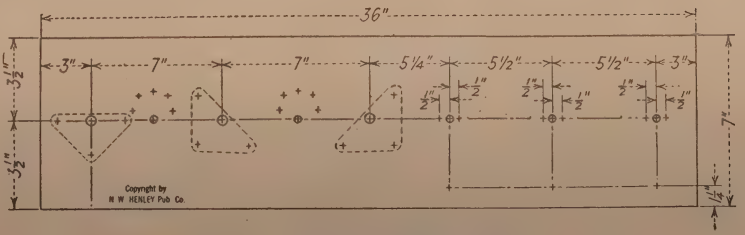


Fig. 67. Panel Drilling Details

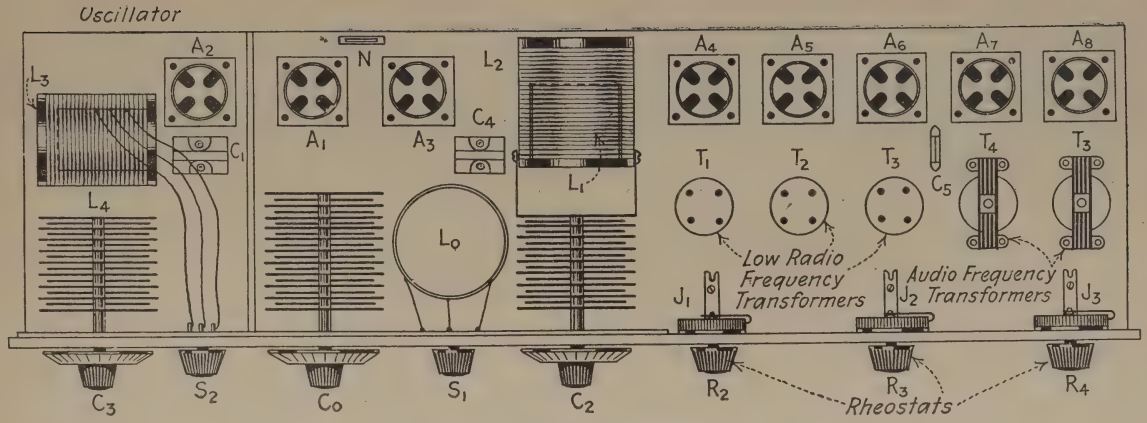


Fig. 68. Layout of Apparatus

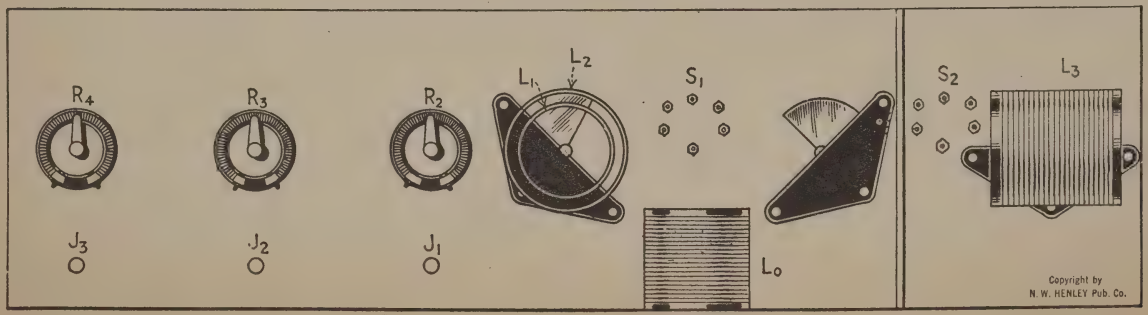


Fig. 69. Rear View of Panel

should also be mounted as far away from shields and other metallic objects as possible. It is also well to mount it at least an inch or two from the nearest tubes. A metal shield of either brass or copper sheeting, at least 1/16″ thick, should be placed at the back of panel and in front of the condensers and various coils. A shield of similar material should be used between the oscillator and the other radio frequency tubes.

A similar shield may also be placed between the radio frequency part of the circuit and the intermediate frequency. This shield has not been indicated in the drawing.

The three intermediate frequency tubes and the two audio frequency tubes are mounted at the rear of the cabinet, and the various transformers are mounted directly in front of the tubes as is clearly indicated in Fig. 68. The three rheostats are mounted on the right half of the panel in such a way that the panel layout is as symmetrical as possible. The three jacks are placed directly underneath the rheostats. Fig. 69 gives a rear view of the receiver to illustrate more clearly how the condensers and coils are mounted.

Constructing the Set. The first step in building the circuit is to obtain all the necessary apparatus. Before purchasing the panel, baseboard and cabinet, lay out the other pieces of apparatus in the best suitable manner on some temporary baseboard to determine the exact size needed. If the dimensions as given in the accompanying figures will fit the particular parts that have been purchased, these or similar specifications may be followed. It must be remembered that a cabinet which is too large is better than one which is just large enough.

After having decided upon the layout, and the required size of the panel and baseboard, these should be purchased. Then prepare the panel. Prepare a template of bristol board or heavy manila paper, of exactly the same size as the panel. Measure all the essential dimensions of the apparatus and lay them out on the template. Check all the dimensions on the template against the dimensions on the apparatus, then clamp the template to the panel, and with a sharp pointed instrument mark the panel through the template. Remove the template

from the panel, and again check the location of the centers on the panel to make sure that they are exactly correct. Having verfied their true location, go over them with a center punch, and make holes deep enough to prevent the drill from slipping. Now clamp the panel to the work bench, and drill the proper size holes. Holes larger than 3/16″ should be drilled with a small drill first, and then enlarged to the proper size.

When the panel has been drilled, prepare the front shield in the same manner. Of course, larger holes must be cut in the shield and the dimensions do not require the same accuracy. Then mount the shield and the various parts on the panel. Attach the panel temporarily to the baseboard, arrange all the parts that go on the baseboard in the best suitable manner, and mark their location with a pencil. Then remove the panel and mount the instruments on the baseboard permanently.

The circuit is now ready to be wired. Put soldering lugs under all terminals and binding posts, on both the panel and baseboard assemblies. Wire as far as possible while these two sections are in separate units, following the schematic diagram of Fig. 64. Then attach the panel permanently to the baseboard, and complete the wiring.

It should be observed that no provision has been made for any binding posts on the panel. It is, of course, optional with the constructor whether to put these on the panel, or at the rear of the set. The receiver will present a much neater appearance if all the binding posts are removed to the rear and mounted on a small sub-panel. This, however, makes the wiring somewhat more difficult.

Calibration of the Set. In order to facilitate the operation of the set, all the tuning controls should be calibrated. The first is the antenna condenser C_0 and the antenna inductance L_0, and the second the two variable condensers, one of which controls the frequency of the local oscillator, and the other the tuning of the modulator.

As has already been pointed out, there are two points on the oscillator condenser at which any particular signal will be found. Both of these points should be calibrated, because in-

terference may be encountered on one of them, and then the other will have to be used.

Prepare a chart similar to that which was explained under the neutrodyne circuit. The first column of this chart should be reserved for call letters and broadcasting stations, the second and third for the frequency in kilocycles and the wave lengths in meters respectively, the fourth for the setting of the antenna condenser C_0, the fifth for the setting of condenser C_2, and the sixth and seventh for the two tuning points on the oscillator condenser C_3. These values should be recorded for the best positions of the inductance switches S_1 and S_2.

Operation of the Set. When the receiver has been tested and found satisfactory, insert the telephone plug in jack J_1 and light all the preceding tubes. Then tune the circuit to some desired station. Set the condenser C_0 at maximum, and the antenna inductance switch S_1 at minimum. The position of switch S_2 is of no great importance at first. Its best value may be found by experiment after the circuit has been tuned. Then start the two condenser C_2 and C_3 at zero, and turn C_3 forward slowly. If there is a signal present it will be heard. If none of that high frequency is present, move condenser C_2 about ten divisions and turn condenser C_3 back and forth very slowly, from 10 to 20 divisions on either side of the corresponding position of C_2. If no signal is heard, again move condenser C_2 about ten divisions and repeat with condenser C_3. In this manner, the whole tuning range of the receiver may be explored, and all signals may be picked up.

When any particular signal has been picked up, increase its strength by carefully tuning C_2 and C_3. Then adjust C_0 and the antenna inductance switch S_1. When the signal is as loud as it can be made in this way, try the inductance switch S_2 to find the best coupling between the oscillator coil and the modulator circuit. If the signal which has been picked up is extremely weak, insert the telephone in either jack J_2 of J_3. It is possible, however, that even on jack J_1 the signals will be entirely too loud for a headset, when it will be necessary to plug in a loud speaker.

The degree of sensitivity of this receiver may be controlled to some extent by the rheostat R_2. The two other rheostats should not be used for that purpose, but should be adjusted for maximum amplification and least distortion. The sensitivity may also be varied by means of the coupling switch S_2, and the tuning of the antenna circuit.

Testing of the Set. When the wiring of this circuit has been completed, it is ready to be tested. First inspect the wiring carefully to make sure that all connections have been properly made. Then, by means of a buzzer, test the continuity of all connections to discover any possible defective joints or short circuits. When this has been done, connect the filament battery to ascertain whether all the filaments of the tubes light. If they do, it is reasonably certain that the filament circuits are correct.

Then connect a low tension battery across the plate terminals, and ascertain whether the voltage reaches all the plate terminals of the tube sockets. If it does not there is an open connection somewhere which must be corrected. Then, when this test has been carried out, the high tension battery may be connected to the proper terminals.

Now connect the receiver to the antenna and ground terminals, and tune the circuit to some signal. First listen in at jack J_1 and determine whether the signal reaches that point. If no signal is heard, the first place to look for the trouble is in the jack itself, which may be defective. If this is found to be correct, test the tubes. This may be done by switching the tubes from one socket to another. Make sure that all the contact springs are clean. Then test the two audio frequency amplifiers by listening in at jack J_2. If this amplifier works properly, the signal should now be many times stronger and free from noticeable distortion. Then try jack J_3. In this stage the signals should be as much louder as the second was over the first, and entirely too loud for the headset.

The testing of the intermediate frequency amplifier was done in adjusting the tuned transformers and is probably correct.

CHAPTER X

The Ultimate Receiver

The Construction of This Receiver Which Includes Battery Supply, A, B and C Battery Supply, Radio Receiver, Audio Frequency Amplifier and Loud Speaker Is Explained in Detail and Amply Illustrated by Drawings and Illustrations

The design of the receivers already described in this book follows conventional lines; that is, the tuning elements, the tubes, and the transformers are enclosed in a box or cabinet, while the loud speaker and the filament and plate batteries are placed in the least inconvenient location in the room. At best, this arrangement is never convenient, is always unsightly, and ultimately will be found unsatisfactory. It will only be tolerated as long as broadcasting is a novelty. As soon as the radio receiver has taken its place as a modern necessity in every home, the demands on the receiving set will be much more exacting. Some of the requirements of the set of the future, or the ultimate set, will be set forth below:

1. It must be sufficiently sensitive to operate satisfactorily a loud speaker from the stations located 2,000 to 3,000 miles away under favorable atmospheric conditions.

2. It must be sufficiently selective to eliminate interference from local stations operating on a frequency 10 to 15 kilocycles different from the frequency of the desired distant station.

3. The receiver must be simple to tune.

4. It must be convenient to operate and inexpensive to maintain.

5. It must be entirely contained in a single cabinet that harmonizes with the rest of the furniture in the room.

6. It must be capable of delivering signals of the highest quality; that is, signals which are as free from distortion as possible.

The first two conditions are satisfactorily met by either a well-made neutrodyne, or a super-heterodyne circuit, but as the latter is considerably the better it has been selected for the

"Ultimate Set," described herein. The super-heterodyne also satisfies the third condition. There are only two critical controls to manipulate, and these may readily be calibrated so that it is only necessary to tune the circuit once for each wave length.

The fourth condition refers particularly to the filament current and plate potential supply. It is obvious that in a set containing eight tubes large enough to operate a loud speaker without distortion, the use of dry cells for heating the filament is out of the question, and the use of alternating currents with a step down transformer is not practicable when so many tubes are used, because of the difficulty of balancing out the A.C. hum. The only alternative is the use of a storage battery which has the proper voltage and ampere hour capacity. Since this battery requires recharging periodically, convenience demands that a charger be installed in the set so that this operation may be performed without removing the battery.

The plate power may be supplied from a dry cell battery, a high voltage storage battery, or a special rectifier set supplied with a smoothing-out filter.

The use of dry cells for this purpose will prove rather expensive, as the heavy drain due to the plate current of the tubes will quickly exhaust the battery. Since this cannot be recharged it must be replaced with a new battery. The use of a high voltage, low capacity storage battery is much more economical and it is fully as convenient. If this type of battery is used, a high voltage charger will be required. This may be made similar to the low voltage charger, or an attachment may be obtained for this charger, which makes it possible to charge the high voltage battery.

Perhaps the most satisfactory method of obtaining a high voltage for the plates is to use a special rectifier with a smoothing-out filter. This method has been used in the set described herein, the details of connection and construction being given in a later section.

The fifth condition will be satisfactorily met if the entire

receiver is placed in a phonograph cabinet, preferably of the console type. This should be sufficiently large so that the receiver proper, the rectifier, the batteries, the filter, and the loud speaker may be placed inside without crowding the apparatus too close. The details of this will be given below.

In order to satisfy the sixth condition, large tubes must be used in the audio frequency amplifier. Tubes smaller than UV201A should not be employed, and 216A should be used if they are obtainable. The audio frequency transformer must be of the best make having a very high impedance in the primary circuit. The loud speaker should be the best that is obtainable. If these conditions for good quality are not observed, the most expensive and elaborate set will only give mediocre results.

The Circuit. The circuit proper of this receiving set is essentially the same as the super-heterodyne circuit described in the previous chapter, and a detailed discussion of it here is not necessary. There are a few points of divergence, however, which will be pointed out.

The present circuit employs the grid condenser, grid leak method of detection in the second detector, whereas the former employs the grid biasing method in both detectors. The present circuit also has an additional volume control. The output or plate circuits of the first detector and the two intermediate frequency amplifier tubes are provided with jacks so that the input circuit of the second detector may be plugged into any of them according to the volume desired. Jacks are also provided in the outputs of the second detector and the two audio frequency tubes so that the loud speaker or headset may be plugged into any of them. There is also a slight difference in the grid batteries to take account of the slightly different plate voltages called for.

If desired, the super-heterodyne with bias voltage on second detector grid, described in Chapter IX, may be used here, provided a potential of about 50 volts is used on the second detector instead of 25 volts.

A circuit diagram giving connections of the complete receiver is shown in Fig. 70. This includes the receiving circuit proper, the storage battery and charger, the high voltage rectifier, and the smoothing-out filter. It shows the proper location of the protecting fuse, indicator lamps and control switches. An explanation of the legends associated with the various symbols on the diagram is given in the summary of circuit specifications.

Filament and Plate Current Supply Set

The current supply set is composed of three main units; namely, the filament supply set, the plate power supply set, and the smoothing-out filter.

The filament supply set consists of a rectifier and a storage battery. The rectifier should preferably be of the vacuum tube type, such as the Tungar of the Rectigon, and it should have a current capacity of five amperes. Either of these may be purchased on the market ready for use, and a description of them is not necessary. The other two units will be described in detail.

The Plate Supply Unit. The plate potential for all the tubes in the receiver is obtained through a special rectifier circuit, which is similar in operation to the filament battery rectifier, except that it operates on a very much higher voltage and a lower current. In this unit two specially constructed transformers T_7 and T_8 and two rectifier tubes A_9 and A_{10} are used. The proper connections for these are clearly shown in Fig. 70. The tubes used in this rectifier may be ordinary UV201A or 216A, but better results will probably be obtained if UV216 tubes are used, because this type has been especially made for this purpose, while the other tubes are ordinary receiving tubes. If the ordinary tubes are used, they should be employed as Fleming valves by connecting together the plates and the grids, that is, converting them into diode valves.

Construction of the Plate Transformer T_7. The plate transformer should be constructed as shown in Figs. 71, 72, 73 and

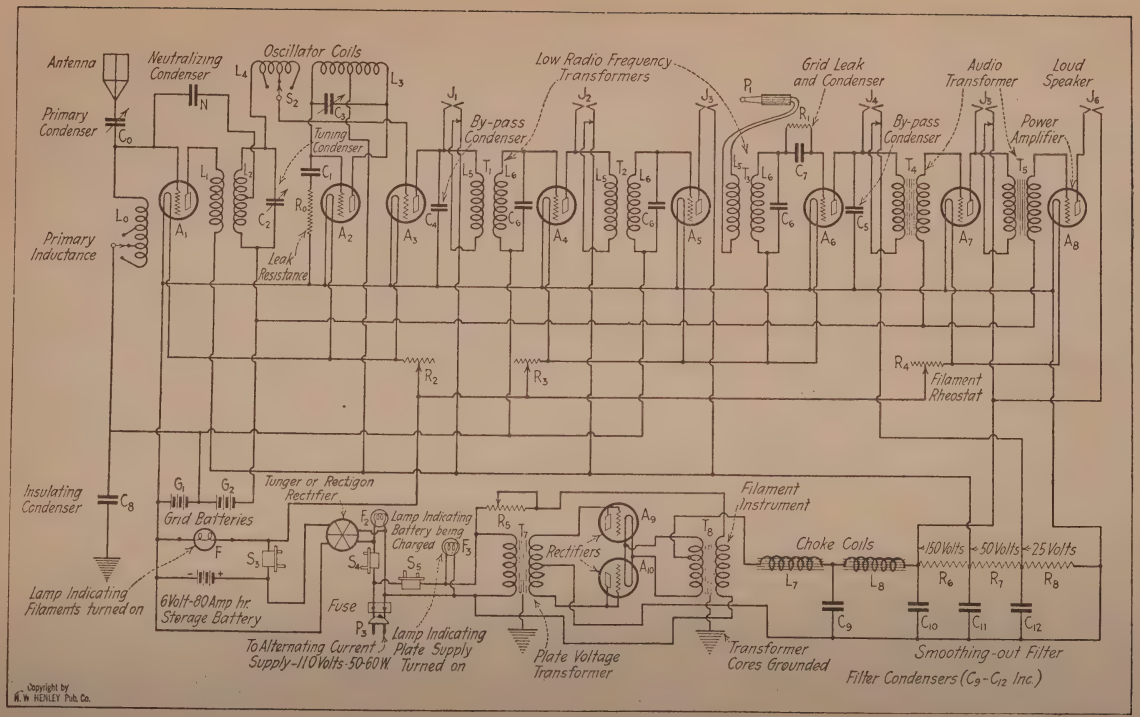


Fig. 70. Circuit of the Ultimate Receiver

74. The core should be made of laminated silicon steel, not thicker than .015", and the cross section of the core should be one square inch. Two stampings, shown in Fig. 71, are used in the assembly of the core. In this figure the method of assembling the cores is also shown. A layer of friction tape is wound over the core to protect the insulation of the windings.

The primary winding is first placed on the core, and this consists of two sections of 600 turns each. This winding should be

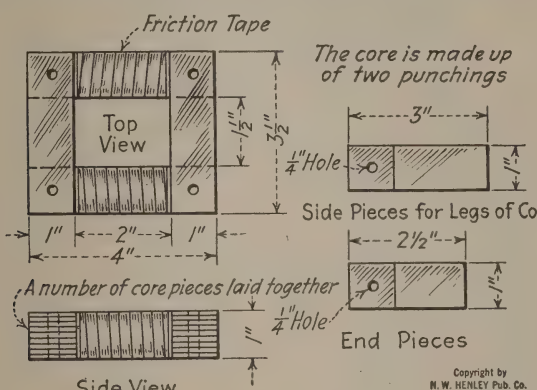


Fig. 71. Transformer Details (For Plate)

wound with No. 26 double silk covered copper wire. One of the sections should be placed on each leg of the core, as is indicated in the drawing, and connected in series aiding.

After the primary turns have been placed on the core, several layers of empire cloth or varnished cambric should be put over the winding to insulate it from the secondary or high potential winding.

The secondary winding should consist of a total of 4200 turns of No. 30 double silk covered copper wire. This should be made up in four sections of 1050 turns each, and two of these sections should be wound over each of the two sections of the primary. All these sections should be connected in series aiding, that is, in such a manner that their inductances add up.

There are five terminals on this transformer, two on the

primary side, and three on the secondary, one of these being taken out on the middle point. These terminals are brought out and carefully insulated with varnished cambric tubing, and connected to fibre or micarta insulating strips, as is in-

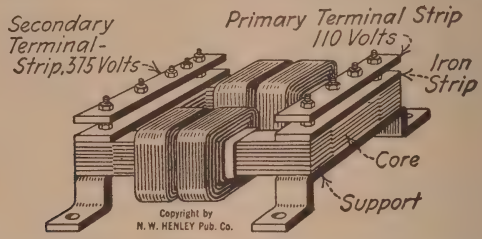


Fig. 72. View of Plate Transformer, Complete

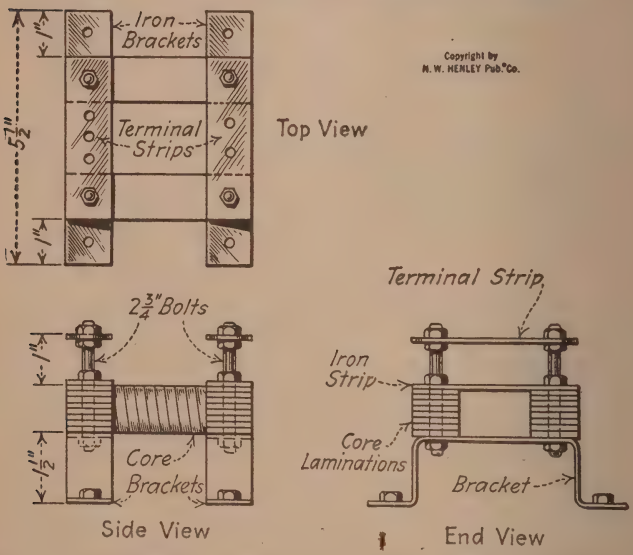


Fig. 73. Transformer Details (For Both Plate and Filament)

dicated in Fig. 72. When the terminals have been attached, and the transformer assembled, attach the mounting lugs, as shown in Figs. 72 and 73. These may be made of iron strips, ⅜" wide, and 1/16" to ⅛" thick. The winding connections of this transformer are shown in Fig. 74.

