EVERYMAN'S GUIDE TO RADIO

HOW TO MAKE RADIO MEASUREMENTS
LEARNING THE LANGUAGE OF DOTS & DASHES
BATTERIES, BATTERY CHARGERS AND B-ELIMINATORS
DIFFERENT TYPES OF RECEIVERS

EVERYMAN'S GUIDE TO RADIO

A PRACTICAL COURSE OF
COMMON-SENSE INSTRUCTION IN
THE WORLD'S MOST FASCINATING SCIENCE

VOLUME III

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Contents

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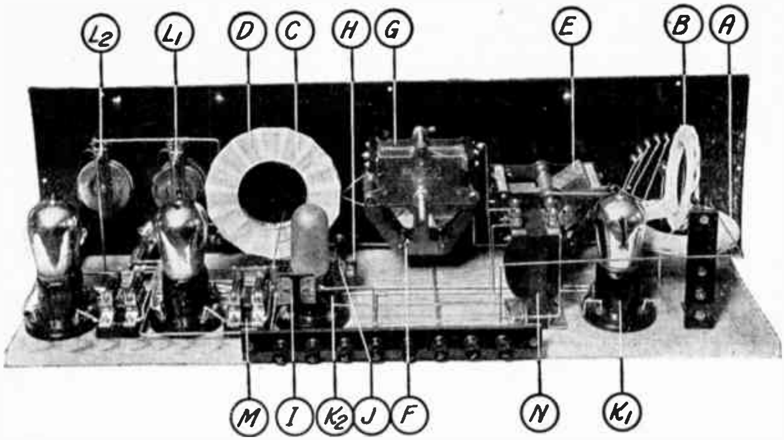


The Sections of the Everyman's Guide to Radio dealing with the various instruments keyed in this illustration may be quickly found by reference to the index below.

ILLUSTRATED INDEX

SECTION XII

Making Simple Radio Measurements

THE student will find in this part much valuable and understandable data concerning the calculation of inductance, wavelengths, capacity, and the like as well as a description of the simple devices with which these measurements may be made. No lengthy or involved formulae are included and any novice with a good grounding in arithmetic may arrive at accurate conclusions by means of the methods given.

Perhaps there is no more important instrument used for radio measurements than the wavemeter. It may be employed in a dozen and one calculations and, contrary to what might be expected, it may be constructed and operated by students of the science with little or no trouble.

A wavemeter is really a combination transmitter and receiver of the calibrated type. That is it may be adjusted to emit a wave of definite length and it may be set to receive a wave of definite length. In this way it is possible to calibrate transmitters and receivers by its use.

Every amateur who operates a transmitting apparatus ought to have a wavemeter—for his own protection. Yet few amateurs own one. No transmitting set can be adjusted properly for wavelength without the aid of an accurate wavemeter. In the proper adjustment of a spark transmitter a wavemeter is indispensable, as a resonant condition between the closed and open circuits is far more essential for maximum efficiency than "antenna current."

In obtaining resonance in a tube transmitter, the amateur is usually guided by the use of various voltmeters, ammeters and milliammeters. But reliance should not be placed upon guess work in determining the length of the emitted wave. Our Government, through the Department of Commerce, has complete jurisdiction over radio communication and has designated the operating wavelengths of various classes of stations, and these wavelengths must be adhered to strictly in transmitting. The amateur who uses a wavelength greater than that to which he is entitled is in danger of forfeiting his license.

The amateur who wants to build his own wavemeter—and the task is not difficult—will find the following instructions of practical value. The apparatus here described is really efficient; for amateur purposes, indeed, it may well take its place alongside the justly famous Kolster decremeter. The specifications call for the following material:

1 pc. bakelite 3/16 by 8½ by 8½ inches.

1 Weston thermo-galvanometer No. 425.

1 1½ volt flashlight cell.

1 Century buzzer.

1 Rotary Switch lever.

2 Contact points.

1 Variable Condenser .001 mfd. with dial.

2 Binding Posts.

1 Suitable oak or mahogany case.

The schematic drawing Fig. B, shows the electrical connections; the dotted lines represent wires which should be of No. 14 solid-copper wire covered with cambric tubing.

In Fig. F is shown a circuit diagram, and in Fig. C a drilling plan of the panel. Across the binding posts A and B (Figs. B and F) are shunted the windings of the wavemeter coil which complete the circuit through either the meter or the buzzer.

To calibrate the receiving set, place the wavemeter near the antenna lead-in wire, insert the desired coil across the binding posts A and B and place the rotary switch in the "on" position, closing the battery circuit through the buzzer and coil. Set the dial of the receiving set at zero and vary the position of the condenser dial on the wavemeter until the maximum sound is received in the head set that is connected to the receiving set.

Continue this process, taking readings

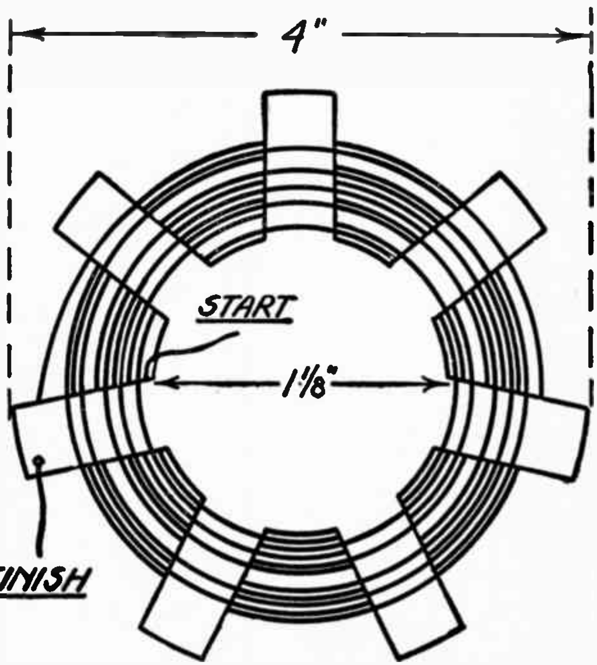


FIGURE A

How to make the coils. Coil 1 has 20 turns on it, and coil 2 has 42 turns. This is the only difference.