Construction of the Filament Transformer T_8. The filament transformer should be wound on a core identical with that of the plate transformer. After the silicon laminations have been assembled, a few layers of empire cloth or friction tape should be wound around the core to protect the insulation of the windings. The primary winding consists of 1200 turns of No. 26 double silk covered wire, and the secondary consists of 74 turns of No. 16 double silk covered wire. The details of con-

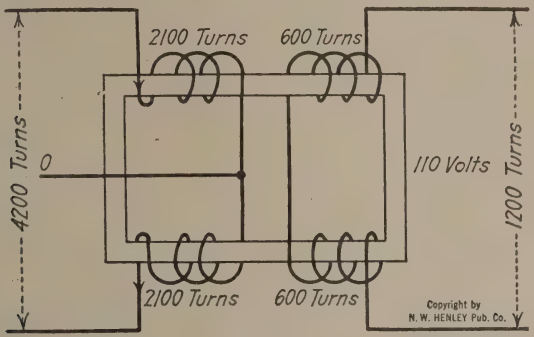


Fig. 74. Connections of Plate Transformer Windings

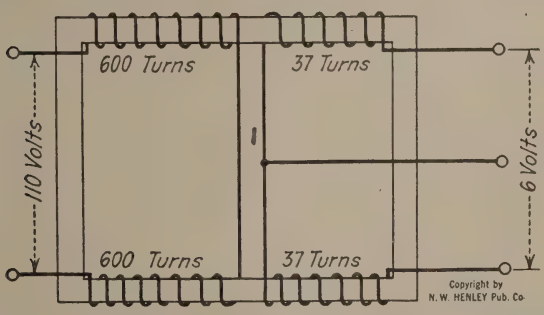


Fig. 75. Connection of Filament Transformer Windings

struction of the windings are essentially the same as in the plate transformer, except for the number of turns. The secondary or low voltage winding of this transformer should have a tap at the middle point. The winding connections are shown in Fig. 75.

Five terminals will be required, and these are brought out and connected to terminal strips, as was done in the high voltage transformer. A filament rheostat of 20 ohms should be used to control the power to the filaments of the rectifier tubes.

The plate power rectifier unit is connected directly to the alternating current mains. A single-throw, single-pole push-button switch is connected in one of the leads so that the power may be cut off when desired, and a small indicator lamp is connected across the leads to show when the power is on. This lamp should be colored blue, to distinguish it from other indicator lamps used in this receiving system.

Construction of the Smoothing-out Filter. When this rectifier is constructed according to these directions, it will deliver a pulsating high voltage current. But a steady direct current potential is required for the supply of the plate power to the tubes, hence it is necessary to use some device for smoothing out the pulsations. A filter consisting of choke coils and condensers is used. The choke coils are connected in series with the output of the rectifier, while the condensers are connected in shunt. The two coils L_7 and L_8 are equal, and each consists of 5000 turns of No. 28 double silk covered wire. The details of construction and the size of the core may be the same as for the plate transformer, T_7, 2500 turns being placed on each leg of the core. These sections are connected in series aiding and the two terminals are brought out to terminal strips.

The condensers used in this filter should be made up of two microfarad units connected in parallel, and they may be of the paper dielectric type, provided the paper insulation is sufficient to withstand the peak voltage of the pulsations. The first condenser C_9 should have a capacity of 12 mfd., C_{10}, 8 mfd., C_{11}, 4 mfd., and C_{12}, 2 mfd. The proper potential for the various tubes of the receiver is obtained by connecting the plate leads from those tubes to the proper point on a resistance through which the output current of the rectifier and filter passes. The total resistance is 12,000 ohms. 25 volts for the second detector may be obtained at a point 2500 ohms from the ground side of

the filter; 50 volts for the other radio frequency tubes may be obtained at 5000 ohms from that side, and 150 volts for the two audio frequency amplifiers at a point 12,000 ohms from the ground potential side.

Assembly of Receiver

One of the main requirements of the "Ultimate Receiver" is that it be enclosed entirely in a single cabinet. The method of assembling the receiver depends largely on the size and shape of cabinet obtained, and that in turn depends on the tastes of the individual builder and on the type of furniture in the room in which it is to be placed. Of course, there are countless possibilities as to size, shape and style of cabinet and arrangement of the various units that go into it. The receiver described herein is based on a console type cabinet, the inside dimensions of which are 42" x 21" x 18".

A general view of the Ultimate Receiver is shown in Fig. 76. It is divided into three parts; namely, the current supply on the right, the circuit proper and control panel in the center, and the loud speaker horn and spare parts on the left. The front view with doors closed is shown in Fig. 77. The only parts that are visible are the three indicator lamps with their control switches and name plates. Directly under this is a door hinged at the bottom. Behind this door are concealed the four rheostats with their name plates. The door on the left conceals the storage battery, the two rectifiers, and the filter, while the door on the right conceals the loud speaker horn. This door should be open when the loud speaker is operating, or else the door should be so arranged that the sound can pass through it without appreciable loss of volume. Symmetry then requires that the other door is made similarly.

In Fig. 78 is shown the front view of the receiver with the doors removed. The plate power supply set is placed on a shelf in the upper left hand corner. To the right of this and directly in the center, space is reserved for the circuit proper. In the lower left hand corner are the storage battery and the

charger. The control panel is shown directly under the circuit and in the center of the cabinet. The mouth of the horn is shown in the space to the right of the control panel and the

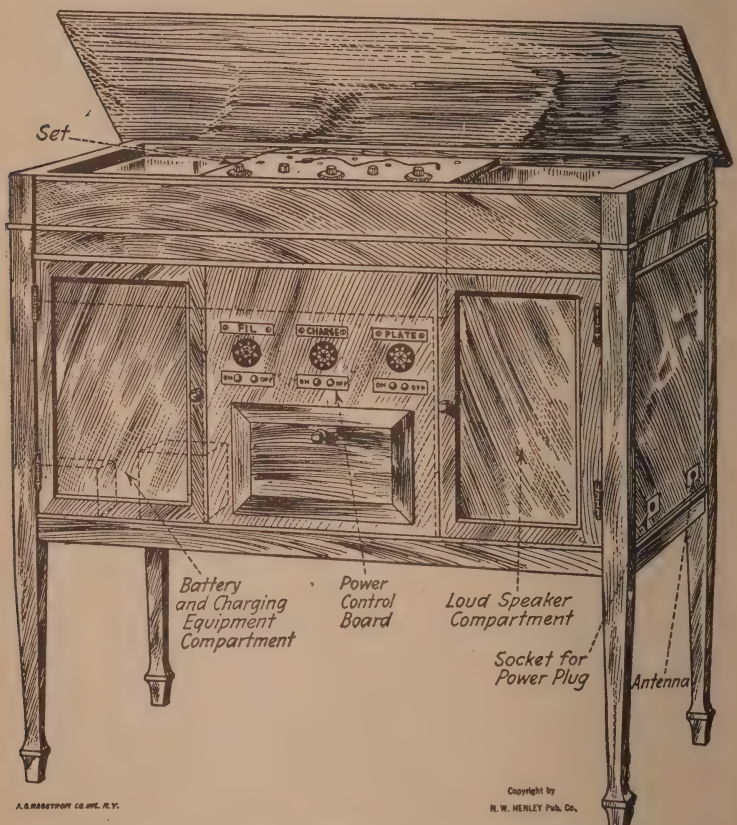


Fig. 76. View of Complete Ultimate Receiver

circuit proper. The horn bends around and is partly behind the control panel. An outline of the position of the horn is shown in Fig. 79 as viewed from above.

The position of the circuit proper is also shown in Fig. 79. In front center is the horizontal tuning panel, and directly

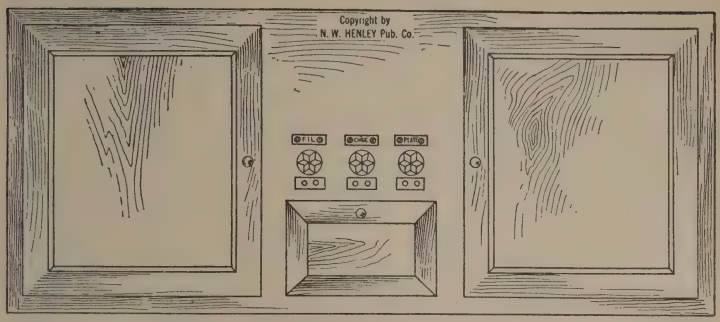


Fig. 77. Front Panel of Receiver

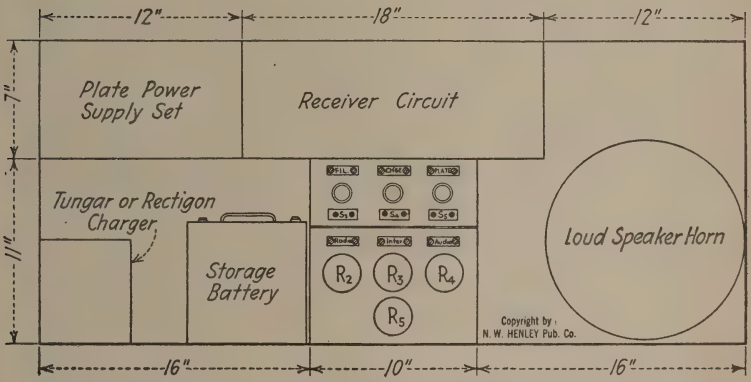


Fig. 78. Apparatus Layout (Power Equipment, Front View)

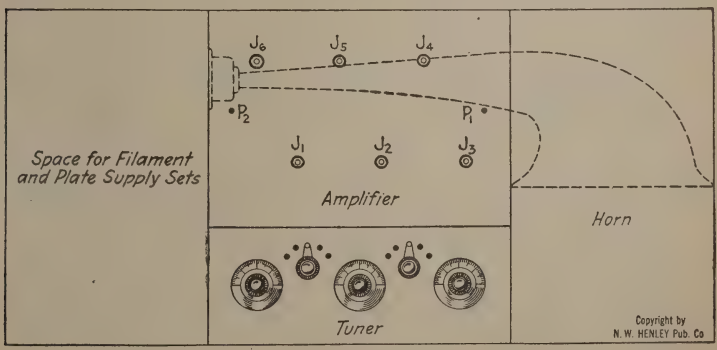


Fig. 79. Top View of Receiver, Cover Open

below it the tuning condensers and inductance coils. Back of the tuner is located the intermediate frequency and audio frequency amplifiers. These are concealed by a lid hinged at

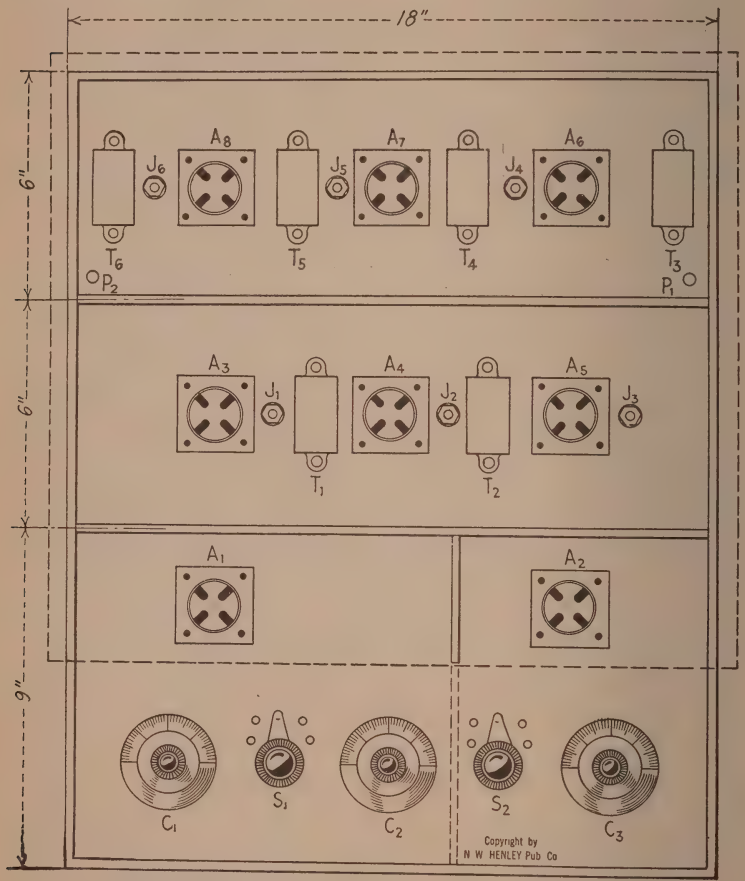


Fig. 80. Apparatus Layout of the Receiver (Top View)

the rear. This lid contains eight holes, two for the plug cords P_1 and P_2, and six for the jacks. The jacks are so mounted that they just project through the lid when it is closed. An-

other hinged cover should be used for the entire cabinet so as to protect the set from dust when the receiver is not in use.

FIGURE 80 shows the plan of the circuit proper with the lid removed. The audio frequency tubes and the second detector are placed at the rear in a shielded compartment. Here are also placed the three audio frequency transformers T_4, T_5 and T_6 and the intermediate frequency transformer T_3, P_1 and P_2 indicate where the plug cords may be anchored. The intermediate frequency tubes and the first detector are placed in a shielded compartment in the middle. Two intermediate transformers are also placed here. The locations of the six jacks in these two compartments are clearly indicated. Note C_1 Fig. 80 is C_0 Fig. 70.

The high frequency oscillator, including A_2, coils L_3 and L_4, the coupling switch S_2, and the tuning condenser C_3, are all placed in a shielded compartment in the right front corner of the circuit section, while the tuning condenser C_1 and C_2, the silencer tube, the primary coil L_0, the switch S_1 and the transformer L_1L_2 are placed in the left front compartment.

All the shielding should be made of brass or copper sheet 1/16″ thick. The shielding should not only separate the various groups, but should also surround the entire circuit.

The Ultimate Set

SUMMARY OF CIRCUIT SPECIFICATIONS

C_0—.0005 mfd. variable air condenser
C_1—.001 mfd. mica condenser
C_2 and C_3—.0005 mfd. variable air condensers, preferably with vernier attachment
C_4—.001 mfd. mica condenser
C_5—.002 mfd. mica condenser
C_6—.0001 mfd. mica condensers 3 required
C_7—.0002 mfd. mica grid condenser
C_8—2 mfd. condenser to insulate set from ground
N—Neutralizing condenser. (See neutrodyne circuit)
L_0—Antenna inductance coil. 150 turns of No. 26 dcc wire on a tube 3″ in diameter, with taps at 50 and 100
L_1—15 turns of No. 25 dcc wire on a tube 2¾″ in diameter
L_2—40 turns of No. 22 dcc wire on a tube 3″ in diameter

L_3—40 turns of No. 22 dcc wire on a tube 3″ in diameter, with a tap at the 20th turn
L_4—24 turns of No. 26 dcc wire on a tube 2″ in diameter, with taps at 8 and 16
L_5 and L_6—Primary and secondary of transformers T_1, T_2 and T_3
L_5—Inside winding. 250 turns of No. 36 dcc wire on a 2″ core
L_6—Outside winding. 1000 turns of No. 36 dcc wire. 3 of each required
S_1 and S_2—Inductance switches, each with 3 points and 2 stops
R_0—12,000 ohm grid leak
R_1—2,000,000 ohm grid leak
R_2, R_3 and R_4—20 ohm filameent rheostats
C_9—12 mfd. paper condensers (6 2 mfd. units in parallel)
C_{10}—8 mfd. paper condensers (4 2 mfd. units in parallel)
C_{11}—4 mfd. paper condensers (2 2 mfd. units in parallel)
C_{12}—2 mfd. paper condensers
R_6—7000 ohm resistance
R_7 and R_8—2500 ohm resistance

These resistances should be of the Ward-Leonard type, and be capable of carrying one-tenth ampere.

G_1 and G_2—Two 4.5 volt grid batteries
T_1, T_2 and T_3—Intermediate frequency transformers

These may be similar to those described in the preceding chapter or may be purchased. Rubicon transformers are recommended.

T_4 and T_5—Audio-frequency transformers
T_6—Loud speaker step-down transformer
J_1, J_2, J_4 and J_5—Double circuit jacks
J_3 and J_6—Single circuit jacks
P_1—Plug for varying number of intermediate frequency tubes used
P_2—Plug for varying number of audio-frequency tubes used
A_1, A_2, A_3, A_4, A_5 and A_6—UV201A vacuum tubes
A_7 and A_8—UV201A or preferably 216A vacuum tubes

Summary of Filament and Plate Current Supply Set

P_3—Wall plug to connect set with house electric a. c. mains
S_3—Push button "on and off" switch for lighting tubes of circuit
S_4—Push button "on and off" switch for charging filament battery
S_5—Push button "on and off" switch for plate current supply set
F—A small pilot lamp to indicate when current is on filaments. This light should be colored green
F_2—A 10 watt pilot lamp to indicate when the battery charger is operating. This should be colored red
F_3—A 10 watt pilot lamp to indicate when plate current supply set is operating. This light should be colored blue. When the red light is on, the other two should be off, and when set is operating, the red light should be off, and the blue and green on
R_5—20 ohm rheostat
T_7—Plate supply transformer as described
T_8—Filament supply transformer as described
A_9 and A_{10}—UV201A, 216A, or better, UV216 vacuum tubes
L_7 and L_8—Iron core choke coils, as described

LIST OF PARTS

2 iron boxes—Columbia metal box
1 plug
1 fuse receptacle and 10 ampere fuses
3 wall switches
1 rectifier
1 80 AH 6 volt storage battery
1 20 ohm rheostat
1 plate transformer
2 vacuum tube sockets
1 filament transformer
2 choke coils
13 2 mfd. condensers
1 7000 ohm resistance
2 2500 ohm resistances
4 terminals and terminal strip
Assembly of power supply in iron box; charger and battery in iron box

Operation of Set. The first step in the operation of the set is the charging of the storage battery, unless this is already charged when it is placed in the cabinet. Turn off switches S_3 and S_5. Then plug P_3 into some convenient a.c. outlet and turn on S_4. The red lamp should now be lighted, indicating that the charger is operating. Leave the charger several hours until the storage battery is fully charged, usually over night. This may be determined with a low voltage voltmeter or a hydrometer. When the battery has received the proper charge, turn off switch S_4. Then connect the antenna and ground leads and turn on switches S_3 and S_5. The green and the blue lights should now be burning, indicating that the receiver is ready for tuning in.

To tune the circuit set C_0 and S_2 on maximum and S_1 on minimum, insert P_1 in jack J_3 and P_2 in jack J_6. Turn all the rheostats on until the filaments glow with the proper degree of incandescence. Then tune with C_2 and C_3. Set C_2 on a point near the zero end of the scale and turn C_3 carefully and slowly back and forth. If there is any signal coming in on the lower wave lengths it will be heard. If not, set C_2 on a point about 10 divisions higher and explore with C_3 as before. Continue this until a station is heard. After a station has been located leave C_3 where the signal is strongest. Then tune with C_2 until it is as strong as it can be made that way. Then tune with C_0 and S_1 until the signal is strongest. If the signal becomes too strong for comfortable reception during this process of tuning, reduce the amplification by plugging P_2 into jacks J_5 or J_4, or by plugging P_1 into J_2 or J_1. The switch S_2 should

be left on the point which gives strongest signals without overloading the first modulator tube.

Two points will be found on the C_3 dial on which any one signal comes in loud. It may be that interference will be encountered at one of the points while the other is clear. For this reason both of these points should be noted and recorded for future reference. The positions of C_0, S_1 and S_2 should also be recorded so that a station that has once been located may again be picked up without having to retune.

A calibration chart should be prepared in which are entered the tuning data of all stations that have been picked up.

Testing the Set. The testing of the receiver proper may be done in the same manner as was done for the super-heterodyne circuit, and hence it is not necessary to repeat it here.

In testing the storage battery charger all that is necessary is to see that connections are good and that they are correct as to polarity. The terminals are plainly marked both on the rectifier and the battery, and no difficulty should be experienced.

Since the plate power supply set is home-made, it requires more thorough testing. Make sure that the different sections of the windings of transformers T_7 and T_8 are connected in the same direction, that the windings are continuous, and that there are no short circuited turns. If the filaments of A_9 and A_{10} light up to the proper brilliancy, and if this brilliancy may be controlled with rheostat R_5, it may be assumed that the filament circuit of this set is correct. The other may be assumed to be correct if the proper d.c. voltages are obtained. This may best be determined with a direct current voltmeter having the proper ranges. These measurements should be taken between the ground side of the filter, or negative side of the filaments of the receiver, and the plates of the tubes. They may also be made across condensers C_{10}, C_{11} and C_{12}. If the proper voltages are obtained here, and if no a.c. hum is heard in the loud speaker, it may be assumed that both the plate power supply set and the smoothing-out filter are operating properly.

CHAPTER XI

Short Wave Low Loss Receiver

The New Developments in Short Wave Work Include the Low Loss Receiver Which, Although Extremely Simple Is Both Very Selective and Very Sensitive. Complete Working Drawings Are Given for the Construction of Such a Receiver, Including a Regenerative Detector and Single Stage Audio Frequency Amplifier

It has been comparatively recently that the average amateur has awakened to a full realization that when selectivity is lacking in a radio receiver the "nigger in the wood-pile" is resistance. It may be laid down as an axiom that if maximum selectivity is desired nothing short of the lowest possible resistance in tuned circuits will suffice. Two of the causes are coil and condenser resistance and they are two which may very easily be reduced by intelligence in their design. Another cause is resistance in some other circuit in shunt with, or coupled to the tuned circuit. For example, in a so-called "single circuit" receiver where the coupling between the antenna and grid circuit is conductive, it is quite well known that the antenna resistance must be kept just as low as possible in order to get even an approach to real selectivity in the grid circuit. Even when the two circuits are inductively coupled it is very advisable to have a low resistance antenna, so that tuning of the secondary or grid circuit will not be too broad with moderately close coupling. The lower the antenna resistance is, the looser the coupling may be, still keeping the signal strength good. If the coil in the grid circuit (the secondary coil) has low resistance there is less waste energy and greater voltage is, under any circumstances, impressed upon the grid of a tube detector.

The advantages of the shorter waves, under 200 meters, are becoming more and more apparent to the average amateur and since some of the sources of resistance greatly increase in im-

portance with a decrease of wave length, (increase of frequency) loss reduction becomes very essential. Because of the absolute necessity of loss reduction for short wave reception

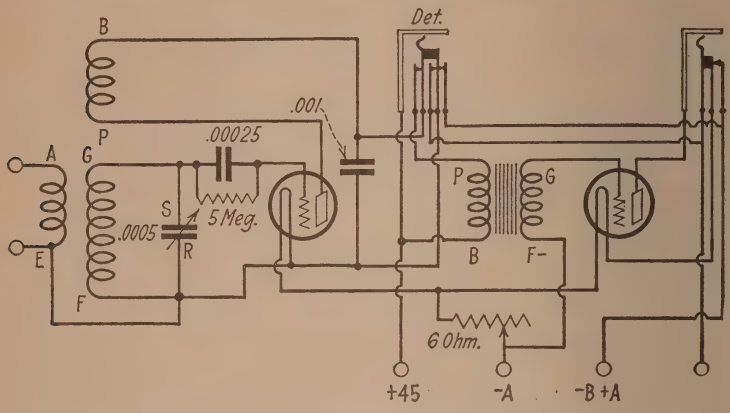


Fig. 81. Circuit Diagram Low Loss Short Wave Receiver

a short wave low loss receiver will be described and details of its construction given.

The wave length range is approximately 75 to 200 meters and, therefore, covers the three higher wave bands allotted to amateurs—between 75 and 200 meters.

At the end of the chapter suggestions are made regarding changing the coils to cover a wave band of about 30 to 80 meters.

Circuit. Most amateurs are either sticking to the old reliable regenerative circuit or returning to it after trying out the various circuits and devices offered as panaceas for lack of selectivity. After all, they find that the simplest is usually the best. The diagram of Fig. 81 is, therefore, not that of a new circuit but the old standby. Only one stage of audio frequency is included since it is almost never advisable to use two stages for long distance reception. More amplification often increases the effect of radio noise, such as atmospherics ("static") and other electrical interferences, to a point where

it is actually more difficult to "copy" the transmitting station. For nearby stations even a single stage of audio frequency amplification is too much at times and a filament control jack is included so that a quick change may be made to detector or back to one stage of audio when needed. No readjustment of the filament rheostat is necessary when these changes are made since there is only a small change in filament current accompanying them. Filament control jacks are, therefore, very convenient.

Coil System. The coil system may be purchased already assembled and ready to mount on the back of a panel if desired. This would obviate the rather difficult construction of suitable mountings. The antenna coil has 6 turns of No. 14 D.C.C. wire wound closely on a hard rubber or bakelite tube 2¾" in diameter and 2" long. There is no advantage in spacing the turns from each other since the distributed capacity of the coil when closely wound will be too small to affect results. This six turn coil makes the antenna circuit untuned since no tuning condenser is used with it. The advantages are that the antenna length has little effect upon the tuning range of the receiver, tuning adjustments are simplified and may be made more rapidly, and there is less liability of receiver radiation.

The secondary coil is more difficult to make and will require some patience. The first step is to lay out, on a piece of wood, a circle 4⅛" in diameter and place 14 steel wire pegs equally spaced around this circle. The pegs may be about 3/32" thick and should be round. No. 12 D.C.C. wire should be used in making a basket winding which may be started at any one of the pegs, passed just inside of the next two, outside of the next one, inside of the next two and so forth until there are 18 complete turns. Some waxed thread may then be passed through the spaces made by winding in this manner and the coil quite firmly secured. The coil may then be lifted carefully off the former and is ready for mounting. Reference to Fig. 82, which shows an assembled coil system, will show how this coil (the middle one) looks when completed.

The tickler coil has 10 turns of No. 20 D.C.C. wire on exactly the same size coil form or tube as the antenna coil. There is no advantage in spacing the turns of this coil and it is not at all

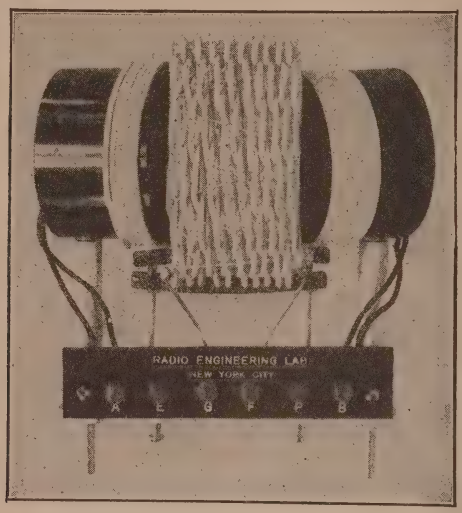


Fig. 82. Assembled Coil System

detrimental to wind either this or the antenna coil on a tube because in neither case will the dielectric losses be anything but very negligible.

If the constructor desires to make his own coil mountings he may do so if it is remembered that no magnetic metal such as iron or steel should be placed in the vicinity of the coils or wires leading to them. Brass and aluminum if used rather sparingly, as shown in Fig. 82 are entirely permissible. The coils should be supported so as to be well back of the panel and there should be no electrical connection between a coil and any metal support. Flexible wires should be soldered to the terminals of the antenna and tickler coils so that they may be freely rotated.

Tuning Condenser. The front panel template of Fig. 83 shows holes to be drilled for a General Radio condenser. This should have a maximum capacity of 0.00025 mfd. If any other type condenser is used it must have a minimum capacity of 0.00001 mfd. and the lowest possible losses and the template should be changed to accomodate it. It is highly inadvisable to use a condenser which is a better sieve than it is a variable capacitance and a few extra dollars may well be spent in securing the best. It makes a distinct difference in a receiver for short wave reception although the difference is not so noticeable in receivers for higher wave lengths. In order that capacity

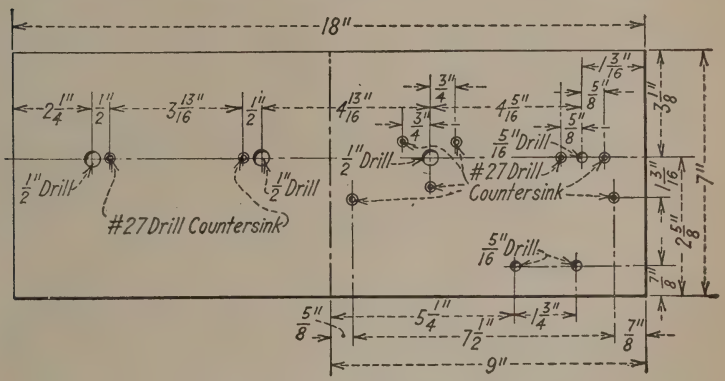


Fig. 83. Front Panel Template

changes may be very gradual and tuning less critical on the very short wave lengths, the rotary plates may be cut away as shown in the condenser of Fig. 87. The plates when so cut are said to be "stagger-cut." Any condenser selected should not extend more than 2¼" back from the front panel when mounted because there is only 2½" clearance between the front panel and the edge of the sub-panel.

Sockets. Two high grade sockets are required and they may have metal shells without in any way detracting from the working of the receiver since present day vacuum tubes practically all have metal shells at their bases. The sub-panel

template of Fig. 84 has been designed to accommodate General Radio sockets but others may be used if the template is changed accordingly.

Transformer. For convenience of mounting beneath the sub-panel, a General Radio transformer is used. The turns ratio

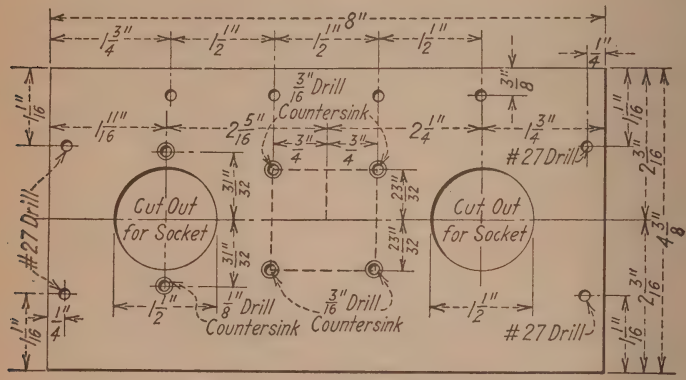


Fig. 84. Sub-Panel Template

of this transformer is somewhat low whereas a high ratio transformer resonant at about 1000 cycles might serve better. The transformer used gives such good results, however, that it was used for the sake of convenience. If any other make is selected the sub-panel may have to be raised up to provide clearance for the transformer between sub-panel and floor of cabinet, or, the transformer may be mounted on top instead of underneath this sub-panel. Mounting below simply keeps the connecting wires out of sight and adds to the appearance of the finished receiver. Regarding high ratio, it is to be remembered that there is no question of distortion in this receiver since it is to be used for radio-telegraph reception.

Grid Condenser and Leak Resistor. The grid condenser should have a mica dielectric and have highest grade insulation. Its capacity should be 0.00025 mfd. The grid leak resistance should be 5 megohms if a UV201A or C301A tube is used as

detector. These tubes are recommended for use in this receiver. If the grid leak resistance is too low regeneration may be hard to control.

By-pass Condenser. A .001 mfd. by-pass condenser should be used as shown in the circuit diagram.

Rheostat. A six ohm rheostat is required if UV201A or C301A tubes are used. The front panel template of Fig. 83 shows the drilling for a Pacent but any other good rheostat may be used and the template changed.

Dials. It is a very good plan to use vernier dials for the tickler and secondary condenser, particularly the latter. A standard dial may be used on the antenna coil shaft.

Jacks. Two jacks are required. One is a double filament control and the other a single filament control jack. The first will be used for the detector circuit and the second for the amplifier. Federal jacks have been provided for in the front panel template but any good jacks will serve providing the panel holes are drilled to accommodate them.

Front Panel. The front panel may be of any of the excellent materials on the market and its dimensions are 7″ x 18″ x 3/16″. A drilling template may be made from the reduced template of Fig. 83. If any parts have been substituted for those mentioned above be sure that the template has been properly altered before the panel is punched. In making the actual template be sure that all the centers are accurate and check all measurements carefully. Manila paper is good for making this template. When the template is finished, clamp it firmly to the panel making certain that its edges line up accurately with the panel edges. Then, with a center punch and a light hammer or mallet, carefully make the punch marks into the panel. The punch should be held vertically at each center point of the drilling circles. All holes shown by double circles are to be countersunk after drilling through. After making all the punch marks, carefully look them all over to make sure that none have been missed. The template may then be removed and the holes drilled with the size of drills indicated

in Fig. 83. When drilling holes it is advisable to lay the panel on a perfectly flat board. Hold the brace vertically and drill slowly to avoid breaking the drill or making a rough opening on the other side of the panel.

Sub-panel. The sub-panel may be of the same insulating material as used for the front panel. Its dimensions should be 4⅜″ x 8″ x 3/16″. A drilling template may be made from the reduced template of Fig. 84. The same care should be taken that the template is changed if there has been any substitution of parts, and the same care in punching and drilling as with the front panel.

Brackets for Sub-panel. Brass brackets should be used for supporting the sub-panel upon which are to be mounted the

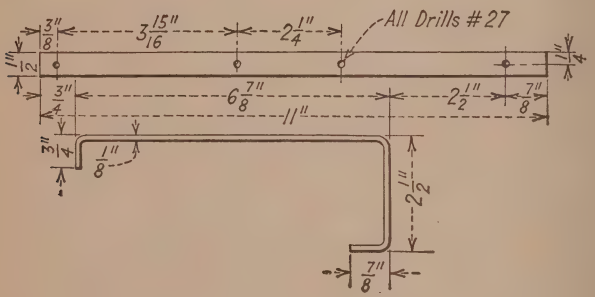


Fig. 85. Bracket Details

sockets, transformers and battery binding posts. Two pieces of ⅛″ stock, each ½″ wide and 11″ long are necessary. Each piece should be bent exactly at right angles as shown in Fig. 85. Bending may be done by clamping the pieces in a vise so that just the part to be bent over sticks out and then hammering the end back until the bend is a right angle. Before bending, however, the holes should be drilled according to Fig. 85.

Assembly and Wiring. When all of the above work has been completed the constructor is ready for the assembly of parts. The sockets should first be secured to the sub-panel by pushing

their shells up through the holes made for them and passing machine screws of the right size through the panel holes, from the top, and down through the socket mounting holes. One or two thick washers may have to be placed underneath the panel between it and the socket and, if so, they should be slipped on the machine screw before the screws are passed through the socket holes. Hexagonal nuts may be then turned onto the machine screws and tightened up to hold the sockets in posi-

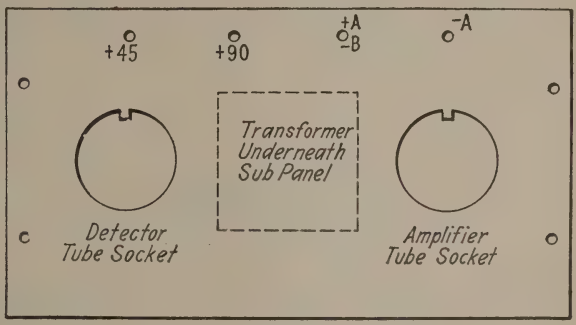


Fig. 86. Sub-Panel Layout

tion. Mounting the transformer is next. If the sub-panel has been drilled for the General Radio transformer and that one is available, line up the holes in its mounting feet with the panel holes making sure that the primary connections are nearest the detector tube. Machine screws of proper size should then be passed through the holes in the panel and mounting feet and hexagonal nuts turned on to the screws and tightened up. The transformer is then mounted bottom side up underneath this sub-panel;—it might be termed "under-slung." The four binding posts may then be fastened into the panel and the panel mounted on its brackets with machine screws and hexagonal nuts.

The constructor is now ready to mount the coil system on the front panel. If the coil system shown is used it is only necessary to fasten it to the back of the panel, bakelite strip

up, with the two machine screws furnished for that purpose. When this has been done the variable condenser may be mounted and wired so that its rotor plates connect directly with the secondary coil terminal marked "F" and the ground binding post marked "E." No. 12 or No. 14 solid bare, round copper wire or tinned bus bar may be used. Then connect the stator (fixed) plates to the secondary coil binding post marked "G." See circuit diagram of Fig. 81.

Everything is now ready for securing the sub-panel to the front panel with machine screws and hexagonal nuts. When this is done the wiring may be completed. (See the circuit

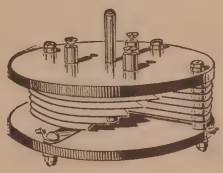


Fig. 87. Condenser with Stagger-cut Rotary Plates

diagram.) When connecting up the tickler coil be sure that its winding is opposite to that of the secondary. If the coil system illustrated has been used, there will be no question as to this if post "P" is connected to the plate terminal of the detector socket and post "B" to the proper spring of the detector jack. When connecting up the transformer, if its terminals are unmarked or incorrectly marked, see that the lead from the inside of the primary winding (next to the core) connects to the proper spring of the detector jack and that the lead from the outside of the secondary winding connects to the grid terminal of the amplifier socket. Otherwise the amplifier might at some time develop a slight howl.

Connecting Batteries and Testing. First connect the "A" battery to the proper binding posts and insert a tube in the detector socket, the rheostat having been turned first to the "off" position. Plug the head telephones into the detector

jack and turn rheostat up slowly whereupon the filament should light. If a D.C. voltmeter reading up to at least 6 volts is handy, connect it to the filament terminals of the detector socket and turn rheostat up until the meter reads 5 volts or a little less. Make a note of this rheostat adjustment. This should be done with an "A" battery up to full voltage. Then put the tube in the amplifier socket, first having pulled the plug out of the detector jack and turn the rheostat back to the "off" position. Plug into the amplifier jack and slowly turn the rheostat up until the voltmeter again reads 5 volts or a little less. The rheostat should now have been turned up as far as it was the first time. Make a permanent note of this adjustment and never turn the rheostat higher when a fresh "A" battery is connected to the set. The filament circuits through the jacks are now probably all right. No tube should light until the plug is pushed into one of the jacks and the amplifier tube should only light when the plug is pushed into the amplifier jack. Now connect the "B" battery to the proper terminals, leaving the tubes out of their sockets if a voltmeter reading up to 100 volts is available. Connect the voltmeter to the negative terminal of the "B" battery and the plate terminal of the detector socket. The meter should read less than the voltage of that portion of "B" battery used in the detector plate circuit. If it reads the same the transformer primary is short circuited, but if it does not read at all then either this primary winding is open or the jack is at fault. First trace the wiring to make sure that it is complete, examine the jack connections to make sure they are properly made and the jack springs to make sure that contacts are being made properly. If this is all O.K. then test directly across the transformer primary with battery and voltmeter and if an open is found, get a new transformer. If the reading was all right plug the telephones into the detector jack and see if voltmeter shows a reading. If it did previously and does not now, then either the jack is not properly connected up, it is not mounted correctly so that tip and sleeve of plug make

contacts with the proper springs or there is an open in the receiver cord, in the receiver magnet windings or between the receiver posts and these windings. Perhaps a connection is off at the receiver case or inside the receiver. If this test is O.K. move the positive voltmeter lead from the plate terminal of the detector socket to the plate terminal of the amplifier socket and plug the head telephones into the amplifier jack. The voltmeter should read less than the full amplifier "B" battery voltage and if it does not the jack is probably at fault.

The receiver is now ready to try out on signals. Although it is sensitive enough to be used in many places without antenna or ground, a good antenna and a good ground will always improve signal strenghth with any receiver. The coupling between the antenna and secondary coils may usually be left as close as it is possible to make it. Only occasionally, when it is necessary to "work through" a nearby station, will the coupling have to be loosened much. If the detector tube goes into oscillation too suddenly (with a bang) the grid leak resistance probably is not of the right value. If it is, then the rheostat may be turned down and perhaps the detector plate voltage lowered also. Sometimes when the antenna capacity is very low the tendency toward oscillation with small tickler coupling is too great. If lowering the detector "B" battery voltage does not improve the situation take off some of the turns of the tickler coil. The tube should go into oscillation at the longest waves within the range of the receiver when the tickler coupling is just about maximum.

The secondary condenser dial settings may be recorded for the various stations providing the antenna coupling is not changed. Changing coupling has some effect upon secondary tuning, as may be expected, but not as much as it would if the antenna coil had more turns. The effect in the case of this receiver is not very great.

If, when increasing the tickler coupling, the signal strength decreases instead of increases as it should, reverse the connections to the tickler coil and the trouble will be cleared up.

Variations of tickler coupling affect the secondary tuning to some extent but not a great deal.

Cabinet. A cabinet sometimes detracts from the performance of a short wave receiver because of capacity effects between it and various portions of the circuit. The receiver will stand up without one. If a cabinet is desired, however, it may be one having dimensions of 7″ x 18″ x 9″.

Change in Coils to Adapt this Set to a Wave Length Range of About 30 *to* 80 *Meters.* This wave length range may be covered with the same condenser (0.00025 mfd.) by putting 4 turns of No. 14 D.C.C. on the antenna coil instead of 6 turns. The secondary winding may be of 6 turns of No. 12 D.C.C. and the tickler coil may have 4 turns of No. 20 D.C.C. wire. The constructor might devise some means allowing a change from one set of coils to another and in this case the use of the same condenser for both wave length bands would be convenient.

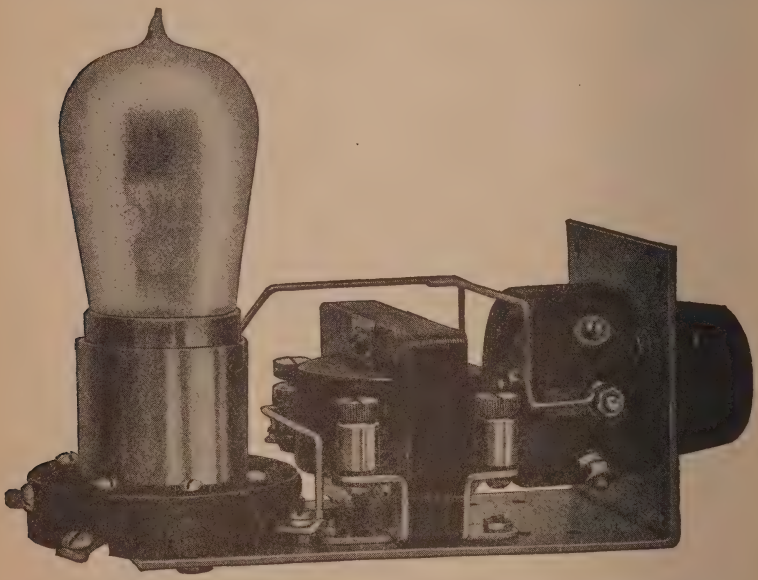
If a smaller condenser were used with a larger secondary coil the ratio of inductance to capacity would be better but, since the smaller condenser would probably not have so great a capacity range, the range of wave lengths would be narrowed down. If regeneration is difficult to secure at the lower wave lengths it may be advisable to shunt a 1 mfd. mica dielectric condenser across the "A" and "B" batteries. A great deal of experimental work is being done by various laboratories, for example NKF, the Naval Experimental Laboratories at Bellevue, near Washington, D. C., on short waves and it would be possible to hear some of this work being done by making the above changes.