of the wavemeter dial when the receiving dial is set at zero, 5, 10, 15, 20 and on. Then by reference to the curve (shown in Figs. D and E) you can ascertain the exact wavelength of each of the various settings of the dial on the receiving set.

Once you have obtained the values at different points, you may plot a new curve for your particular receiver; thereafter you need merely to refer to this curve to learn at a glance the exact wavelength of an incoming signal.

This meter, it will be noticed, is also equipped with two extra binding posts to accommodate a pair of telephones to be used in conjunction with the crystal detector as shown in the circuit diagram in Fig. F and in the photograph on page 16.

To tune a transmitting set, the only change necessary on the wavemeter is to move the rotary switch to the "off" position; when the transmitter is in operation, bring the wavemeter near the apparatus and move the wavemeter dial until the maximum deflection of the thermo-galvanometer is noted. By refer-

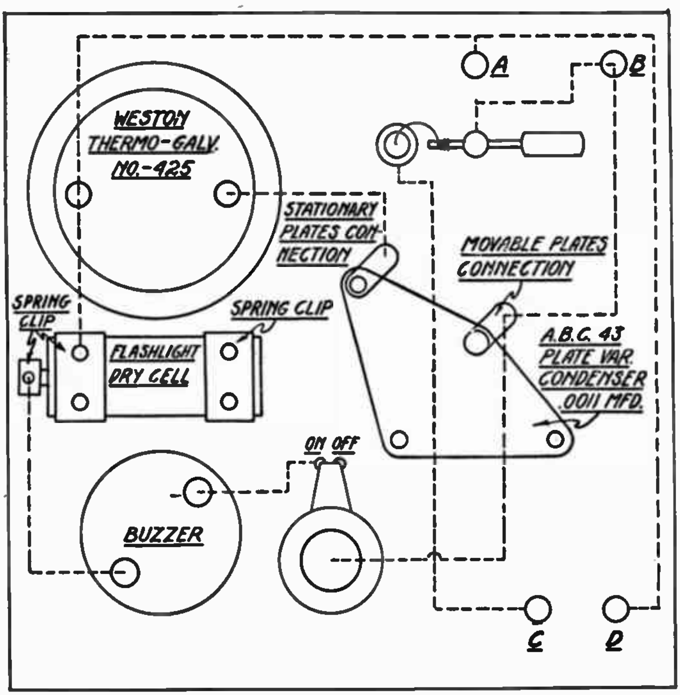


FIGURE B

Figure B shows a schematic drawing of the instrument layout with the circuit connections indicated by dotted lines.

ence to the curve you can immediately ascertain the exact wavelength of your transmitter.

Care should be exercised not to place the wavemeter too near the transmitter, as the thermo-galvanometer shown is very sensitive; the full scale deflection is equivalent to only 115 milliamperes. A thermo-coupled milliammeter of 0-100 scale will also be suitable for this purpose.

For construction of the coils across A and B, see Fig. A. If every detail is followed closely in making the coils, the curves shown in Figs. D and E are accurate within a small percentage.

The instrument described will be a guarantee that you do not exceed the wavelength allotted to you.

An inductance coil or inductor is sometimes improperly called an "inductance." An inductance coil or inductor possesses an electrical property called inductance, but it also possesses electrical resistance and a certain amount of capacity when used in circuits at radio frequencies. The latter property is usually spoken of as "distributed capacity," as it is made up of innumerable small capacities between the various

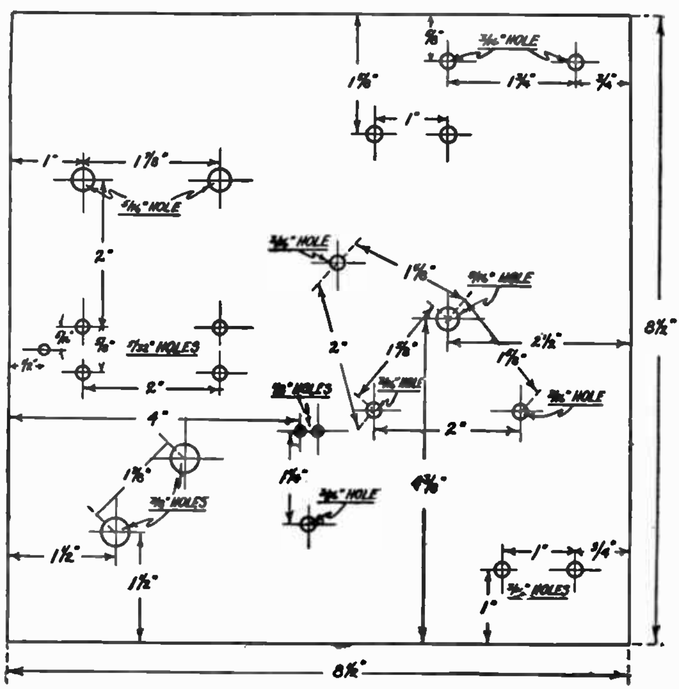


FIGURE C

Where to drill the holes in the panel. Follow this diagram and know exactly what size the holes should be and exactly where they should be drilled.

turns of wire in the coil and between the coil and surrounding objects.

Fig. I (a) represents the usual method of denoting an inductor in a circuit. If we take account of the distributed capacity, we might think of it as in Fig. I (b) where all the innumerable small capacities enter in.

The characteristics of an inductor which we will consider at radio frequencies will be the apparent inductance, the pure inductance, the distributed capacity and the natural frequency.

In measuring these characteristics, in addition to the inductor to be measured, it will be necessary to have one or more calibrated variable condensers of different values sufficient to cover the desired range of frequencies or wavelengths, a calibrated wavemeter which may or may not be equipped with a buzzer, a pair of telephone receivers and a crystal detector.

First, we will determine the apparent inductance of a coil using the buzzer driven wavemeter as a driver and repeat the measurements using the radio-frequency generator as the driver. First connect the terminals of the inductor to the terminals of the calibrated variable condenser and connect the crystal detector and telephone receivers at one point of this circuit as shown in Fig.

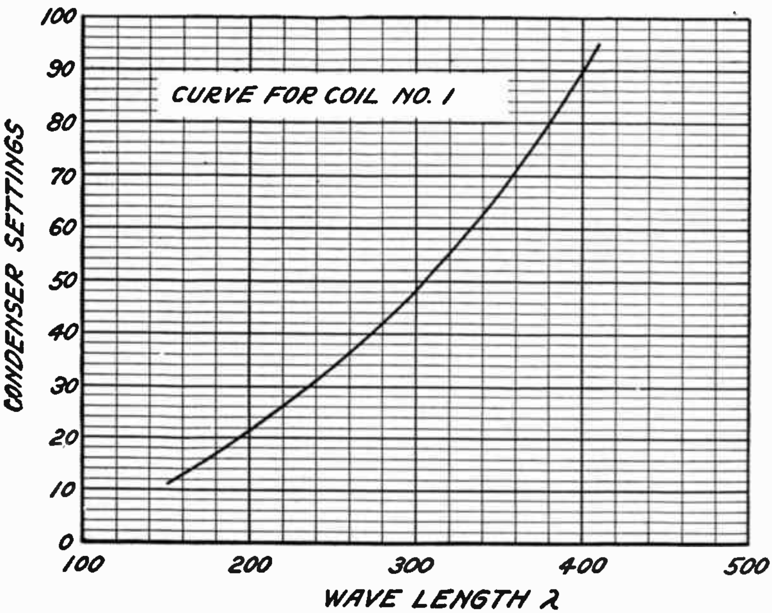


FIGURE D

The wavelength chart for coil number 1. Run along the horizontal line, which corresponds to the number on the dial of the condenser in the wavemeter for a given setting, until you strike the curve; then run down the vertical line to the bottom of the chart to find the wavelength. Thus for a setting of 21 on the condenser we find a wavelength of 200 meters, on which amateurs transmit.

J. The connections between the inductor and condenser should be as short as possible. The buzzer on the wavemeter is started and the wavemeter coil is brought near the coil under test so that the coupling between the coils is rather close. The setting of the variable condenser in the test circuit is then varied until the buzzer note is heard in the telephone receivers.

The coupling between the two circuits may now be loosened so that the buzzer note is heard only at a very definite setting of the condenser S, which setting is recorded and also the setting of the wavemeter. If the condenser of the wavemeter is changed to another setting a different frequency or wavelength will be set up and another point on condenser C may be found. As many points as desired may be taken in this way.

Upon completion of these tests we will have two columns of data from which to make our calculations of apparent inductance, one column of condenser settings for which we know the corresponding capacity values, and a

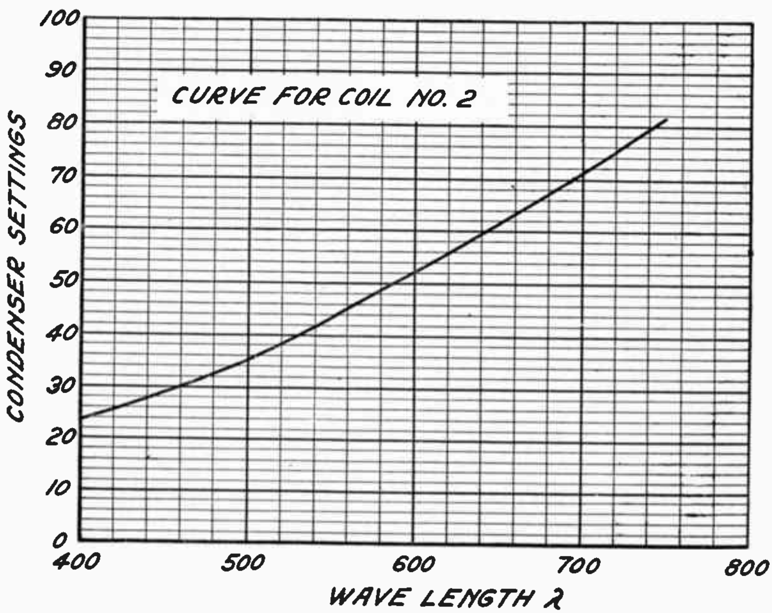


FIGURE E

The wavelength chart for coil 2. This chart is used in the same manner as the chart shown in Figure D. It will be noticed that coil 1 has a wavelength range of 150 to 400 meters and that coil 2 has a range of 400 to 740 meters. If the experimenter desires to make his wave meter a still more useful device by increasing its range beyond the points made possible with the two coils described, it is only necessary to make longer coils and to draw up curves to match them.

second column of condenser settings for which we know the corresponding frequency or wavelength values. These values might appear as shown in the first and third column of Table 1.