CHAPTER XII

Commercial Types of Receivers

Many of the Better Types of Commercial Receivers Are Described and Illustrated By Cuts So That the Reader May See Just How These Manufacturers Solved Their Mechanical and Electrical Problems. The Effect of Location on Radio Reception Is Included So That a Better Understanding of Why Signals Are Strong in Some Locations and Weak in Others May Be Had

The illustrations shown in this chapter are included for the purpose of giving the amateur builder an idea of how designers of commercial radio receivers treat their subjects. This will



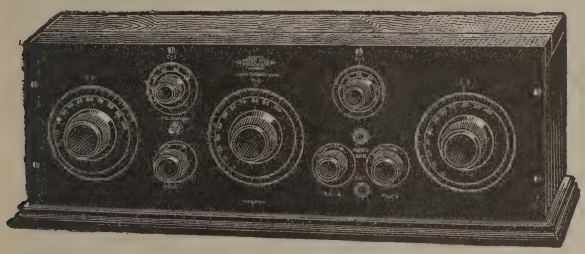
Courtesy of General Radio Co.

Fig. 88. Single Stage General Radio Amplifier Unit

not only help the amateur in building the circuits described in this book, but will be of value in case he decides to deviate from these descriptions in favor of some other design.

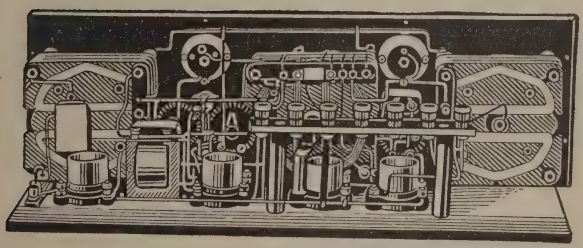
FIGURE 88 shows a single stage amplifier unit designed and sold by the General Radio Co. A rheostat is provided for the tube so that the filament current may be adjusted to the proper value.

In Fig. 89 is shown a typical commercial design of a radio frequency receiver. This employs tuned coupling between the



Courtesy of Amsco Products Co.

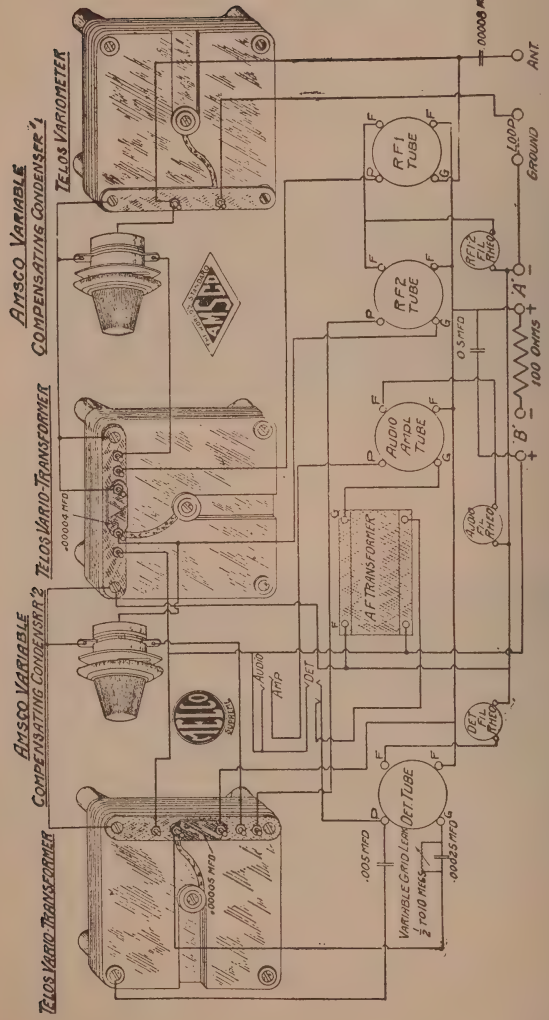
Fig. 89. Melco Receiver



Courtesy of Amsco Products Co.

Fig. 90. Interior of Melco Receiver

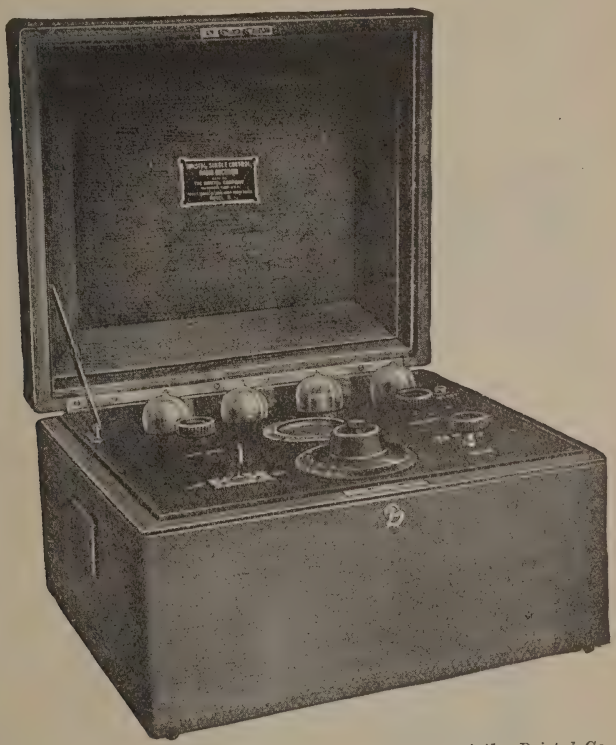
stages, and the circuit is of the neutrodyne type with variable neutralizing condensers. The interior arrangement of the various parts may be seen in Fig. 90. It will be observed that "D" type variometers of special construction are employed. The circuit diagram of this receiver is shown in Fig. 91.



Courtesy of Amsco Products Co.

Fig. 91. Circuit of Melco Receiver

FIGURE 92 shows the design of a single Control radio receiver. This set embodies the Grimes Inverse Duplex circuit. It includes two stages of radio frequency, a detector, and three stages of audio frequency amplification. One rheostat is used



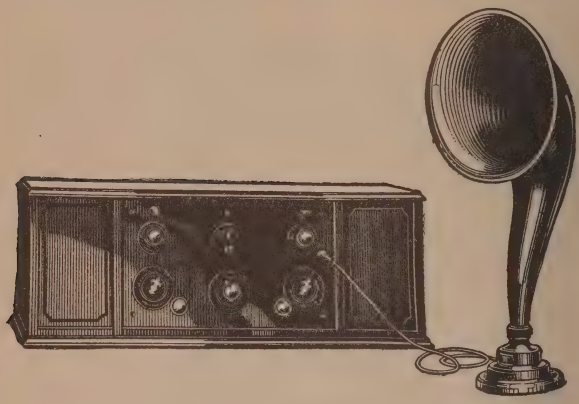
Courtesy of the Bristol Co.

Fig. 92. Bristol R. F. Receiver

for the detector and one for the three amplifier tubes. A voltmeter is also mounted on the panel to show the filament voltages at which the amplifier tubes are operated.

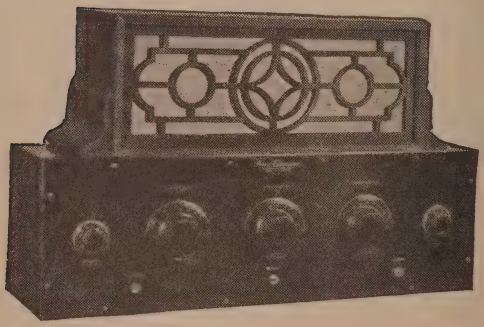
FIGURE 93 illustrates a new commercial receiver in which the reflex principle is used. The design of this receiver deviates

considerably from ordinary receivers on the market. It is self-contained, as the batteries and various accessories are placed in compartments at both ends of the cabinet. The tuning controls are mounted directly on a wooden panel, no special



Courtesy of the Radio Corporation of America

Fig. 93. Regenoflex Receiver



Courtesy of Freed-Eismann Radio Corporation

Fig. 94. Freed-Eismann Receiver

insulating panel being used, as is customary in most receivers. It is designed to deliver sufficient volume to operate a loud speaker, when connected into a low resistance antenna circuit.

FIGURE 94 shows the arrangement of the panel of one of the

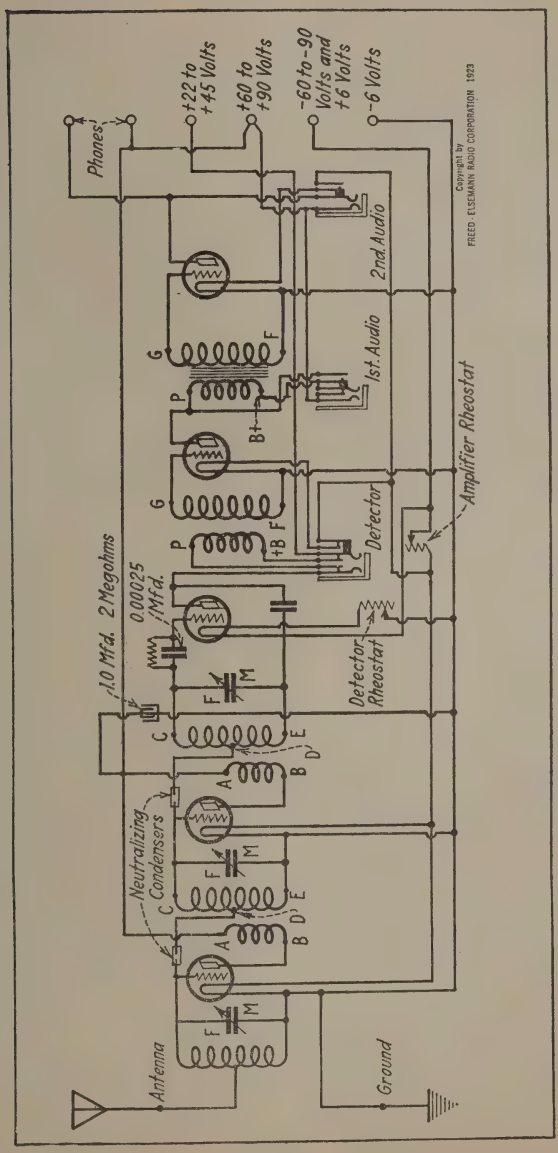
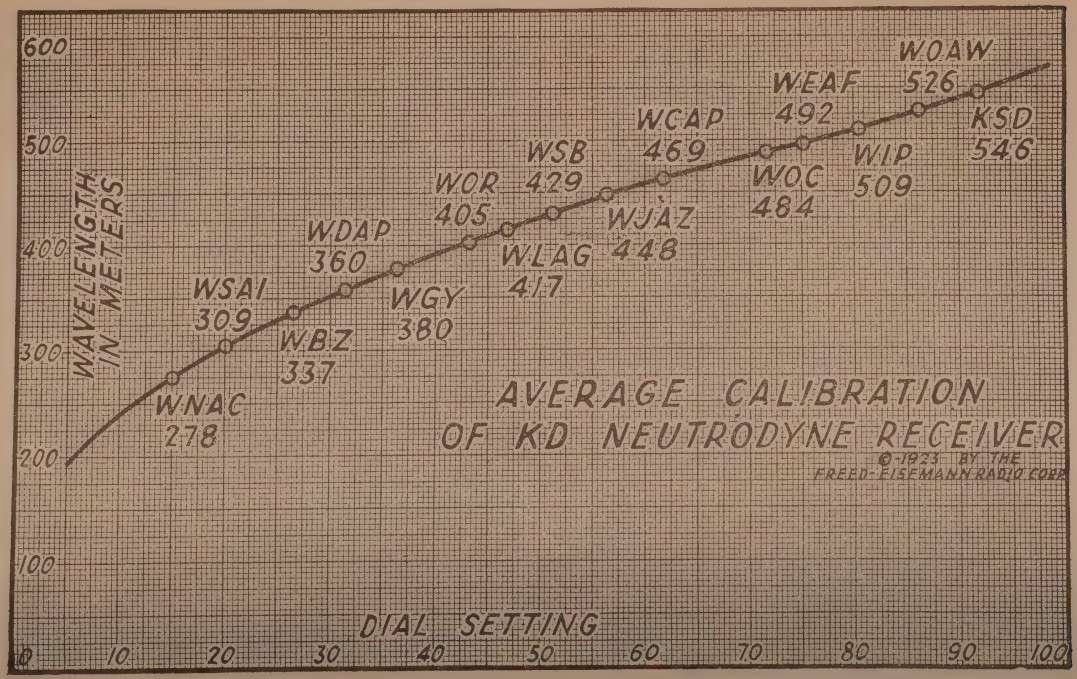


Fig. 95. Neutrodyne Circuit Diagram

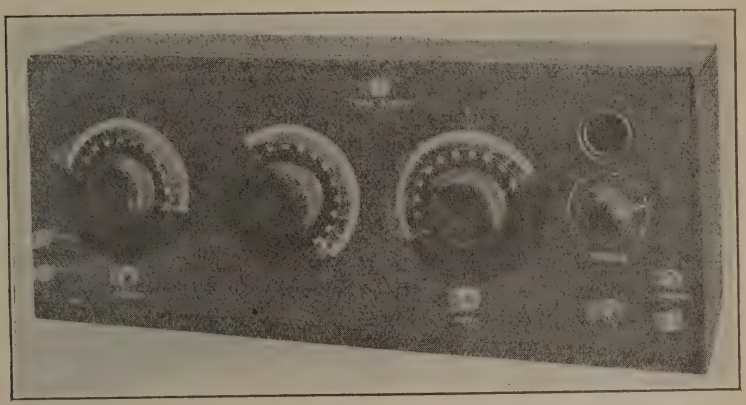
These dial settings are approximate and may vary according to the individual receiver. They may also vary with any accidental change in wavelength of the broadcasting station



Courtesy of Freed-Eismann Radio Corporation

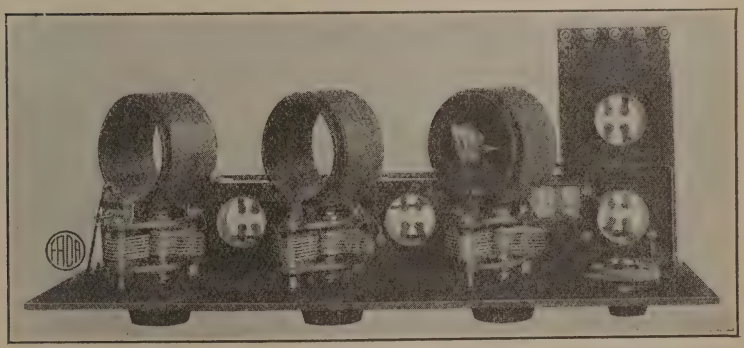
Fig. 96. Typical Neutrodyne Calibration Chart

standard Neutrodyne receiving sets. This is a five tube receiver, somewhat similar to the one described in Chapter VIII of this book. It comprises two stages of neutralized radio frequency amplification, a detector, and two stages of audio fre-



Courtesy of F. A. D. Andrea, Inc.

Fig. 97. Front of "Fada 160" Set



Courtesy of F. A. D. Andrea, Inc.

Fig. 98. Interior of "Fada 160" Set

quency amplification. It is a very efficient and sensitive set, and will deliver loud speaker volume from distant stations with a reasonably good antenna. It is sufficiently selective to

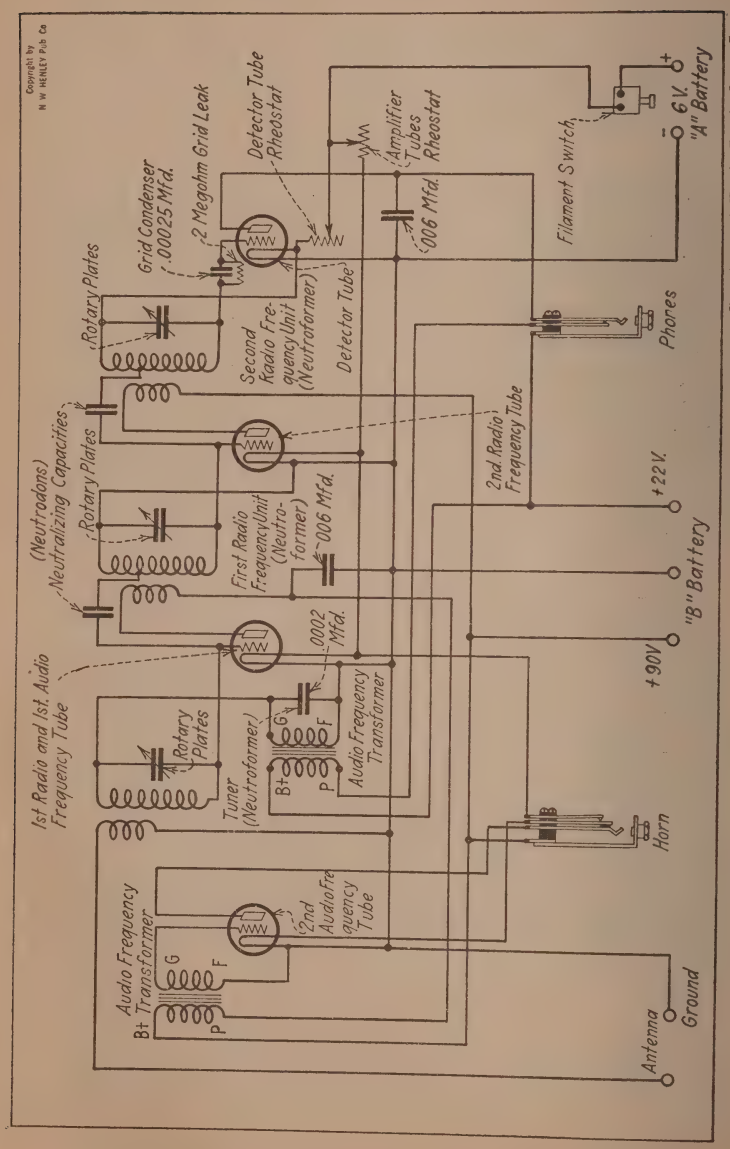


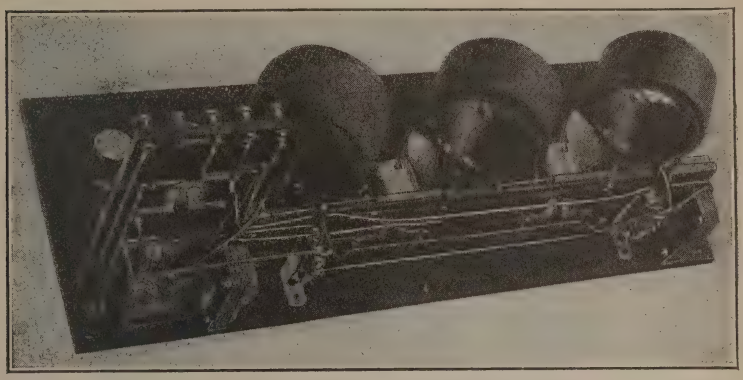
Fig. 99. Schematic Wiring of "Pada 160" Set

Courtesy of F. A. D. Andrea, Inc.

separate two signals of approximately equal intensity, differing about five meters in the neighborhood of 400 meters without noticeable interference.

The circuit of this receiver is similar to that shown in Fig. 95.

A receiver of this type should be calibrated so that the tun-



Courtesy of F. A. D. Andrea, Inc.

Fig. 100. Rear View of "Fada 160" Neutrodyne

ing operations may be simplified as much as possible. A typical calibration of one of these receivers is shown in Fig. 96.

FIGURE 97 illustrates the panel layout of another Neutrodyne receiver. This receiver is fundamentally the same as the previous circuit. This receiver only employs four tubes, however, as the first audio frequency stage is reflexed.

The interior view of this receiver is shown in Fig. 98 and the schematic wiring diagram in Fig. 99.

FIGURE 100 illustrates the rear view of the receiver. It shows clearly the arrangement of the tubes, the "Neutroformers" the neutralizing condensers, and the audio frequency transformers. Most of the wiring is plainly visible.

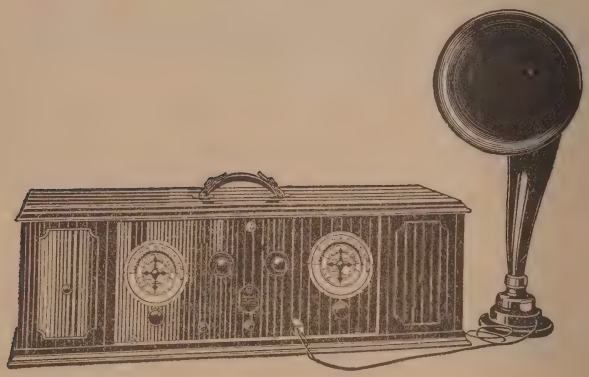
FIGURE 101 illustrates a semi-portable super-heterodyne receiver. This instrument is also self contained. Batteries are placed in two compartments at opposite ends of the cabinet and

the tuning elements are in the center. A small loop inside the cabinet or an exterior loop may be employed as desired. This receiver employs six UV199 Radiotrons. It is sensitive and selective, and will deliver moderate loud speaker volume without appreciable distortion.