TABLE NO. 1

Determination of apparent inductance of coil

Condenser Setting S	Capacity, Micromicro-farads	Wavemeter Setting and Coil		Wave Length, Meters	Apparent Inductance, Microhenries
10.1	114.5	179.4	B3	822	1660
30.1	247.2	94.5	A4	1150	1506
50.2	375.8	4.5	B4	1400	1467
80.1	565	96.4	B4	1700	1440
139.9	951	36.8	C4	2188	1422
170.0	1144	81.2	C4	2400	1416

The apparent inductance in Table 1 was calculated from the following formula:

$$La = \frac{0.2818\lambda^2}{C}$$

Where

La = the apparent inductance in microhenries,

λ = the wavelength in meters,

and

C = the capacity in micromicrofarads of the known condenser.

The same measurement may be made with greater ease and accuracy by using an electron tube radio-frequency generator as the driver, a wavemeter to determine its frequency and a thermogalvanometer and single turn of wire to determine the resonance point.

The connections are indicated in Fig. K.

The procedure is similar to that given above in that the radio-frequency generator is started and the condenser in the circuit of the coil under test is varied until a maximum deflection is obtained in the circuit consisting of the thermogalvanometer and single turn of wire. The single turn of wire may be from four to six inches in diameter and is placed two or three inches from the coil under test so as to have its axis parallel to the axis of the larger coil.

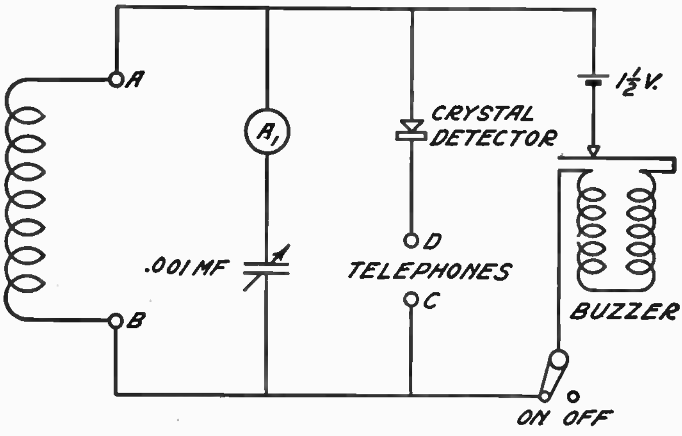


FIGURE F

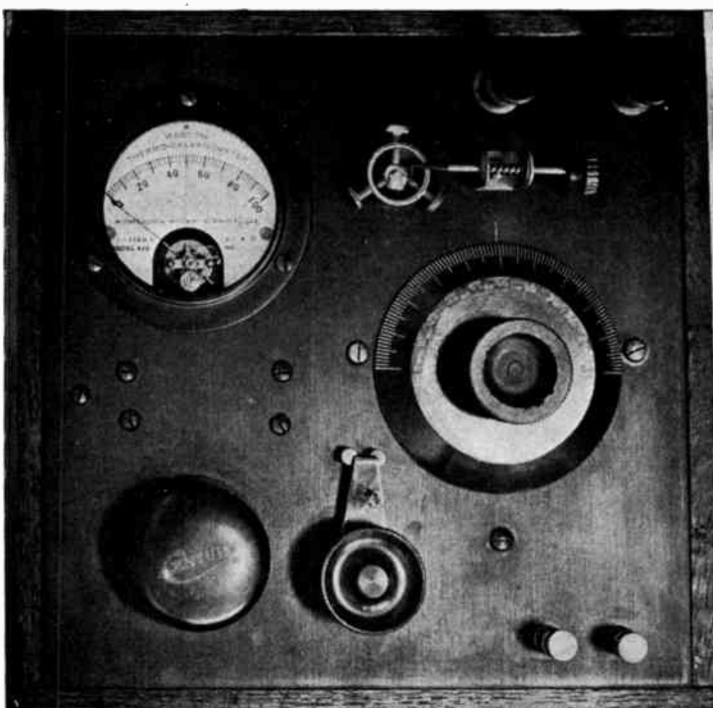
This circuit diagram shows the electrical hook-up for the apparatus. Either coil 1 or coil 2 may be used across the binding posts in accordance with the wavelength range to be covered.

The coupling between the coil and generator should be kept as loose as possible and yet have a deflection in the thermogalvanometer which is readily seen. Having determined the resonance point, the setting of the condenser S is read and the wavelength of the generator is determined with the wavemeter. Several points may be obtained and a curve may be drawn showing the change in apparent inductance with frequency or wavelength. Fig. L shows the values of inductance and wavelength in Table 1 in plotted form.

If we should make measurements of the inductance of this same coil, using direct current or alternating current at 1,000 cycles a second (for instance), we might find that the values we obtained that way would be somewhat less than the values we have just obtained at radio frequencies. This is because in the equation used above for calculating the apparent inductance it has been assumed that the only capacity present was in the variable condenser.

We stated at the beginning that the coil itself had some capacity in itself which we call distributed capacity.