The Effect of Location on Radio Reception

Nearly every radio listener has observed the fact that radio signals may be received much better in some localities than in others with the same receiving equipment, and at the same distance from the broadcasting station.

The reason for this varying intensity of the received waves



Courtesy of Radio Corporation of America

Fig. 101. Radiola Super-Heterodyne

is usually due to local obstruction, which cast a shadow over the country beyond them. Any radio receiver which is placed in the shadow of such obstructions is eclipsed, so to speak, and very little energy reaches it directly from the broadcasting station. Such places have usually been termed radio pockets, or "dead spots."

The simplest way to understand the effects of various natural and man-made obstructions is to compare the radio wave with

other waves which may be observed more readily, such as water waves, sound waves, light waves and heat waves.

For instance, consider the water wave. If a rock is dropped into a large body of still water, waves will start at the point of disturbance and travel outward in concentric circles, as

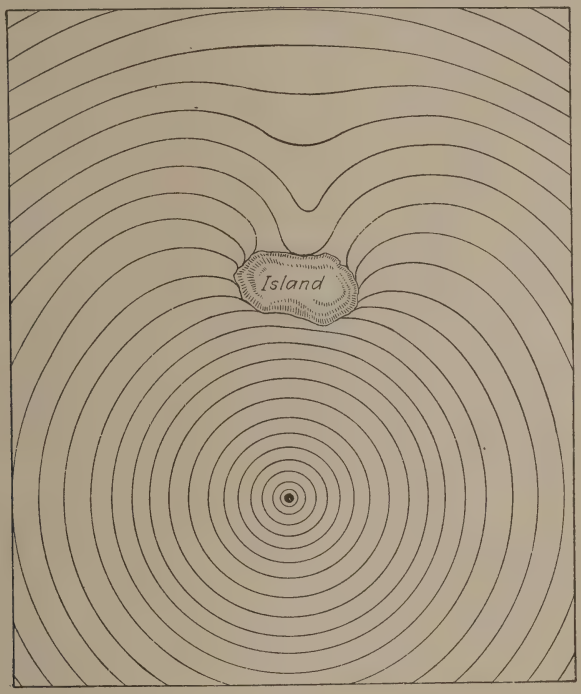


Fig. 102. Water Waves

shown in Fig. 102. If an obstacle, such as an island, is located in the way of the waves, the waves will partly be reflected when they strike the island and partly be absorbed, as illustrated in Fig. 102. The waves in the other direction, away from the land, will travel on and bend around the island, so that a considerable distance beyond the obstacle the waves will again

meet and continue in circles almost as if the obstacle had not been present. The longer the waves are in comparison to the extent of the obstacle, the sooner they will meet, and the effect of the obstruction healed up.

The same phenomena occurs in sound, although it cannot be so readily observed. Behind every obstacle there is a sound shadow, and a person who is located in the shadow area receives the energy mostly from the edges and the top of the obstacle. At a short distance back of the obstacle the sound appears to come from the source just as if the obstacle had not been present. This effect is not very readily observed except with very delicate instruments.

When the waves are very short in comparison to the extent of the obstacle the shadow is more pronounced, which is the case of light waves, which are very short in comparison to any obstacle which we may perceive. The separation between the shadow and light area seems to follow a straight line. There is, however, a bending inward into the shadow area, and this phenomenon is known as diffraction. The light which reaches the shadow area is partly due to diffraction and partly to diffused reflection.

Theory tells us that the radio wave travels away from the point of disturbance in space equally in all directions, so that the wave front is always the surface of a sphere. This, however, is under ideal conditions, which are never met with in practice. A radio wave, if one side of the radiator is grounded, is always attached to the ground, and travels away from the center of disturbance in the form of a hemisphere.

The intensity of the wave at any point is inversely proportional to the distance away from the radiator. The actual strength of the magnetic field due to a radio wave is never as great as that which one would expect from theoretical considerations, due to absorption in material obstructions in the path of waves, such as objects on the surface of the ground, and particles of dust in the air.

The nearest approach to the theoretical conditions which we

meet with in practice is that of the surface of the sea. This may be regarded as a fairly good conducting plane surface, which is homogeneous in all directions. Here the results obtained under actual experimental conditions agree very well with results deduced theoretically.

On land the results obtained experimentally deviate to a much greater degree, and the extent of the absorption depends largely on the nature of the soil and the topography of the ground over which the waves travel. A mountain located between a broadcasting station and a receiver casts a shadow around the receiver in exactly the same way as an opaque body casts a shadow around objects placed on the side away from a light source. The longer and higher the mountain is, the greater will be the shadow; also the closer the receiver is to the mountain the more intense will be the shadow. When the radio waves strike the mountain, the energy is divided into three parts; part is transmitted through it, like the light which passes through a semi-opaque body; part is reflected, like light is reflected from most surfaces; and part is absorbed. The energy therefore reaches the receiver in two ways; first, by direct transmission through the mountain, and second, by diffraction around and above the mountain.

Large steel buildings, such as are erected in big cities, are very opaque to electro-magnetic waves, and this opacity is very often selective so that some wave lengths are nearly absorbed, while others pass through more readily. This is due to natural tuned circuits in such places.

Experimental results obtained under actual broadcasting conditions clearly indicate that radio waves follow the same laws as other types of waves, and that various effects may be predicted by comparing the corresponding phenomena.

Consider the radio contour maps given in Figs. 103, 104 and 105. These show in graphic form the results obtained by the American Telephone and Telegraph Company in a series of field measurements around its broadcasting stations WEAF, New York, and WCAP, Washington, D. C.

FIGURE 103 shows the distribution of the radio energy from WEAF over the metropolitan district, in which the effects of water courses and different obstacles may be seen clearly. The

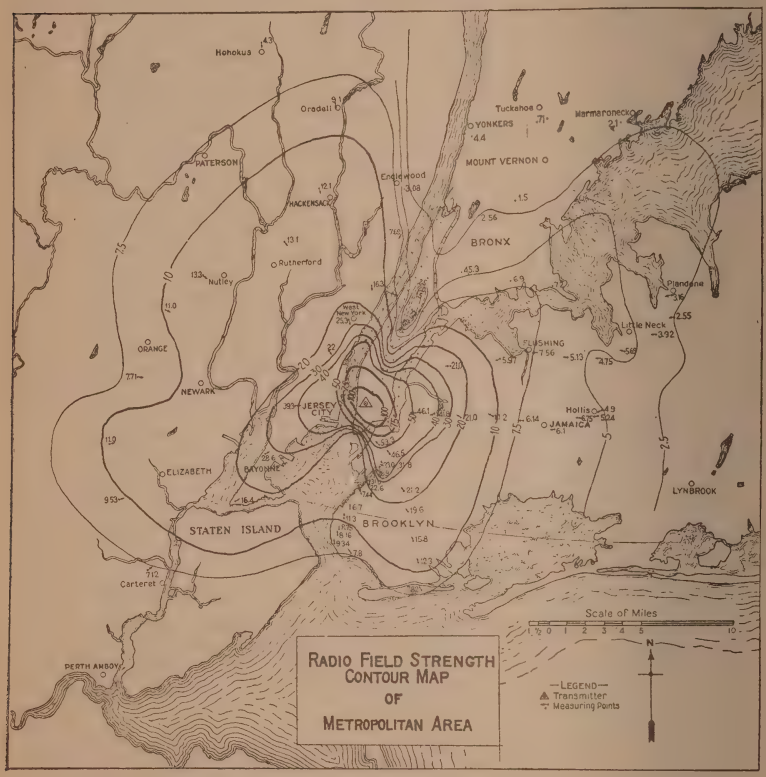


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Fig. 103. Contour Map WEAF

tall steel skyscrapers on lower Manhattan cast a dense shadow over the upper bay, and this shadow has not entirely disappeared at the Narrows between Staten Island and Brooklyn. Another heavy shadow is cast over Central Park by the mass of up-town steel buildings. This shadow extends up to Yonkers

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Fig. 104. Aerial Photograph of Manhattan Island

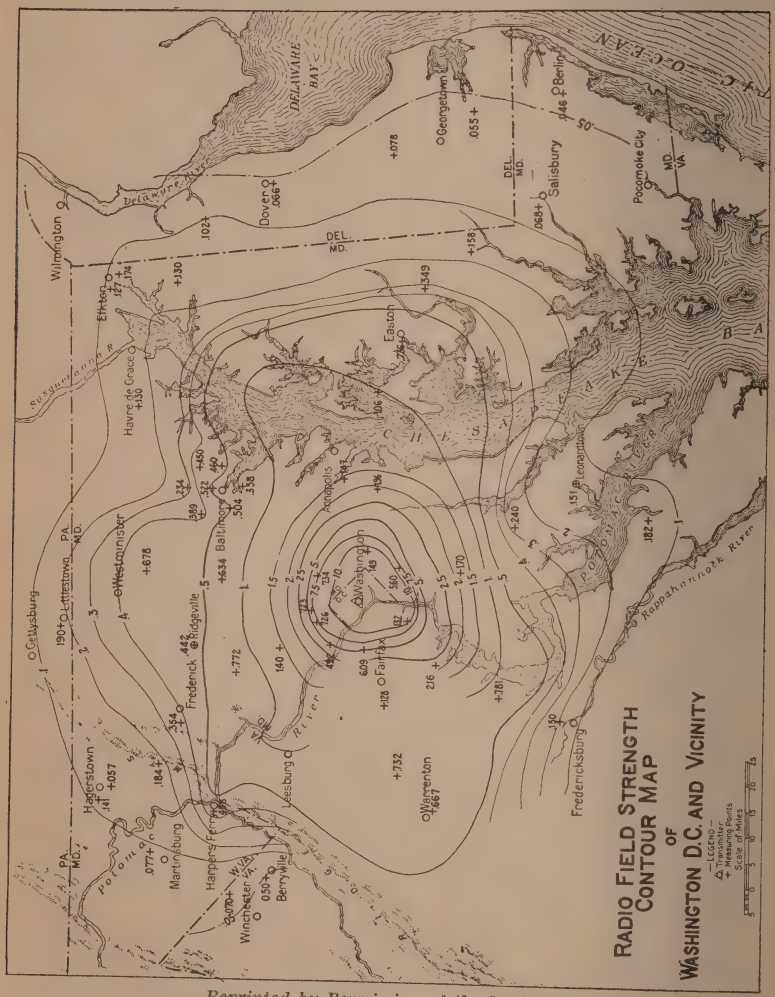

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Fig. 105. Contour Map WCAP

and beyond. Another shadow is cast by Newark over the country beyond, although it is not very intense.

The transmission along water courses and valleys is much more favorable. Thus, in Long Island Sound the contours are far apart and the field is strong at a relatively long distance from the broadcasting station. The same effect is seen along the rivers and valleys in New Jersey.

The same effects are also clearly seen on the aerial photograph map of lower Manhattan shown in Fig. 104. Governor's Island in the foreground is almost wholly eclipsed by the mass of steel at the tip of Manhattan Island. The shadow on Central Park is very pronounced, while a lesser shadow is seen near Yonkers. The conducting effect of the bridges across the East River is also clearly shown. We are indebted to *Radio Broadcast* for the use of this illustration.

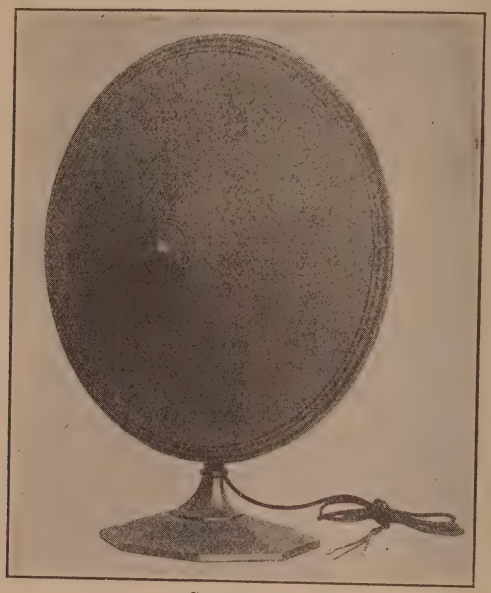
In Fig. 105 is shown a radio contour map around station WCAP, Washington, D. C. The distribution of energy over this territory is much more uniform than in the case of station WEAF. There are no pronounced radio shadows, but there are retardation effects over dry land. The effects of water courses are more apparent. The transmission along the Potomac River, both above and below Washington, is noticeably better than over dry land. The same holds true of Chesapeake Bay.

A New Loud Speaker

Just as this book was going to press a new loud speaker came on the market which is quite different from the average, in that it really reproduces speech and music faithfully. Not having a horn, it has no characteristic horn sound and is neither low pitched nor high pitched but accurately reproduces whatever goes into it.

Its manufacturers give its characteristics as follows:—Input Impedance 8,500 ohms, which means that it is designed to be used with most of the radio receivers on the market. The reproduction of piano, orchestra, band and organ music as well as

speech and vocal music proved in tests to be as nearly natural as could be hoped for. With a power amplifier, volume can be increased to an enormous extent without distortion in the



Courtesy of Western Electric Co.

Fig. 106. Up-to-Date Type Loud Speaker, Type 540-AW

speaker itself. Of course, in order to avoid all distortion there must be none in the amplifier.

Complete List of Broadcasting Stations in the United States

Call Signal	Location of Station	Wave Length	Power (Watts)
KDKA	East Pittsburgh, Pa., Westinghouse Electric & Mfg. Co.	326	1,000
KDPM	Cleveland, Ohio, Westinghouse Electric & Mfg. Co.	270	500
KDPT	San Diego, Calif., Southern Electric Co.	244	50
KDYL	Salt Lake City, Utah, Newhouse Hotel	360	100
KDYM	San Diego, Calif., Savoy Theater	280	100
KDYQ	Portland, Oreg., Oregon Inst. of Technology	360	50
KDZB	Bakersfield, Calif., Frank E. Siefert	240	100
KDZE	Seattle, Wash., Rhodes Co.	270	100
KDZR	Bellingham, Wash., Bellingham Pub. Co.	261	50
KFAD	Phoenix, Ariz., McArthur Bros. Mercantile Company	360	100
KFAE	Pullman, Wash., State College of Washington	330	500
KFAF	Denver, Colo., Western Radio Corp.	360	50
KFAJ	Boulder, Colo., University of Colorado	360	100
KFAR	Hollywood, Calif., Studio Lighting Service Company	280	100
KFAU	Boise, Idaho, Boise High School	270	150
KFAW	Santa Ana, Calif., The Radio Den	280	10
KFAY	Medford, Oreg., Virgin's Radio Service	283	50
KFBB	Havre, Mont., F. A. Buttrey & Co.	360	50
KFBC	San Diego, Calif., W. K. Azvill	278	5
KFBE	San Luis Obispo, Calif., Reuben H. Horn	242	10
KFBG	Tacoma, Wash., First Presbyterian Church	360	50
KFBK	Sacramento, Calif., Kimball-Upson Co.	283	100
KFBL	Everett, Wash., Leese Bros.	224	10
KFBS	Trinidad, Colo., Trinidad Gas & Electric Supply Co. and The Chronicle News	360	10
KFBU	Laramie, Wyo., The Cathedral	283	50
KFCB	Phoenix, Ariz., Nielsen Radio Supply Co.	238	10
KFCF	Walla Walla, Wash., Frank A. Moore	360	100
KFCL	Los Angeles, Calif., Leslie E. Rice, Los Angeles Union Stock Yards	236	500
KFCP	Ogden, Utah, Ralph W. Flygare	360	25
KFCV	Houston, Tex., Fred Mahaffey, Jr.	360	10
KFCZ	Omaha, Nebr., Omaha Central High School	258	50
KFDD	Boise, Idaho, St. Michaels Cathedral	252	10
KFDH	Tucson, Ariz., University of Arizona	268	50
KFDJ	Corvallis, Oreg., Oregon Agricultural College	360	50
KFDX	Shreveport, La., First Baptist Church	360	100
KFDY	Brookings, S. Dak., South Dakota State College	360	150
KFDZ	Minneapolis, Minn., Harry Q. Iverson	231	5

Call Signal	Location of Station	Wave Length	Power (Watts)
KFEC	Portland, Oreg., Meier & Frank Co.	248	50
KFEK	Minneapolis, Minn., Augsbury Seminary	261	100
KFEL	Denver, Colo., Winner Radio Corporation	254	50
KFEQ	Oak, Nebr., J. L. Scroggin	268	100
KFER	Fort Dodge, Iowa, Auto Electric Service Co.	231	10
KFEV	Casper, Wyo., Felix Thompson Radio Shop	263	50
KFEY	Kellogg, Idaho, Bunker Hill & Sullivan Mining & Concentrating Co.	360	10
KFFB	Boise, Idaho, Jenkins Furniture Co.	240	10
KFFE	Pendleton, Oreg., Eastern Oregon Radio Co.	360	10
KFFP	Moberly, Mo., First Baptist Church	266	50
KFFR	Sparks, Nev., Nevada State Journal	226	10
KFFV	Lamoni, Iowa, Graceland College	280	100
KFFX	Omaha, Nebr., McGraw Co.	278	100
KFFY	Alexandria, La., Pincus & Murphey	275	50
KFGB	Utica, Nebr., Heidbreder Radio Supply Co.	224	10
KFGC	Baton Rouge, La., Louisiana State University	254	100
KFGD	Chickasha, Okla., Chickasha Radio & Electric Co.	248	200
KFGH	Stanford University, Calif., Leland Stanford University	273	500
KFGL	Arlington, Oreg., Snell & Irby	234	5
KFGQ	Boone, Iowa, Crary Hardware Co.	226	10
KFGX	Orange, Tex., First Presbyterian Church	250	500
KFGZ	Berrien Springs, Mich., Emmanuel Missionary College	286	500
KFHA	Gunnison, Colo., Western State College of Colorado	252	50
KFHD	St. Joseph, Mo., Utz Electric Co.	226	100
KFHH	Neah Bay, Wash., Ambrose A. McCue	261	50
KFHJ	Santa Barbara, Calif., Fallon & Co.	360	100
KFHR	Seattle, Wash., Star Electric & Radio Co.	283	50
KFI	Los Angeles, Calif., Earle C. Anthony (Inc.)	469	500
KFID	Iola, Kans., Ross Arbuckle's Garage	246	30
KFIF	Portland, Oreg., Benson Polytechnic Institute	360	100
KFIL	Louisburg, Kans., Windisch Electric Farm Equipment Co.	234	30
KFIO	Spokane, Wash., North Central High School	252	50
KFIQ	Yakima, Wash., First Methodist Church	242	50
KFIU	Juneau, Alaska, Alaska Electric Light & Power Co.	226	10
KFIX	Independence, Mo., Reorganized Church of Jesus Christ of Latter Day Saints	240	250
KFIZ	Fond du Lac, Wis., Daily Commonwealth and Oscar A. Huelsman	273	100
KFJB	Marshalltown, Iowa, Marshall Electric Co.	248	10
KFJC	Seattle, Wash., Seattle Post-Intelligencer	270	100
KFJF	Oklahoma City, Okla., National Radio Manufacturing Co.	252	20
KFJI	Astoria, Oreg., Liberty Theater	252	10
KFJK	Bristow, Okla., Delano Radio & Electric Co.	233	100
KFJL	Ottumwa, Iowa, Hardsacg Manufacturing Co.	242	10

Call Signal	Location of Station	Wave Length	Power (Watts)
KFJM	Grand Forks, N. Dak., University of North Dakota	280	100
KFJQ	Grand Forks, N. Dak., Electric Construction Co., Valley Radio Division	280	5
KFJR	Stevensville, Mont. (near), Ashley C. Dixon & Son	258	5
KFJX	Cedar Falls, Iowa, Iowa State Teachers College	280	50
KFJY	Fort Dodge, Iowa, Tunwall Radio Co.	246	50
KFJZ	Fort Worth, Tex., Texas National Guard, One Hundred and Twelfth Cavalry	254	20
KFKA	Greeley, Colo., Colorado State Teachers College	273	50
KFKB	Milford, Kans., Brinkley-Jones Hospital Association	286	500
KFKQ	Conway, Ark., Conway Radio Laboratories	250	100
KFKV	Butte, Mont., F. F. Gray	283	50
KFKX	Hastings, Nebr., Westinghouse Electric & Mfg. Co.	341	1,000
KFKZ	Colorado Springs, Colo., Nassour Bros. Radio Co.	234	10
KFLA	Butte, Mont., Abner R. Wilson	283	5
KFLB	Menominee, Mich., Signal Electric Manufacturing Co.	248	50
KFLD	Franklinton, La., Paul E. Greenlaw	234	10
KFLE	Denver, Colo., National Education Service	268	25
KFLQ	Little Rock, Ark., Bizzell Radio Shop	261	20
KFLR	Albuquerque, N. Mex., University of New Mexico	254	100
KFLU	San Benito, Tex., Rio Grande Radio Supply House	236	100
KFLV	Rockford, Ill., A. T. Frykman	229	100
KFLW	Missoula, Mont., Missoula Electric Supply Co.	234	10
KFLX	Galveston, Tex., George R. Clough	240	10
KFLZ	Atlantic, Iowa, Atlantic Automobile Co.	273	100
KFMB	Little Rock, Ark., Christian Churches of Little Rock	254	...
KFMQ	Fayetteville, Ark., University of Arkansas	263	100
KFMR	Sioux City, Iowa, Morningside College	261	10
KFMT	Minneapolis, Minn., George W. Young	231	5
KFMW	Houghton, Mich., M. G. Sateren	266	50
KFMX	Northfield, Minn., Carleton College	283	500
KFNF	Shenandoah, Iowa, Henry Field Seed Co.	266	500
KFNG	Coldwater, Miss., Wooten's Radio Shop	254	10
KFNJ	Warrensburg, Mo., Warrensburg Electric Shop	234	50
KFNL	Paso Robles, Calif., Radio Broadcast Association	240	10
KFNV	Santa Rosa, Calif., L. A. Drake	234	5
KFNY	Helena, Mont., Montana Phonograph Co.	261	5
KFNZ	Burlingame, Calif., Royal Radio Co	231	10

Call Signal	Location of Station	Wave Length	Power (Watts)
KFOA	Seattle, Wash., Rhodes Co.	455	500
KFOC	Whittier, Calif., First Christian Church	236	100
KFOD	Wallace, Idaho, The Radio Shop	224	10
KFOJ	Moberly, Mo., Moberly High School Radio Club	246	5
KFOL	Marengo, Iowa, Leslie M. Schafbuch	234	10
KFON	Long Beach, Calif., Echophone Radio Shop	234	100
KFOO	Salt Lake City, Utah, Latter Day Saints University	261	10
KFOQ	Galveston, Tex., Ora W. Chancellor	240	50
KFOR	David City, Nebr., David City Tire & Electric Co.	226	20
KFOT	Wichita, Kans., College Hill Radio Club	231	50
KFOU	Richmond, Calif., Hommel Manufacturing Company	254	100
KFOX	Omaha, Nebr., Technical High School (Board of Education)	248	100
KFOY	St. Paul, Minn., Beacon Radio Service	226	50
KFOZ	Fort Smith, Ark., Leon Hudson Real Estate Company	233	20
KFPB	Seattle, Wash., Edwin J. Brown	224	15
KFPG	Los Angeles, Calif., Garretson & Dennis	238	100
KFPH	Salt Lake City, Utah, Howard C. Mailander	242	50
KFPL	Dublin, Tex., C. C. Baxter	242	20
KFPN	Jefferson City, Mo., Missouri National Guard Headquarters Company, 70th Infantry Brigade	242	10
KFPO	Denver, Colo., Colorado National Guard, Forty-fifth Division Tank Co.	231	500
KFPP	Olympia, Wash., G. & G. Radio and Electric Shop	236	20
KFPR	Los Angeles, Calif., Los Angeles County Forestry Department	231	500
KFPS	Casper, Wyo., Carter A. Ross Motor Service Company	242	10
KFPT	Salt Lake City, Utah, Cape & Johnson	268	500
KFPV	San Francisco, Calif., Heintz & Kohlmoos	236	50
KFPW	Carterville, Mo., St. Johns Church	268	20
KFPX	Pine Bluff, Ark., First Presbyterian Church	242	100
KFPY	Spokane, Wash., Symons Investment Co.	283	100
KFQA	St. Louis, Mo., The Principia	261	50
KFQB	Fort Worth, Tex., Searchlight Publishing Company	254	100
KFQC	Taft, Calif., Kidd Brothers Radio Shop	227	100
KFQD	Anchorage, Alaska, Chovin Supply Co.	280	100
KFQE	Colorado Springs, Colo., Dickenson-Henry Radio Laboratories	224	5
KFQF	Minneapolis, Minn., Donald A. Boult	224	10
KFQG	Los Angeles, Calif., Armory, Southern California Radio Association	226	100
KFQH	Hillsborough, Calif., Albert Sherman	231	50
KFQI	Culver City, Calif., Thomas H. Ince Corp.	234	100
KFQJ	Oklahoma, Okla., Harbour-Longmire Co.	236	50

Call Signal	Location of Station	Wave Length	Power (Watts)
KFQK	Fayette, Mo., Democrat Leader	236	10
KFQL	Muskogee, Okla., Oklahoma Free State Fair Association	252	20
KFQM	Austin, Tex., Texas Highway-Bulletin	268	100
KFQN	Portland, Oreg., Third Baptist Church	283	5
KFQO	Russell, Kans., Meier Radio Shop	261	10
KFQP	Iowa City, Iowa, George S. Carson, Jr.	224	10
KFQR	Oklahoma, Okla., Walter L. Ellis	250	10
KFQS	Manitou, Colo., Dickenson-Henry Radio Laboratories	246	10
KFQT	Denison, Tex., Texas National Guard, Thirty-sixth Signal Co.	252	10
KFQU	Holy City, Calif., W. Riker	234	100
KFQV	Omaha, Nebr., Omaha Grain Exchange	231	100
KFQW	North Bend, Wash., C. F. Knierim Photo Radio & Electric Shop	248	50
KFQX	Seattle, Wash., Alfred M. Hubbard	233	250
KFSG	Los Angeles, Calif., Echo Park Evangelistic Association	278	500
KGB	Tacoma, Wash., Tacoma Daily Ledger	252	50
KGG	Portland, Oreg., Hallock & Watson Radio Service	360	50
KGO	Oakland, Calif., General Electric Co.	312	1,000
KGU	Honolulu, Hawaii, Marion A. Mulrony	360	500
KGW	Portland, Oreg., Portland Morning Oregonian	492	500
KGY	Lacey, Wash., St. Martins College	258	5
KHJ	Los Angeles, Calif., Times-Mirror Co.	395	500
KHQ	Seattle, Wash., Louis Wasmer	360	100
KJQ	Stockton, Calif., C. O. Gould	273	5
KJR	Seattle, Wash., Northwest Radio Service Co.	283	50
KJS	Los Angeles, Calif., Bible Institute of Los Angeles	360	750
KLS	Oakland, Calif., Warner Bros. Radio Supplies Company	360	250
KLX	Oakland, Calif., Tribune Publishing Co. (Oakland Tribune)	509	500
KLZ	Denver, Colo., Reynolds Radio Co.	283	500
KMJ	Fresno, Calif., San Joaquin Light & Power Corporation	248	50
KMO	Tacoma, Wash., Love Electric Co.	360	10
KNT	Kukak Bay, Alaska, Walter Hemrich	263	100
KNX	Los Angeles, Calif., Electric Lighting Supply Company	360	100
KOB	State College, N. Mex., New Mexico College of Agriculture and Mechanic Arts	360	500
KOP	Detroit, Mich., Detroit Police Department	286	500
KPO	San Francisco, Calif., Hale Bros.	423	500
KQP	Hood River, Oreg., Apple City Radio Club	360	10
KQV	Pittsburgh, Pa., Doubleday-Hill Electric Co.	270	250
KQW	San Jose, Calif., Charles D. Herrold	360	50
KRE	Berkeley, Calif., Berkeley Daily Gazette	275	50
KSD	St. Louis, Mo., Post-Dispatch	546	500

Call Signal	Location of Station	Wave Length	Power (Watts)
KTW	Seattle, Wash., First Presbyterian Church	360	750
KUO	San Francisco, Calif., Examiner Printing Co.	360	150
KUY	El Monte, Calif., Coast Radio Co.	256	50
KWG	Stockton, Calif., Portable Wireless Telephone Company	360	50
KWH	Los Angeles, Calif., Los Angeles Examiner	360	250
KYQ	Honolulu, Hawaii, The Electric Shop	270	100
KYW	Chicago, Ill., Westinghouse Electric & Mfg. Company	536	1,000
KZM	Oakland, Calif., Preston D. Allen	360	100
WAAB	New Orleans, La., Valdemar Jensen	268	100
WAAC	New Orleans, La., Tulane University	360	400
WAAD	Cincinnati, Ohio, Ohio Mechanics Institute	360	25
WAAF	Chicago, Ill., Chicago Daily Drover Journal	286	200
WAAM	Newark, N. J., I. R. Nelson Co.	263	250
WAAN	Columbia, Mo., University of Missouri	254	50
WAAW	Omaha, Nebr., Omaha Grain Exchange	286	500
WABB	Harrisburg, Pa., Harrisburg Sporting Goods Company	266	10
WABD	Dayton, Ohio, Parker High School	283	10
WABE	Washington, D. C., Y. M. C. A.	283	100
WABH	Sandusky, Ohio, Lake Shore Tire Co.	240	10
WABI	Bangor, Me., Bangor Railway & Electric Co.	240	100
WABL	Stoors, Conn., Connecticut Agricultural College	283	100
WABM	Saginaw, Mich., F. A. Doherty Automotive & Radio Equipment Co.	254	100
WABN	La Crosse, Wis., Ott Radio (Inc.)	244	500
WABO	Rochester, N. Y., Lake Avenue Baptist Church	283	10
WABP	Dover, Ohio, Robert F. Weinig	266	100
WABQ	Haverford, Pa., Haverford College Radio Club	261	50
WABR	Toledo, Ohio, Scott High School	270	50
WABT	Washington, Pa., Holliday-Hall	252	100
WABU	Camden, N. J., Victor Talking Machine Co.	226	50
WABW	Wooster, Ohio, College of Wooster	234	20
WABX	Mount Clemens, Mich., Henry B. Joy	270	500
WABY	Philadelphia, Pa., John Magaldi, Jr.	242	50
WABZ	New Orleans, La., Coliseum Place Baptist Church	263	50
WAHG	Richmond Hill, L. I., N. Y., A. H. Grebe & Co.	316	500
WBAA	West Lafayette, Ind., Purdue University	283	250
WBAH	Minneapolis, Minn., The Dayton Co.	417	1,000
WBAN	Paterson, N. J., Wireless Phone Corporation	244	100
WBAO	Decatur, Ill., James Millikin University	360	50
WBAP	Fort Worth, Tex., Wortham-Carter Publishing Co. (Star Telegram)	476	750
WBAV	Columbus, Ohio, Erner & Hopkins Co.	423	500
WBAX	Wilkes-Barre, Pa., John H. Stenger, Jr.	360	20
WBAY	New York, N. Y., Western Electric Co.	492	500

Call Signal	Location of Station	Wave Length	Power (Watts)
WBBA	Newark, Ohio, Newark Radio Laboratories	240	10
WBBD	Reading, Pa., Barbey Battery Service	234	50
WBBG	Mattapoisett, Mass., Irving Vermilya	248	500
WBBH	Port Huron, Mich., J. Irving Bell	246	50
WBBL	Richmond, Va., Grace Covenant Church	283	5
WBBM	Lincoln, Ill., Frank Atlass Produce Co.	226	200
WBBN	Wilmington, N. C., A. B. Blake	275	10
WBBP	Petoskey, Mich., Petoskey High School	246	100
WBBR	Rossville, N. Y., Peoples Pulpit Associations	273	500
WBBT	Philadelphia, Pa., Lloyd Bros.	234	5
WBBU	Monmouth, Ill., Jenks Motor Sales Co.	224	10
WBBV	Johnstown, Pa., Johnstown Radio Co.	248	5
WBBW	Norfolk, Va., Ruffner Junior High School	222	50
WBBY	Charleston, S. C., Washington Light Infantry	268	20
WBBZ	Indianapolis, Ind., Noble S. Watson	227	50
WBL	Anthony, Kans., T. & H. Radio Co.	261	100
WBS	Newark, N. J., D. W. May (Inc.)	360	50
WBT	Charlotte, N. C., Southern Radio Corporation	360	250
WBZ	Springfield, Mass., Westinghouse Electric & Mfg. Co.	337	1,000
WCAD	Canton, N. Y., St. Lawrence University	280	250
WCAE	Pittsburgh, Pa., Kaufmann & Baer Co.	462	500
WCAG	New Orleans, La., Clyde R. Randall	268	100
WCAH	Columbus, Ohio, Entrekin Electric Co.	286	100
WCAJ	University Place, Nebr., Nebraska Wesleyan University	283	500
WCAK	Houston, Tex., Alfred P. Daniel	263	50
WCAL	Northfield, Minn., St. Olaf College	360	500
WCAO	Baltimore, Md., Sanders & Stayman Co.	360	50
WCAP	Washington, D. C., Chesapeake & Potomac Telephone Co.	469	500
WCAR	San Antonio, Tex., Southern Radio Corporation of Texas	360	100
WCAS	Minneapolis, Minn., William Hood Dunwoody Industrial Institute	280	100
WCAT	Rapid City, S. Dak., South Dakota State School of Mines	240	50
WCAU	Philadelphia, Pa., Durham & Co.	286	250
WCAV	Little Rock, Ark., J. C. Dice Electric Co.	360	10
WCAX	Burlington, Vt., University of Vermont	360	50
WCAY	Milwaukee, Wis., Milwaukee Civic Broadcasting Station	266	250
WCAZ	Carthage, Ill., Carthage College	246	50
WCBA	Allentown, Pa., Charles W. Heimbach	280	10
WCBC	Ann Arbor, Mich., University of Michigan	280	200
WCBD	Zion, Ill., Wilbur G. Voliva	345	500
WCBE	New Orleans, La., Uhalt Radio Co.	263	5
WCBF	Pittsburgh, Pa., Paul J. Miller	236	50
WCBG	Pascagoula, Miss. (portable), Howard S. Williams	268	10
WCBH	Oxford, Miss. (near), Univ. of Mississippi	242	10
WCBI	Bemis, Tenn., Nicoll, Duncan & Rush	226	100

Call Signal	Location of Station	Wave Length	Power (Watts)
WCBJ	Jennings, La., J. C. Mans	244	20
WCBK	St. Petersburg, Fla., E. Richard Hall	266	500
WCBL	Houlton, Me., Northern Radio Manufacturing Co.	280	50
WCBM	Baltimore, Md., Charles Swarz	229	50
WCBN	Fort Benjamin Harrison, Ind., James P. Boland, Lieutenant, U. S. A., 3d F. A.	266	50
WCBO	Memphis, Tenn., Radio Shop (Inc.)	250	20
WCBQ	Nashville, Tenn., First Baptist Church	236	100
WCBR	Providence, R. I. (portable), Charles H. Messter	246	5
WCBT	Worcester, Mass., Clark University	238	250
WCBU	Arnold, Pa., Arnold Wireless Supply Co.	254	50
WCBV	Tullahoma, Tenn., Tullahoma Radio Club	252	10
WCBW	Macon, Ga., George P. Rankin, Jr., and Maitland Soloman	226	10
WCBX	Newark, N. J., Radio Shop of Newark	233	100
WCBY	Buck Hill Falls, Pa., Forks Electrical Shop	268	10
WCBZ	Chicago Heights, Ill., Coppotelli Brothers Music House	248	50
WCK	St. Louis, Mo., Stix-Baer & Fuller Dry Goods Co.	360	100
WCX	Detroit, Mich., Detroit Free Press	517	500
WDAE	Tampa, Fla., Tampa Daily Times	360	250
WDAF	Kansas City, Mo., Kansas City Star	411	500
WDAG	Amarillo, Tex., J. Laurance Martin	263	100
WDAH	El Paso, Tex., Trinity Methodist Church (South)	268	50
WDAK	Hartford, Conn., The Courant	261	100
WDAR	Philadelphia, Pa., Lit Brothers	395	500
WDAS	Worcester, Mass., Samuel A. Waite	360	5
WDAU	New Bedford, Mass., Slocum & Kilburn	360	100
WDAY	Fargo, N. Dak., Radio Equipment Corp.	244	50
WDBA	Columbus, Ga., Fred Ray	236	20
WDBB	Taunton, Mass., A. H. Waite & Co.	229	10
WDBC	Lancaster, Pa., Kirk, Johnson & Co.	258	50
WDBD	Martinsburg, W. Va., Herman E. Burns	268	5
WDBE	Atlanta, Ga., Gilham-Schoen Electric Co.	252	10
WDBJ	Roanoke, Va., Richardson-Wayland Electrical Corporation	229	20
WDBK	Cleveland, Ohio, M. F. Bros. Radio Co.	248	100
WDBN	Bangor, Me., Maine Electric Light & Power Co.	252	5
WDBO	Winter Park, Fla., Rollins College	240	50
WDBP	Superior, Wis., Superior State Normal School	261	50
WDBQ	Salem, N. J., Morton Radio Supply Co.	234	10
WDBR	Boston, Mass., Tremont Temple Baptist Church	256	100
WDBS	Dayton, Ohio, S. M. K. Radio Corporation	283	5
WDBT	Hattiesburg, Miss., Taylor's Book Store	236	10
WDBU	Skowhegan, Me., Somerset Radio Co.	258	10

Call Signal	Location of Station	Wave Length	Power (Watts)
WDBV	Fort Wayne, Ind., Strand Theater	258	100
WDBW	Columbia, Tenn., The Radio Den	268	20
WDBX	New York, N. Y., Otto Baur	233	5
WDBY	Chicago, Ill., North Shore Congregational Church	258	500
WDBZ	Kingston, N. Y., Boy Scouts of America, Ulster County Council	233	5
WDM	Washington, D. C., Church of the Covenant	234	50
WDZ	Tuscola, Ill., James L. Bush	278	10
WEAA	Flint, Mich., Frank D. Fallain	250	10
WEAF	New York, N. Y., American Telephone & Telegraph Co.	492	1,000
WEAH	Wichita, Kans., Wichita Board of Trade	280	50
WEAI	Ithaca, N. Y., Cornell University	286	500
WEAJ	Vermilion, S. Dak., University of S. Dakota	283	100
WEAM	North Plainfield, N. J., Borough of North Plainfield	286	150
WEAN	Providence, R. I., Shepard Co.	273	100
WEAO	Columbus, Ohio, Ohio State University	360	500
WEAP	Mobile, Ala., Mobile Radio Co.	360	100
WEAR	Baltimore, Md., Evening News Publishing Company	261	50
WEAU	Sioux City, Iowa, Davidson Bros. Co.	275	100
WEAY	Houston, Tex., Iris Theater	360	500
WEB	St. Louis, Mo., Benwood Co.	273	500
WEBA	Highland Park, N. J., 11 South Eighth Ave., The Electric Shop	233	15
WEBC	Superior, Wis., 1011 North Twenty-first St., Walter C. Bridges	242	10
WEBD	Anderson, Ind., Electrical Equipment & Service Co.	246	10
WEBE	Cambridge, Ohio, 319 Wall Ave., Roy W. Waller	248	10
WEBH	Chicago, Ill., Edgewater Beach Hotel	370	1,000
WEBI	Salisbury, Md., 121 Dock St., Walter Gibbons	242	15
WEBJ	New York, N. Y., Third Avenue Ry. Co.	273	500
WEBP	New Orleans, La., Spanish Fort Amusement Park	280	50
WEV	Houston, Tex., Hurlburt-Still Electrical Co.	263	100
WEW	St. Louis, Mo., St. Louis University	280	100
WFAA	Dallas, Tex., Dallas News & Dallas Journal	476	500
WFAB	Syracuse, N. Y., Carl F. Woese	234	100
WFAH	Port Arthur, Tex., Electric Supply Co.	236	150
WFAM	St. Cloud, Minn., Times Publishing Co.	273	20
WFAN	Hutchinson, Minn., Hutchinson Electric Service Co.	360	100
WFAV	Lincoln, Nebr., University of Nebraska	275	250
WFBB	Eureka, Ill., Eureka College	240	50
WFBG	Altoona, Pa., William F. Gable Co.	261	100
WFBH	New York, N. Y., Concourse Radio Corpor.	273	500

Call Signal	Location of Station	Wave Length	Power (Watts)
WFBW	Cincinnati, Ohio, Ainsworth-Gates Radio Company	309	750
WFI	Philadelphia, Pa., Strawbridge & Clothier	395	500
WGAL	Lancaster, Pa., Lancaster Electric Supply and Construction Co.	248	10
WGAN	Pensacola, Fla., Cecil E. Lloyd	360	50
WGAQ	Shreveport, La., Youree Hotel	252	150
WGAZ	South Bend, Ind., South Bend Tribune	360	250
WGI	Medford Hillside, Mass., American Radio and Research Corporation	360	100
WGL	Philadelphia, Pa., Thomas F. J. Howlett	360	500
WGN	Chicago, Ill., Drake Hotel	370	1,000
WGR	Buffalo, N. Y., Federal Telephone & Telegraph Co.	319	750
WGY	Schenectady, N. Y., General Electric Co.	380	1,000
WHA	Madison, Wis., University of Wisconsin	360	500
WHAA	Iowa City, Iowa, State University of Iowa	484	100
WHAD	Milwaukee, Wis., Marquette University	280	100
WHAG	Cincinnati, Ohio, University of Cincinnati	222	100
WHAH	Joplin, Mo., Hafer Supply Co.	283	250
WHAK	Clarksburg, W. Va., Roberts Hardware Co.	258	15
WHAM	Rochester, N. Y., University of Rochester (Eastman School of Music)	283	100
WHAR	Atlantic City, N. J., Seaside House	275	100
WHAS	Louisville, Ky., Courier-Journal and Louisville Times	400	500
WHAV	Wilmington, Del., Wilmington Electrical Specialty Co.	360	50
WHAZ	Troy, N. Y., Rensselaer Polytechnic Institute	380	500
WHB	Kansas City, Mo., Sweeney School Co.	411	500
WHK	Cleveland, Ohio, Radiovox Co.	283	100
WHN	New York, N. Y., George Schubel	360	500
WHO	Des Moines, Iowa, Bankers Life Co.	526	500
WIAB	Rockford, Ill., Art A. Johnson's Garage	252	50
WIAC	Galveston, Tex., Galveston Tribune	360	100
WIAD	Philadelphia, Pa., Howard R. Miller	254	100
WIAK	Omaha, Nebr., Journal-Stockman Co.	278	...
WIAQ	Marion, Ind., Chronicle Publishing Co.	226	10
WIAS	Burlington, Iowa, Home Electric Co.	283	100
WIK	McKeesport, Pa., K. & L. Electric Co.	234	100
WIL	Washington, D. C., Continental Electrical Supply Co.	360	10
WIP	Philadelphia, Pa., Gimbel Bros.	509	500
WJAB	Lincoln, Nebr., American Electric Co.	229	100
WJAD	Waco, Tex., Jackson's Radio Engineering Laboratories	360	150
WJAG	Norfolk, Nebr., Norfolk Daily News	283	250
WJAK	Greentown, Ind., Clifford L. White	254	30
WJAM	Cedar Rapids, Iowa, D. M. Perham	268	20
WJAN	Peoria, Ill., Peoria Star	280	100
WJAR	Providence, R. I., The Outlet Co.	360	500