We will now make a few calculations



A PANEL VIEW OF THE COMPLETED WAVEMETER

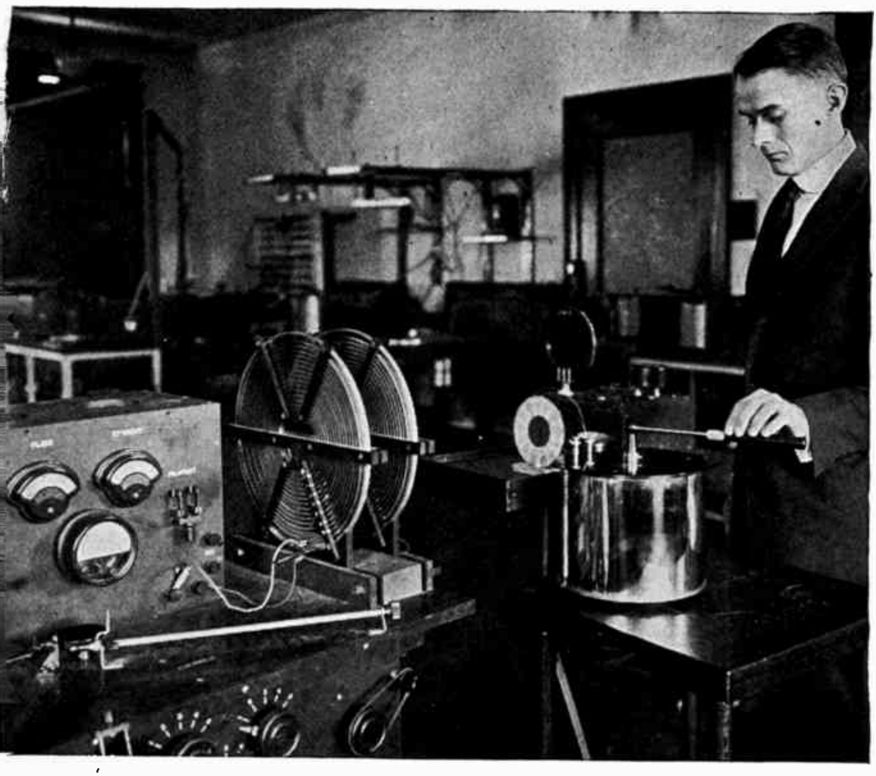
Figure G: With this apparatus the amateur may check up on two important points—the wavelength of the signals that he is transmitting and the wavelength of the signals that he is receiving. No radio installation is complete without this important measuring instrument.

to determine the value of the distributed capacity of the coil. We may select three or more sets of observations from the data already taken in determining the apparent inductance. We will determine the capacity of the condenser and the wavelength of the generator for these points. After squaring the values of wavelengths, plot these values as ordinates against the corresponding values of capacity in micromicrofarads. (See Fig. M.)

If the measurements have been carefully made, these points will lie on a straight line which may be drawn through these points and extended to the abscissa axis, as in Fig. M.

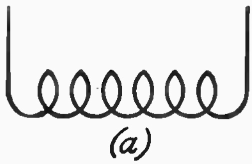
It is seen that this line cuts the ordinate axis some distance from the origin and continues to the left of this axis. The distance OA, measured by the same scale as OC, is the value of the distributed capacity for the coil, and in this case is about 20 micromicrofarads.

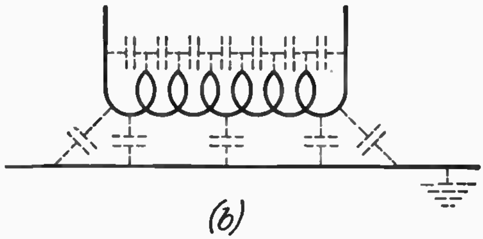
One perhaps wonders how this small value of capacity, the distributed ca-



THE NECESSARY APPARATUS FOR DETERMINING THE CONSTANTS OF COILS USED IN RECEIVERS

Figure H: The small spiderweb coil under test is shown connected to a laboratory standard variable condenser with the oscillator at the left and tne wavemeter in the background.





TWO VISUALIZATIONS OF INDUCTORS

Figure I: The upper diagram (a) is the conventional inductance symbol. The lower diagram (b) indicates the existence of the distributed capacities of an inductive circuit that are never graphically represented.

pacity, enters into the fundamental equation for the wavelength of a circuit made up of an inductance coil and a condenser in series, which may be written

$$\lambda = K\sqrt{LC},$$

λ being in meters, K a constant, L the inductance in the circuit and C the capacity in the circuit. The quantity C in this equation is made up of the capacity in the condenser and the distributed capacity of the coil.

The pure inductance of the coil may be calculated from the equation:

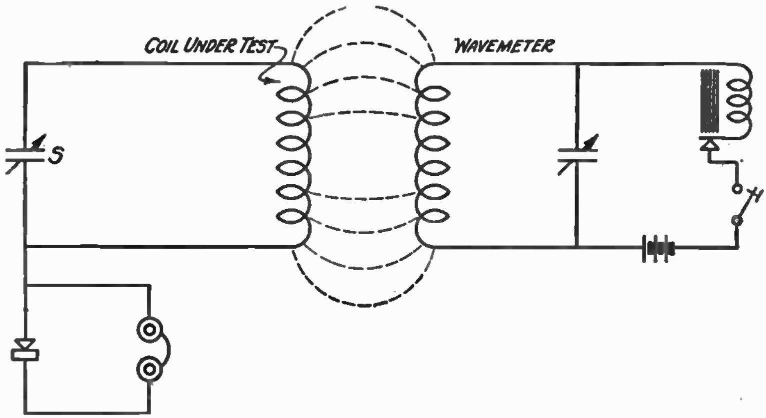
$$L_p = \frac{0.2818\lambda^2}{(C+C_o)}$$

Where

L_p = pure inductance in microhenries,
λ = wavelengths in meters,
and
C = capacity of condenser in micromicrofarads.
C_o = distributed capacity of coil in micromicrofarads.

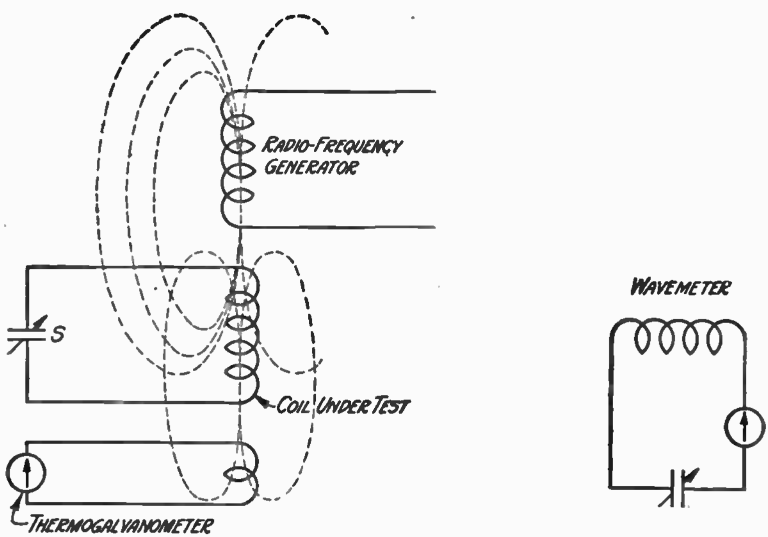
It was stated above that the distributed capacity of an inductor may be made up of innumerable small capacities between the various turns of wire in the coil. If this is true it would seem that a given inductance coil might have one or more frequencies or wavelengths to which it would respond or go into resonance. That is the case and one or more frequencies can usually be found at which the coil will be in resonance when the two ends of its winding are not connected to anything. To determine one or more of these frequencies the coil is placed near a radio-frequency electron tube generator and a resonance indicator consisting of a thermogalvanometer and a turn of wire are coupled to the coil. The frequency of the generator is varied until a resonance indication is observed, when the frequency or wavelength of the generator is measured with a wavemeter.

Fig. O shows the connections.



CIRCUIT DIAGRAM OF THE AUDIBLE MEASUREMENT METHOD

Figure J: This shows the hook-up that employs a buzzer-driven wavemeter to excite the circuit under test. A crystal detector and phones are connected to this circuit to detemine its resonance point.

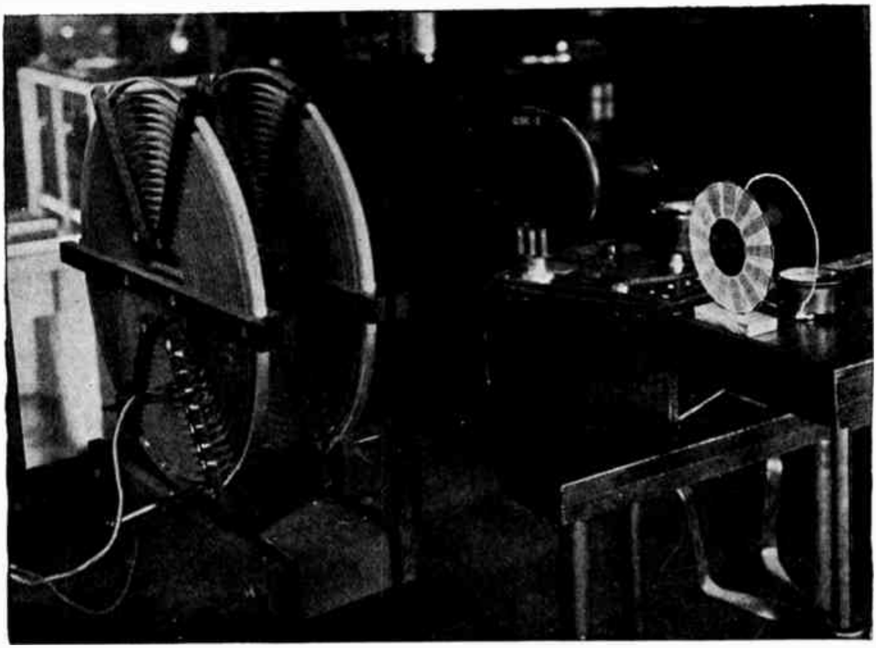


HOOK-UP OF THE SIMPLER AND MORE ACCURATE METHOD OF MEASURING FREQUENCIES

Figure K: This diagram indicates the mode of frequency determination that employs an electron tube radio-frequency generator as a driver, a wavemeter and a thermogalvanometer for indicating the resonance of the circuit under test.

The frequency giving the greatest indication in the thermogalvanometer will be the natural frequency of the coil and will be the shortest wavelength at which resonance may be found. The natural period is usually much higher than the frequency to which the coil would be in resonance if the circuit contained any capacity of such values as are ordinarily employed.