Call Signal	Location of Station	Wave Length	Power (Watts)
WJAS	Pittsburgh, Pa., Pittsburgh Radio Supply House	286	500
WJAX	Cleveland, Ohio, Union Trust Co.	390	500
WJAZ	Chicago, Ill., Chicago Radio Laboratory	268	20
WJD	Granville, Ohio, Denison University	229	10
WJY	New York, N. Y., Radio Corporation of America	405	500
WJZ	New York, N. Y., Radio Corporation of America	455	500
WKAA	Cedar Rapids, Iowa, H. F. Paar	278	50
WKAD	East Providence, R. I., Charles Looff (Crescent Park)	240	20
WKAF	Wichita Falls, Tex., W. S. Radio Supply Co.	360	100
WKAN	Montgomery, Ala., United Battery Service Company	226	15
WKAP	Cranston, R. I., Dutee W. Flint	360	50
WKAQ	San Juan, P. R., Radio Corporation of Porto Rico	360	100
WKAR	East Lansing, Mich., Michigan Agricultural College	280	500
WKAV	Laconia, N. H., Laconia Radio Club	254	50
WKBF	Cranston, R. I., Dutee W. Flint	286	500
WKY	Oklahoma, Okla., WKY Radio Shop	360	100
WLAG	Minneapolis, Minn., Cutting & Washington Radio Corporation	417	500
WLAH	Syracuse, N. Y., Samuel Woodworth	234	100
WLAL	Tulsa, Okla., Naylor Electrical Co.	360	100
WLAP	Louisville, Ky., W. V. Jordon	286	15
WLAQ	Kalamazoo, Mich., Arthur E. Schilling	283	10
WLAW	New York, N. Y., Police Department, City of New York	360	500
WLAX	Greencastle, Ind., Putnam Electric Co. (Greencastle community broadcasting station)	231	10
WLB	Minneapolis, Minn., University of Minnesota	360	5
WLBL	Stevens Point, Wis., Wisconsin Department of Markets	278	500
WLS	Chicago, Ill., Sears, Roebuck & Co.	345	500
WLW	Cincinnati, Ohio, Crosley Mfg. Co.	423	500
WMAC	Cazenovia, N. Y., Fernwood St., Clive B. Meredith	261	100
WMAF	Dartmouth, Mass., Round Hills Radio Corporation	360	500
WMAH	Lincoln, Nebr., General Supply Co.	254	100
WMAK	Lockport, N. Y., Norton Laboratories	273	500
WMAL	Trenton, N. J., Trenton Hardware Co.	256	50
WMAN	Columbus, Ohio, First Baptist Church	286	10
WMAQ	Chicago, Ill., Chicago Daily News	448	500
WMAV	Auburn, Ala., Alabama Polytechnic Institute	250	500
WMAY	St. Louis, Mo., Kingshighway Presbyterian Church	280	100
WMC	Memphis, Tenn., Commercial Appeal	500	500

Call Signal	Location of Station	Wave Length	Power (Watts)
WMU	Washington, D. C., Doubleday-Hill Electric Company	261	100
WNAC	Boston, Mass., Shepard Stores	278	100
WNAD	Norman, Okla., University of Oklahoma	360	50
WNAP	Springfield, Ohio, Wittenberg College	275	100
WNAR	Butler, Mo., First Christian Church	231	20
WNAT	Philadelphia, Pa., Lennig Brothers Co.	360	100
WNAW	Fort Monroe, Va., Henry Kunzman, box 167	360	5
WNAX	Yankton, S. Dak., Dakota Radio Apparatus Company	244	100
WNYC	New York, N. Y., City of New York	526	1,000
WOAC	Lima, Ohio, Page Organ Co. (H. P. Maus)	266	50
WOAE	Fremont, Nebr., Midland College	280	15
WOAF	Tyler, Tex., Tyler Commercial College	360	10
WOAG	Belvidere, Ill., Apollo Theatre	273	100
WOAH	Charleston, S. C., Palmetto Radio Corp.	360	10
WOAI	San Antonio, Tex., Southern Equipment Co.	385	500
WOAN	Lawrenceburg, Tenn., James D. Vaughn	360	200
WOAO	Mishawaka, Ind., Lyradion Mfg. Co.	360	50
WOAT	Wilmington, Del., Boyd M. Hamp	360	100
WOAV	Erie, Pa., Pennsylvania National Guard, One Hundred and Twelfth Infantry	242	50
WOAW	Omaha, Nebr., Woodmen of the World	526	500
WOAX	Trenton, N. J., Franklyn J. Wolff	240	500
WOC	Davenport, Ia., Palmer School of Chiropractic	484	500
WOI	Ames, Iowa, Iowa State College	360	500
WOO	Philadelphia, Pa., John Wanamaker	509	500
WOQ	Kansas City, Mo., Western Radio Co.	360	500
WOR	Newark, N. J., L. Bamberger & Co.	405	500
WOS	Jefferson City, Mo., Missouri State Marketing Bureau	441	500
WPAB	State College, Pa., Pennsylvania State College	283	500
WPAC	Okmulgee, Okla., Donaldson Radio Co.	360	100
WPAJ	New Haven, Conn., Doolittle Radio Corporation, 39 Center St.	268	100
WPAK	Agricultural College, N. Dak., North Dakota Agricultural College	283	50
WPAL	Columbus, Ohio, Avery & Loeb Electric Co.	286	500
WPAM	Topeka, Kans., Auerbach & Guettel	275	100
WPAR	Beloit, Kans., Ward Battery & Radio Co.	236	10
WPAU	Moorhead, Minn., Concordia College	286	20
WPAZ	Charleston, W. Va., John R. Koch	273	10
WQAA	Parkesburg, Pa., Horace A. Beale, Jr.	360	500
WQAC	Amarillo, Tex., E. B. Gish	234	100
WQAE	Springfield, Vt., Moore Radio News Station	275	50
WQAF	Sandusky, Ohio, Sandusky Register	240	5
WQAM	Miami, Fla., Electrical Equipment Co.	283	100
WQAN	Scranton, Pa., Scranton Times	280	50
WQAO	New York, N. Y., Calvary Baptist Church	360	100
WQAQ	Abilene, Tex., West Texas Radio Co. (Abilene Daily Reporter)	360	100

Call Signal	Location of Station	Wave Length	Power (Watts)
WQAS	Lowell, Mass., Prince-Walter Co.	266	100
WQAX	Peoria, Ill., Radio Equipment Co.	248	100
WQJ	Chicago, Ill., Calumet Baking Powder Co.	448	500
WRAF	Laporte, Ind., The Radio Club	224	10
WRAL	St. Croix Falls, Wis., Northern States Power Company	248	100
WRAM	Galesburg, Ill., Lombard College	244	100
WRAN	Waterloo, Iowa, Black Hawk Electrical Co.	236	10
WRAO	St. Louis, Mo., St. Louis Radio Service Co.	360	10
WRAV	Yellow Springs, Ohio, Antioch College	242	100
WRAW	Reading, Pa., Avenue Radio Shop	238	10
WRAX	Gloucester City, N. J., Flexon's Garage	268	100
WRBC	Valparaiso, Ind., Immanuel Lutheran Church	278	500
WRC	Washington, D. C., Radio Corporation of America	469	500
WRK	Hamilton, Ohio, Doron Bros. Electrical Co.	360	200
WRL	Schenectady, N. Y., Union College	360	500
WRM	Urbana, Ill., University of Illinois	360	500
WRR	Dallas, Tex., City of Dallas, Police and Fire Signal Department	360	30
WRW	Tarrytown, N. Y., Tarrytown Radio Research Laboratory	273	500
WSAB	Cape Girardeau, Mo., Southeast Missouri State Teachers College	360	100
WSAC	Clemson College, S. C., Clemson Agricultural College	360	500
WSAD	Providence, R. I., J. A. Foster Co.	261	100
WSAI	Cincinnati, Ohio, United States Playing Card Company	309	500
WSAJ	Grove City, Pa., Grove City College	360	250
WSAN	Allentown, Pa., Allentown Radio Club	229	10
WSAP	New York, N. Y., Seventh Day Adventist Church	263	250
WSAR	Fall River, Mass., Doughty & Welch Electrical Co.	254	100
WSAU	Chesham, N. H., Camp Marienfeld	229	10
WSAV	Houston, Tex., Clifford W. Vick Radio Construction Co.	360	100
WSAY	Port Chester, N. Y., Port Chester Chamber of Commerce	233	100
WSAZ	Pomeroy, Ohio, Chase Electric Shop	258	50
WSB	Atlanta, Ga., Atlanta Journal	429	500
WSL	Utica, N. Y., J. & M. Electric Co.	273	10
WSOE	Milwaukee, Wis., School of Engineering	246	100
WSY	Birmingham, Ala., Alabama Power Co.	360	500
WTAB	Fall River, Mass., Fall River Daily Herald Publishing Co.	266	100
WTAC	Johnstown, Pa., Washington St., Penn Traffic Company	275	150
WTAF	New Orleans, La., Louis J. Gallo	268	10
WTAG	Providence, R. I., Kern Music Co	258	10
WTAJ	Portland, Me., The Radio Shop	236	10

Call Signal	Location of Station	Wave Length	Power (Watts)
WTAL	Toledo, Ohio, Toledo Radio & Electric Co.	252	10
WTAM	Cleveland, Ohio, Willard Storage Battery Company	390	1,000
WTAP	Cambridge, Ill., Cambridge Radio & Electric Company	242	50
WTAQ	Osseo, Wis., S. H. Van Gorden & Son	254	100
WTAR	Norfolk, Va., Reliance Electric Co.	280	100
WTAS	Elgin, Ill., Charles E. Erbstein	286	500
WTAT	Boston, Mass. (portable), Edison Electric Illuminating Co.	244	100
WTAU	Tecumseh, Nebr., Ruegg Battery & Electric Company	242	10
WTAW	College Station, Tex., Agricultural and Mechanical College of Texas	280	250
WTAX	Streator, Ill., Williams Hardware Co.	231	50
WTAY	Oak Park, Ill., Oak Leaves Broadcasting Station	283	500
WTAZ	Lambertville, N. J., Thomas J. McGuire	283	15
WTG	Manhattan, Kans., Kansas State Agricultural College	273	50
WVX	Poughkeepsie, N. Y., H. C. Spratley Radio Company	360	20
WWAB	Trenton, N. J., Hoenig, Swern & Co.	226	10
WWAD	Philadelphia, Pa., Wright & Wright (Inc.)	360	100
WWAE	Joliet, Ill., Lawrence J. Crowley	227	500
WWAO	Houghton, Mich., Michigan College of Mines	244	250
WWI	Dearborn, Mich., Ford Motor Co.	273	250
WWJ	Detroit, Mich., Detroit News	517	500
WWL	New Orleans, La., Loyola University	280	500

Important Canadian Broadcasting Stations

Call Signal	Location of Station	Wave Length	Power (Watts)
CFAC	Calgary, Alberta, The Calgary Herald	430	1,000
CFCA	Toronto, Ont., Star Pub. & Print. Co.	400	1,000
CFCF	Montreal, Quebec, Marconi Wireless Tel. Co.	440	1,000
CFCH	Iroquois Falls, Ont., Abitibi Power & Paper Company	400	250
CFCK	Edmonton, Alberta, Radio Supply Co.	410	125
CFCL	Victoria, B. C., Centennial Me., Church	400	250
CFCN	Calgary, Alberta, W. W. Grant Radio, Ltd.	440	500
CFQC	Saskatoon, Sask., The Electric Shop	400	100
CFUC	Montreal, Quebec, Univ. of Montreal	400	1,000
CHBC	Calgary, Alberta, The Albertan Pub. Co.	410	250
CHCL	Vancouver, B. C., The Vancouver Merchants Exchange	440	1,000

Call Signal	Location of Station	Wave Length	Power (Watts)
CHYC	Montreal, Quebec, Northern Elec. Co.	341	1,000
CJCA	Edmonton, Alberta, The Edmonton Journal	450	250
CJCE	Vancouver, B. C., Sprott-Shaw Radio Co.	420	125
CJCI	St. John, N. B., Maritime Radio Corp.	400	100
CJCN	Toronto, Ont., Simons, Agnew & Co.	410	1,000
CJCX	Shackleton Olds, Alberta, Percival Wesley	400	100
CJGC	London, Ontario, London Free Press Print. Company	430	100
CJSC	Toronto, Ont., The Evening Telegraph	430	250
CKAC	Montreal, Que., La Presse Pub. Co.	425	1,000
CKCD	Vancouver, B. C., Vancouver Daily Province	410	1,000
CKCE	Toronto, Ontario, Canadian Independent Tel.	450	1,000
CKCK	Regina, Sask., Leader Pub. Co.	420	1,000
CKY	Winnipeg, Man., Manitoba Tel. System	450	1,000

Dictionary of Radio Terms

"A" Battery. The battery which supplies the current for heating the filament of a tube.

Absorption. The diminution of the amplitude of a radio wave due to losses which occur in the atmosphere and in the ground over which the waves travel. This lost energy is converted into heat.

A. C. Abbreviation for alternating current.

A. C. C. W. Abbreviation for alternating current continuous waves. Pertaining to a system in which high frequency oscillations are generated with alternating currents on the plate.

Aerial. See antenna.

A. F. Abbreviation for audio frequency.

Alternating Current. An electrical current which changes its direction periodically. It starts from zero and gradually increases in one direction up to the maximum amplitude, then regularly decreases to zero, reverses its direction, and goes through the same change in the opposite direction until it finally comes back to the starting point.

Ammeter. An instrument for measuring electric current in amperes; an ampere meter.

Ampere. The practical unit of electric current. If the electrical pressure is one volt across a resistance of one ohm, the current which flows through it will be one ampere.

Ampere-hour. A commercial unit of electric quantity equal to the product of the current in amperes by the time in hours. It is the usual unit for rating the capacity of storage batteries; for instance, a storage battery having a rating of 80 ampere-hours will deliver one ampere for 80 hours.

Ampere-turns. In an electromagnet the product of the current in amperes and the number of turns is called ampere-turns. It is a convenient measure of magneto motive force.

Amplifier. A circuit or other device which increases the intensity of electric current; usually, it is a circuit comprising one or more three-electrode vacuum tubes.

Amplitude. The maximum value of an a. c. current or voltage in a cycle, measuring from zero to its greatest deviation, either in the positive or negative direction.

Antenna. That part of a radio circuit which collects energy from, or radiates it into the ether. See aerial.

Aperiodic. Pertaining to a vibrating system which has no free period of oscillation of its own; for instance, a pendulum suspended in molasses or heavy oil would be aperiodic because it would not swing. In air it would be periodic. It would swing to and fro.

Arc. A passage of electricity through a gas, which depends on the volatilazation of one or both electrodes. In radio the oscillation arc is used as a generator of high frequency oscillations e. g. Poulsen arc—Federal arc.

Attenuation. The attenuation of any electrical device is defined as the natural logarithm of the ratio of the current flowing into the device to the current coming out. The natural unit of attenuation is the napier. The practical unit is the attenuation of a mile of standard cable. The napier is independent of frequency, while the practical unit is a function of frequency. At 1,000 cycles one napier is approximately equal to ten miles.

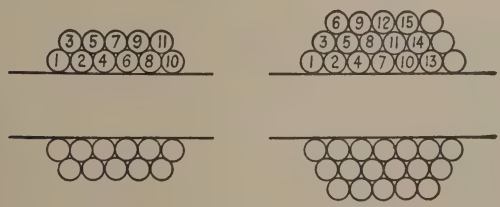
Audibility. A measure of signal strength. The unit of audibility is taken as that strength of signal which just enables dots and dashes to be distinguished.

Audio Frequency. Frequencies which may be perceived by the human ear. They usually lie between 20 and 20,000 vibrations per second.

Audio. Pertaining to hearing; capable of being heard.

Audion. A name given to the three-electrode vacuum tube by Dr. De Forest, its inventor. See vacuum tube.

Bank Winding. A method of winding coils in vertical layers, or in staggered relation; for instance, two turns may first be placed on the form side by side, and the third is wound on top and between



Sectional View of Bank Wound Coils

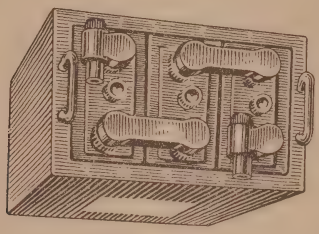
the first two. The fourth is placed at the side of the second, and the fifth on top of the fourth, beside the third, and so on.

Battery. Two or more electrical cells connected together in one unit, either in series or parallel, or in series-parallel.

"B" Battery. The battery which supplies power to the plate circuit of a vacuum tube. See plate battery.

Beats. Periodic variations in the amplitude of two vibrations of different frequencies, due to the interaction of the two; for instance, when two musical tones of nearly equal pitch are sounded together, beats may be heard.

Bias. A potential applied to the grid of a tube to maintain it at a potential which is different from the average potential of the filament. Usually, a negative potential. It may be applied by means of



Storage Battery

a small battery inserted in the grid circuit or by means of a voltage drop in a resistance in the filament circuit.

Binding Post. A convenient terminal for making connections in an electrical circuit.

Blocking Condenser. A small condenser which is inserted in a circuit for the purpose of stopping low frequency and direct current, but which is large enough to admit high frequency currents. Also called the stopping condenser.

Break-in. An arrangement whereby the transmitting key automatically disconnects the receiving set from the antenna, and substitutes the transmitting set, allowing listening when the key is up, and transmitting when the key is depressed.

Bridging Condenser. See by-pass condenser.

Bus-bar. A heavy electrical conductor which serves as a common connector for several circuits.

Buzzer. A type of electro-magnetic interrupter which is used for generating a tone, or high frequency currents.

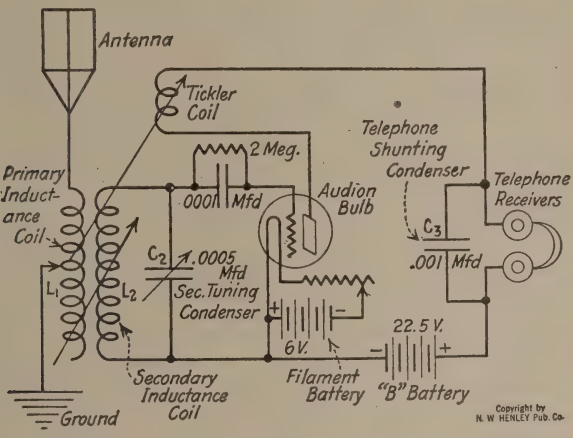
By-pass Condenser. A condenser used for providing a low impedance path for high frequency currents across low frequency apparatus. Its function is the exact opposite of a blocking condenser.

Calibration. A comparison of any instrument with a standard, and recording the data thus obtained. Thus a receiver is calibrated when it is known that for

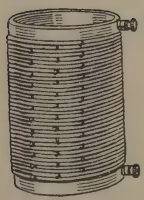
20° setting 326 meters will be received
40° " 469 " " " "
60° " 492 " " " "

Capacity. The property of an electrical condenser which determines what quantity of electrical energy may be stored in it with a given voltage. Capacity is measured in farads or in micro-farads (.000001 farad).

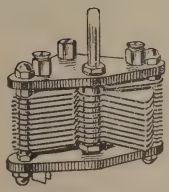
Charger. A device used for charging storage batteries. It may be a direct current generator, a motor-generator, a vibrating rectifier, an electrolytic rectifier, or a vacuum tube rectifier. If the source is direct current, it only is a resistance, such as a bank of lamps.



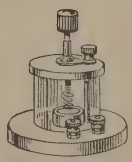
Double Circuit Regenerative Receiver Using Tickler



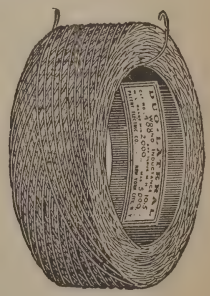
Typical Solenoidal Inductance Coil



Variable Air Condenser



Crystal Detector



Duo Lateral Coil

Choke Coil. See reactance coil.

Circuit. Electrical instruments and apparatus taken collectively when connected for a given purpose.

Coil. Wire wound on a spool or in the form of a helix.

Colpits Oscillator. One of the fundamental types of oscillator circuits in which electrostatic feed-back is employed.

Condenser. An electrical instrument consisting of two conductors separated by a non-conductor or insulator, and capable of storing electrical energy in electro-static form.

Conductor. Material which passes electricity freely.

Continuous Waves. Radio waves which do not diminish in amplitude as time passes, but continue with undiminished strength as long as the generator is going.

Core. The substance upon which a coil is wound. A coil which is wound on a hollow tube is considered to have an air-core. If the hollow space is filled with iron, the coil has an iron core.

Counterpoise. An artificial ground system. It is a network of wires similar to an antenna, and suspended directly under it, a short distance above ground, from which it is insulated.