Measurements upon some coils will show little, if any, change of apparent inductance with frequency or wavelength and the distributed capacity will be found to be very small also. Measurements upon two spider-web coils gave such results, also the measurements upon a cylindrical spaced single layer coil. Coils of these two types give sharp tuning in radio circuits and are well-suited for use in some radio receiving sets. The data given in the table is for a coil of 70 turns bank wound in four layers, and wound on a tube about 6½ inches in diameter. The apparent inductance of this coil varied from 1,660 to 1,415 microhenries over the range from 820 to 2,330 meters. Its pure inductance or low-frequency inductance was about 1,390 microhenries and its distributed capacity about 20 micro-microfarads. All of these values may be changed by the *method of mounting the coil*, the *presence of metal objects* in the immediate vicinity of the coil and the *absorption of moisture* by the form upon



Harris & Ewing

THE EQUIPMENT FOR DETERMINING THE NATURAL FREQUENCY OF INDUCTORS

Figure L: The apparatus (from left to right) is a radio-frequency electron-tube generating set with pancak e coils, a wavemeter, a spider-web coil under test and a loop of wire connected to a thermogalvanometer.

which the coil is wound. The consideration of these factors in coil construction is often overlooked.

All of the above remarks have been made concerning fixed inductors or coils. There are on the market continuously variable inductors often incorrectly called variometers. This is a misnomer because a meter usually is used to measure something, while in these instruments the inductance is simply changed and no measuring is done. Any of the above characteristics could be obtained upon a variable inductor in much the same manner as explained above. Measurements of the inductance of such apparatus are often made at an audio frequency such as 1,000 cycles a second. Such results are absolutely useless for work at radio frequencies, as the apparatus behaves entirely different at audio frequencies. In many of the variable inductors where a large amount of insulating material is in the field of the coil, the distributed capacity becomes very large. Because of the large

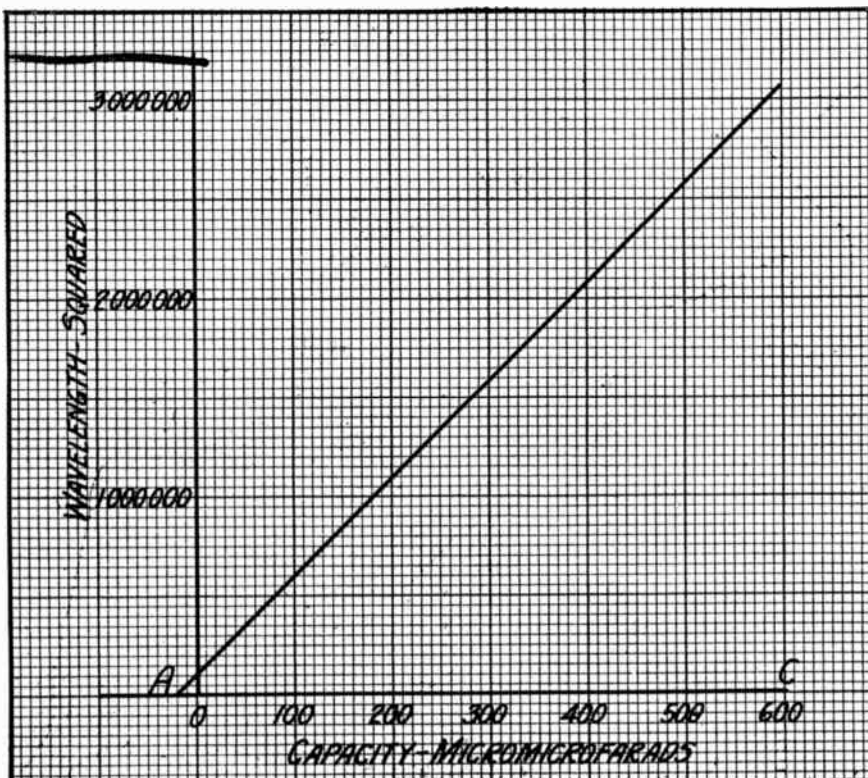


CHART OF THE SQUARE OF THE WAVELENGTH PLOTTED AGAINST CAPACITY

Figure M: If a coil had no distributed capacity, the straight-line curve shown above would pass through the rigin 0. The distance 0-A represents the distributed capacity of the coil under test.

distributed capacity, the apparent inductance for any setting of the variable inductor will vary with frequency or wavelength. The apparent inductance for a given setting will be larger for the higher frequencies or lower wavelengths than for the lower frequencies or higher wavelengths. As the wavelength is increased the values will come closer and closer to the values obtained at audio frequencies, but it is obvious that measurements must be made at high frequencies if the results are to be employed for operation at these higher frequencies.

The primary standard of radio frequency of the Bureau of Standards[1] consists of two standard wavemeters which cover the frequencies in general use, *viz.*, from about 18 to 4,600 kilocycles a second (16,650 to 65 meters). These wavemeters are similar in general construction, each consisting of a variable air condenser, four fixed condensers, a number of interchangeable inductors, and a resonance indicating device, all mounted in a fixed position upon a specially constructed movable table.

The variable air condenser is of about 0.001 microfarad maximum capacity and is a Bureau of Standards type of condenser, having its movable plates connected to a metal shield which is connected to ground when in use. Four shielded mica condensers are also provided having capacities of 0.001, 0.002, 0.004 and 0.008 microfarad, respectively.