Coulomb. The practical unit of quantity of electricity. If one ampere flows for one second, the quantity is one coulomb.

Coupling. The means for transferring energy from one part of an electrical system to another; it may be by means of condensers, inductances or resistances (capacitive)—(inductive)—(resistive).

Crystal. A mineral used to rectify frequency current for the purpose of detection. (Crystal detector.)

C. W. Abbreviation for continuous waves. Usually applied to telegraph transmission.

Cycle. A complete reversal of the current or potential in an alternating current circuit; also period.

Damped Waves. Radio waves which are started suddenly by the discharge of a condenser into an oscillatory circuit, and which do not persist, but are damped out quickly by a high effective resistance in the circuit.

"Dead Spot." A term applied to regions in which radio waves from a particular broadcasting station are very weak, in comparison with regions immediately surrounding it. An electromagnetic shadow.

Design. The electrical design of a circuit is the specification of particular values for the various constituent parts of that circuit.

Detector. Any device which renders radio frequency signals perceptible; usually a rectifier.

Dial. A graduated disc attached to rotating parts, so that the adjustment may be noted.

Diaphragm. A thin disc used for transferring sound energy into electric, or vice versa.

Dielectric. Any material which offers a very high resistance to the passage of an electric current, especially when used for insulating the plates of a condenser.

Diffraction. The bending of a wave into the shadow region behind an obstacle.

Diode. A name given to a vacuum tube containing two elements, the filament and the plate. Also called the oscillation valve. It is used as a rectifier for detecting high frequency current.

Direct Current. An electrical current which flows in one direction only.

Dry Cell. Primary electric cell in which the active material is in the form of a paste. Carbon is used for the positive electrode and zinc for the negative.

Duo-lateral. A type of winding for concentrated inductance coils similar to the honeycomb winding. It is differentiated from the honeycomb winding by a lateral shift of the turns of successive layers.

Electrode. A terminal used for passing electricity from one medium to another, as for example, from a metal to an electrolyte. The filament grid and plate elements of a vacuum tube are called electrodes.

Electrolysis. The decomposition and analysis of a compound into its elements by passing an electrical current through it.

Electrolyte. The active liquid in an electrical cell, such as the dilute sulphuric acid in a lead storage battery.

Electro-magnet. A temporary magnet which is magnetized by induction when placed in a magnetic field. Usually, it is a piece of soft iron around which many turns of wire, through which an electrical current passes, have been wound.

Electromotive Force. The force which drives an electrical current through a closed circuit. It is measured in volts. If the e. m. f. is one volt and the total impedance in the circuit is one ohm, the current will be one ampere.

Electron. The natural unit of negative electrical charge. The small particle which always carries this charge.

Electro-static. Pertaining to an electrically charged body through which no current flows.

Emission. The escape of free electrons from a heated metal.

E. M. F. Abbreviation for electromotive force.

Ether. The hypothetical medium through which radio waves are said to be propagated through space.

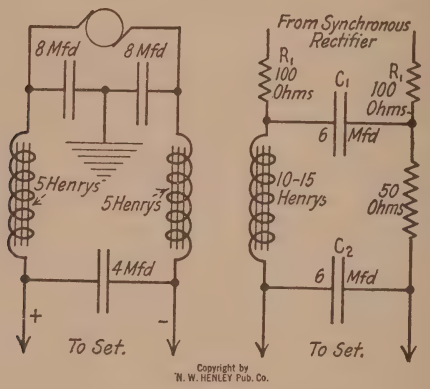
Fading. The irregular fluctuation of the strength of a radio signal from a distant station, observed especially at night. Its cause has not yet been definitely determined.

Farad. The practical unit of capacity. If a steady current of one ampere flows into a condenser, and the voltage across the condenser is one volt at the end of one second, the capacity of that condenser is one farad. A microfarad is .000001 farad.

Feed-back. In a regenerative circuit, the feed-back is the energy returned to the grid circuit, and the means by which it is returned.

Field Strength. A measure of the intensity of the signals that may be obtained at a point with a given receiver.

Filament. The electron-emitting electrode in a vacuum tube.



Filters Using Condensers and Reactance Coils

Filter. An electrical device which passes currents of certain frequencies more readily than currents of other frequencies.

Fleming Valve. See diode.

Frequency. The number of complete periods or cycles per second of any vibration, or oscillation.

Frequency Trap. See wave trap.

Gain. The gain of an electrical amplifier device may be defined as the natural logarithm of the ratio of the current delivered to the current flowing into it. Sometimes the gain is considered as merely the ratio of the current delivered to the current flowing into a device. The gain is the negative of attenuation, and is measured in the same units.

Generator. A machine which converts mechanical energy into electrical energy.

Grid. The electrode in a three element vacuum tube which is used to control the electron stream from the filament to the plate.

Grid Bias. A negative potential applied to the grid. See bias.

Grid Leak. A high resistance customarily connected across a condenser in the grid circuit to prevent the grid from accumulating a high negative charge, which would block the proper functioning of the tube.

Ground. An electrical connection to earth, or to a large conductor which is at earth potential.

Harmonics. Vibrations having frequencies which are integral multiples of the frequency employed, which is the fundamental. The

Jack

Grid Leak

Hydrometer

Head Set

fundamental is usually regarded as the first harmonic; the second harmonic is a frequency twice the fundamental; and the third harmonic a frequency three times the fundamental.

Hartley Oscillator. One of the fundamental types of oscillating circuits in which inductive feed-back is used.

Headset. A pair of telephone receivers arranged with a suitable head-band to fit over the ears.

Henry. The practical unit of inductance. If the current in a coil is changing at the rate of one ampere per second, and the resultant electromotive force in the coil is one volt, then the inductance of the coil is one henry.

Heterodyne. V., to produce beats with an incoming C. W. signal by supplying a locally generated frequency. Adj., pertaining to a system of reception which depends upon beats between the receiving frequency and one locally generated.

Honeycomb. A type of winding for inductance coils, which resembles a honeycomb. The wires are wound criss-cross from side to side, to prevent the turns of successive layers from lying parallel.

Hook-up. Slang expression for circuit.

Hydrometer. An instrument for measuring the specific gravity of liquids. Ordinarily, it is used for the purpose of determining the condition of charge of a storage battery.

Hysteresis. The lagging of the current in a dielectric behind the e. m. f., or the magnetic flux in an electromagnet behind the m. m. f., due to energy losses in the material.

I. C. W. Abbreviation for interrupted continuous waves.

Impedance. The total opposition offered by a circuit to the passage of an alternating electrical current. The ratio of the e. m. f. in the circuit to the current produced by it. The impedance may be either dissipative or reactive. The former is due to resistance, and the latter to inductance and capacity.

Impulse. A force acting for a very short time, such as a quick blow.

Inductance. The property of a coil of wire which determines the strength of the magnetic field around it when a given current is flowing through the wire of the coil.

Induction. The total magnetic flux per square centimeter in a magnetic field. The production of an e. m. f. in a circuit, due to the variation of the magnetic flux threading it or due to the change of current in an adjacent circuit.

Input. The energy impressed upon an electrical device.

Insulator. Any substance which does not pass an electrical current.

Interference. Any electrical disturbance originating outside the receiving set, which prevents clear reception of the desired signal.

Interrupter. A device which intermittently breaks and closes an electrical circuit.

Jack. A special type of socket into which a connector may be inserted for connecting telephones or other instruments into the circuit.

Key. A type of switch, by means of which the current may be stopped and started for signaling purposes.

Kilo. A prefix meaning one thousand.

Kilocycle. One thousand cycles.

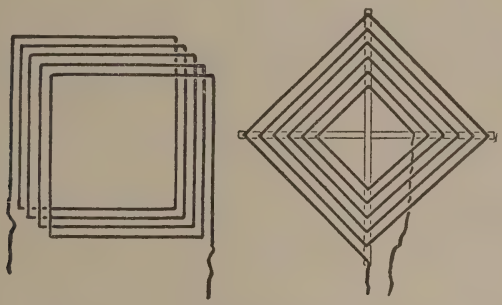
Lead. A wire leading from one instrument to another.

Lead-in. The conductor or wire which connects the antenna with the receiving or transmitting set.

Lightning Arrester. A safety device connected across the receiving or transmitting set to prevent lightning or other high voltage discharges from injuring the apparatus.

Loading Coil. An inductance coil inserted into a circuit for tuning.

Loop. A large coil used as an antenna.



Loop Antennas

Magnet. A piece of steel which has been magnetized so that it has the property of attracting other pieces of steel or iron.

Mega. A prefix meaning one million.

Megohm. One million ohms.

Meissner Oscillator. A type of oscillator in which mutual inductance is used to obtain feed-back. It is similar to the Hartley Oscillator.

Micro. A prefix meaning one millionth.

Microfarad. One millionth farad.

Micro-microfarad. One millionth microfarad.

Microphone. An instrument for converting minute sounds into an electrical current. It usually refers to a carbon granule device.

Microwatt. One millionth of a watt.

Milli. A prefix meaning one thousandth.

Milliampere. One thousandth ampere.

Millihenry. One thousandth henry.

Millivolt. One thousandth volt.

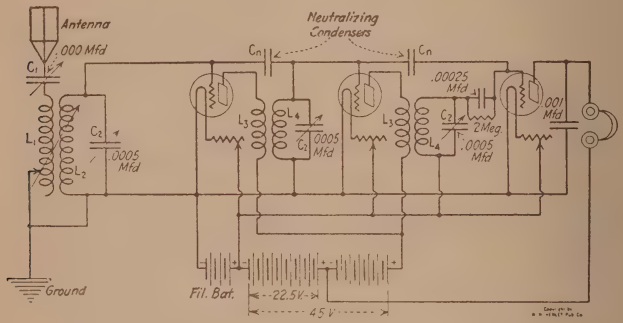
M. M. F. Abbreviation for magneto motive force. The magnetic force which produces a magnetic field about a conductor carrying an

electric current. It is proportional to the current strength in amperes flowing through the conductor and to the number of turns in the coil, if the conductor is coiled as is customary. The unit of M. M. F. is the Gilbert.

Modulator. A device for varying the amplitude of one current in accordance with the amplitude of a current having a lower frequency.

Motor-generator. An electrical machine comprising a motor and a generator in which the rotors are both on one shaft. It may be either direct or alternating current. It is used to step up or step down direct current, or to convert from a. c. to d. c. or vice versa.

Natural Frequency. The frequency with which a circuit is in tune by virtue of its self-inductance and capacity.



Neutrodyne Type of Circuit

Neutrodyne. A system of receiving radio frequency coils in which a balancing condenser is used to overcome the effect of the capacity between the grid and plate circuits of the tube, and thereby to prevent self-oscillation in the circuit.

Ohm. The practical unit of resistance. A circuit has a resistance of one ohm when one volt is required to force a current of one ampere through it.

Oscillations. Electrical or mechanical vibrations, or rapid to and fro motion.

Oscillator. An electrical circuit designed for the production of oscillations or high-frequency currents.

Output. The useful energy delivered by an electrical device.

Panel. A sheet of insulating material used for mounting radio instruments.

Parallel (connection). The method of connecting electrical apparatus in such a way that the current divides, part passing through one branch, and part through the other. When batteries are connected in parallel, the currents add up, while the voltage of the combination remains the same as the voltage of the individual units.

Peak. The maximum value of a current or voltage during a cycle. Amplitude.

Phase. The time elapsed from the beginning of a cycle to a given instant.

Phase Angle. The difference in phase between the e. m. f. and the current. It is the anti-tangent of the ratio of the reactance to the resistance in a circuit.

Phase Difference. In an inductance coil, condenser or a dielectric material, it is more convenient to speak of the phase difference than the phase angle. It is defined as the complement of the phase angle; that is, 90° minus the phase angle. When the resistance is small it is equal to the ratio of the resistance to the reactance.

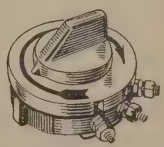
Pitch. An acoustic term describing the frequency of a musical tone.

Plate. The electrode in a vacuum tube which receives the electrons emitted from the filament.

Plate Current. The direct current in the plate circuit which is due to the electron stream from the filament to the plate.

Plug. A device for connecting the telephone receivers or loud speaker to a jack.

Plug



Potentiometer or Rheostat

Pole. The end of a magnet from which the magnetic field seems to leave or enter the iron. The terminals of a battery are sometimes designated as poles.

Potential. The electrical pressure which determines the flow of current through a given resistance or impedance.

Potentiometer. A device for measuring potential. Usually employed as a voltage divider.

Power Amplifier. An audio-frequency amplifier designed to deliver sufficient electrical energy to a sound reproducer to make the signal audible in a large hall or auditorium.

Primary. The first winding on a transformer, or the winding on which current is impressed.

Pulsations. Intermittent, uni-directional electrical currents.

Radiation. The energy which leaves a transmitting antenna in the form of radio waves.

"Radio Pocket." Same as "dead spot."

Reactance. That part of the total impedance in a circuit which is due to capacity and inductance. It is the non-dissipative part of the total impedance.

Reactance Coil. A coil whose inductive reactance is large compared to its resistance.

Receiver. A circuit with accessory apparatus used for the reception of radio signals. A headset is sometimes called a receiver.

Rectifier. An electrical device which converts alternating currents to direct, or uni-directional currents.

Reflection. The bending backwards of a wave when it strikes the boundary between two media of different density. For instance, light striking a mirror, or a water wave striking shore, is reflected backwards.

Reflex. A type of receiving circuit in which one tube is used twice for the same signal; once to amplify it at radio frequency, and once at audio frequency.

Refraction. The change in direction of a wave when it enters a medium of different density. For instance, a ray of light entering water will bend upward.

Regeneration. Increasing amplification in a vacuum tube by returning part of the output energy to the grid circuit to be reamplified.

Rejector Circuit. See wave trap.

Relay. An electromagnetic switch by means of which a local power circuit is controlled. A repeater in which little energy controls a device capable of handling a greater amount.

Resistance. That part of the total impedance which is due to dissipation of energy in the circuit.

Resonance. When the reactance due to capacity is equal to the reactance due to inductance, the total reactance in the circuit is zero, and the only impedance offered to a current is the resistance in that circuit. When this condition exists for a given frequency, the circuit is said to be in resonance with that frequency.

Rheostat. A variable resistance used for regulating the flow of current.

Rotor. That part of any radio apparatus which turns, such as movable plates of a condenser, the revolving part of a vario-coupler, or variometer, or the rotating part of an electrical machine.

Secondary. The second winding of a transformer, or the winding which delivers energy.

Selectivity. The property of a tuned circuit which determines its ability to select any desired frequency to the exclusion of others.

Series (connection). The method of connecting electrical apparatus in such a way that the total current passes through all. When batteries are connected in series the voltages add up.

Series Aiding. An inductance coil is said to be connected in series aiding when the mutual inductance between them is positive; that is, when the total inductance is larger than the sum of the two.

Series Opposing. Two inductance coils are said to be in series opposing when the mutual inductance between the two is negative; that is, when the total inductance of the combination is less than the sum of the two.

Shadow. The region behind an obstacle into which the waves from a given wave source do not penetrate. Thus, the quiet water on the leeward side of an island may be considered as the shadow of that island. Sound, radio and heat shadows also exist behind obstacles away from the radiating source.

Shunt. A parallel connection. An instrument or piece of apparatus is connected in shunt when it is connected across the line or some other instrument in the circuit.

Signal. An electrical current conveying a message or carrying intelligence.

Skin Effect. A term applied to the change in resistance of a conductor with the change in frequency of the current. High frequency currents have a tendency to travel over the surface of the conductor. The higher the frequency, the less it will penetrate into the interior of the conductor. For this reason, the effective area of a conductor becomes less as frequency increases, and therefore the resistance greater.

Solenoid. An inductance coil which is long in comparison to its diameter. A cylindrical inductance coil.

Space Current. Same as plate current.

Static. The electrical disturbance due to atmospheric discharges, such as lightning, or charges sometimes accumulating on the antenna due to moisture.

Stator. That part of an electrical apparatus which is fixed in position, such as, stationary winding of variometers and vario-couplers, the stationary plates of a condenser, or the fixed windings of an electrical machine.

Storage Battery. An electrical battery which is capable of being charged by the passage of an electrical current through it in the direction opposite to the direction of discharge of the battery.

Super-audible. A frequency which lies above the audible range. Usually above 20,000 cycles per second.

Super-heterodyne. Pertaining to a method of receiving radio frequency waves in which a beat current, having super-audible frequency, is produced by modulating the output of a local high frequency amplifier with the incoming radio wave, and amplifying this to any desired extent, by an amplifier which is tuned to the super-audible beat frequency before final detection.

Super-regeneration. A method of amplifying radio frequency signals, in which self-oscillation is prevented by periodically damping the circuit. This is uually done by introducing resistance in the tuned circuit by means of an oscillator having a frequency of about 10,000 cycles per second.

Taps. Connections made to an inductance coil to vary the number of turns included in the circuit.

Tickler. An inductance coil, by means of which energy from the plate circuit is returned to the grid circuit, in order to obtain regeneration.

Transformer. An electro-magnetic device for changing the potential to a higher or lower value. It usually consists of two windings, very closely coupled. The turns ratio, that is the ratio turns, determines the ratio of the voltages, or the potentials.

Tuner. That portion of a radio receiver in which tuning is done.

Tuning. The process of bringing a circuit into resonance with any desired radio frequency wave.

Turns-ratio. The ratio between the turns in a transformer.

Ultraudion. A type of unstable oscillator developed by De Forest, in which the stray capacity between the oscillating coil and the filament plays an important part.

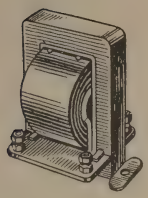
Undamped Waves. Continuous waves. Waves which continue with undiminished amplitude as long as the action which causes them is continued.

Vacuum Tube. An electron emission device having two or three electrodes enclosed in a vessel from which air and other gases have been removed to a high degree of vacuum. An electron relay.

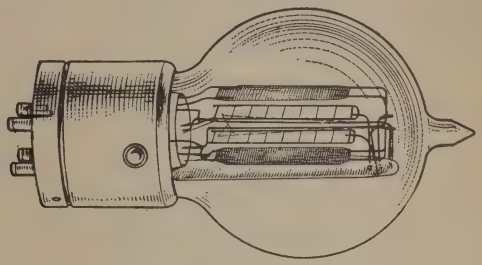
Valve. See diode.

Vario-coupler. A radio frequency transformer in which the relative positions of the two coils may be changed.

Variometer. A small variable inductance used in a radio circuit. The variation of the inductance is done by varying the coupling between the stator and rotor.



Audio Frequency Transformer



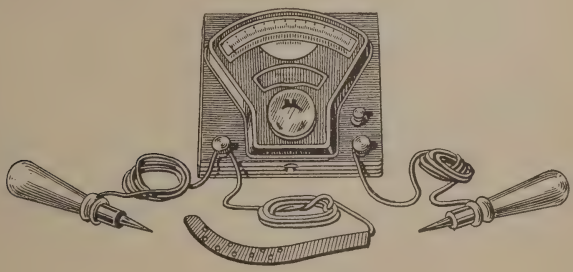
Vacuum Tube

Vernier. A device by means of which accurate readings of a meter may be obtained, or by means of which a fine variation of instruments can be effected.

Vibration. Rapid to and fro motion.

Volt. The practical unit of potential.

Voltage. See potential.



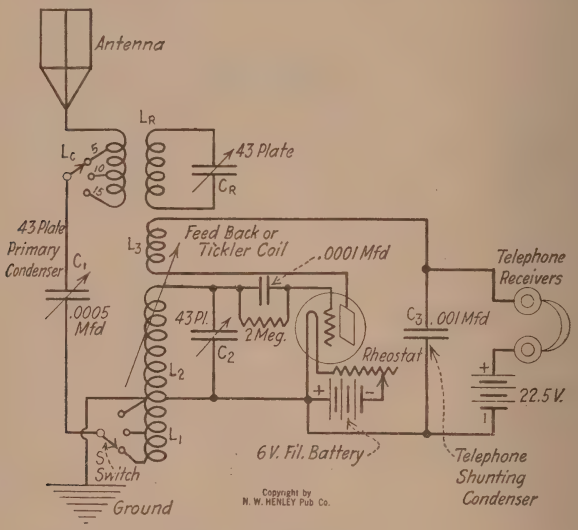
Voltmeter

Voltmeter. An instrument for measuring potential in terms of volts.

Watt. Practical unit of power. If the current flowing is one ampere, and the difference of potential between two points in a conductor is one volt, the power expended in the circuit between those two points is one watt. The power expended in watts may be obtained by multiplying the voltage in volts and the current in amperes.

Wave Length. The distance between two corresponding points in a radio wave; as, for instance, the distance between two consecutive crests of the wave.

Wave Meter. An instrument used to measure the wave length emitted by a transmitting circuit or to calibrate a receiving circuit.



Wave Trap Used with Regenerative Type Receiver

It is usually a series tuned circuit with a current indicating device to show resonance.

Wave Trap. A resonant circuit used to eliminate an interfering signal (Rejective circuit, Frequency Trap).

Wired Radio. An application of the principles of radio communication to signaling over wire. Carrier current communications over wire.

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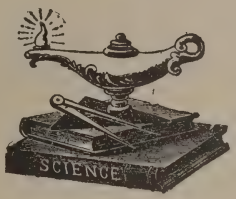

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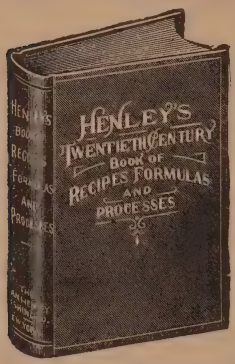

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