For the one of the two wavemeters which serves as primary standard five

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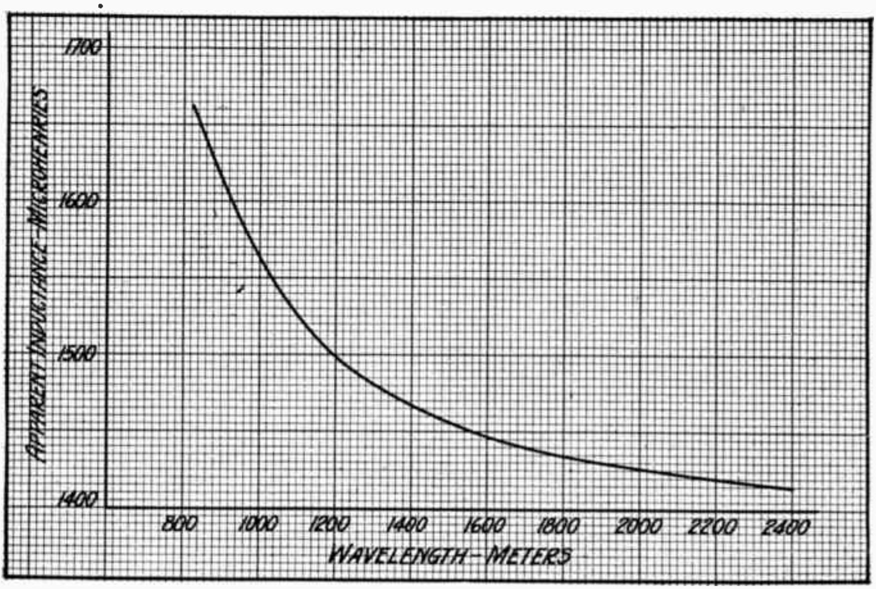


CURVE OF THE CHANGES OF APPARENT INDUCTANCE WITH WAVELENGTH

Figure N: This graph shows that the apparent inductance of a coil increases much more rapidly at the lower wavelengths or higher frequencies.

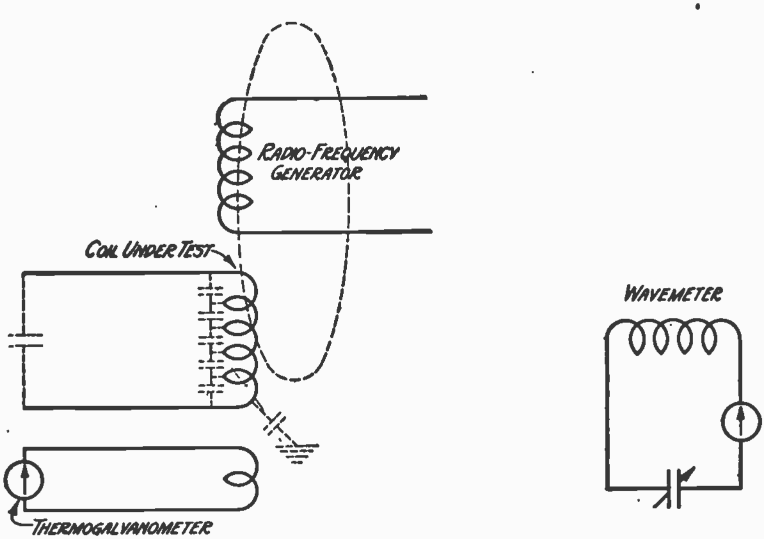
inductors are provided. Four of these five inductors are of the single-layer, spaced-winding type, employing skeleton frames of laminated phenolic insulating material wound with high-frequency cable and forming coils of polygonal cross-section. The inductors are provided with terminals so that they are interchangeable. The three smallest coils are boxed in to prevent changes in the inductor constants from the displacement of a portion of the winding by handling.

The resonance indicator consists of two turns of heavy wire fixed in position near the wavemeter inductor and two indicating instruments. A thermogalvanometer is used for coarse adjustments and a crystal detector and direct current milliammeter for finer adjustments, the latter instrument permitting of much more accurate indication of the resonance point than the former.

In the wavemeters of this general design formerly used by the Bureau the condenser and inductors were mounted separately. After tests were completed with a wavemeter of this type, the condenser, inductor and connectors were put away in a case until needed again. There was always the chance of changing the calibration of the condenser by carrying it from one place to another, as well as the chance that errors might be introduced by using different connecting wires or by accidental bending of the wires.

Much of this chance of error was overcome by mounting permanently a standard variable air condenser and connecting leads for the coil terminals upon a table equipped with rubber-tired wheels.

The resonance indicator for the wavemeter built on this principle was a combination of a single turn of wire and



CIRCUIT DIAGRAM OF THE MEANS OF FINDING THE NATURAL FREQUENCY OF COILS

Figure O: With the coil under test left open, the wavelength of the circuit can be determined as in Figure K; (using the electron tube radio-frequency generator as a driver with a thermogalvanometer) and the capacity corresponding to this wavelength is the distributed capacity of the coil.

a Weston "thermogalvanometer" Model 425, the latter consisting of a thermo-element and a direct-current indicating instrument. The single turn of wire was mounted with its plane parallel to the turns on the wavemeter inductor but was not fixed in position. It could be moved along a line perpendicular to the axis of the wavemeter coil. The indicating instrument and the turn of wire were connected to the grounded terminal of the wavemeter. This wavemeter covered a range of from 30 to 4,600 kilocycles (10,000 to 65 meters) using a condenser of about 0.001 microfarad capacity and six fixed inductors.

Among the improvements in a wavemeter of this type was the addition of the four mica condensers which could be connected in parallel with the variable air condenser in order to extend the range of the wavemeter. A micrometer adjustment for the movable plates of the variable air condenser was added also.

The wavemeter now in use is a still further improvement on this type. The connections to the inductor are made of

TABLE No. 1

CONSTANTS OF THE INDUCTORS FOR THE PRIMARY STANDARD WAVEMETER

	INDUCTOR				
	E	F	G	H	L
Diameter, centimeters	12.5	12.5	22.8	27.9	38.0
Length, centimeters	6.6	7.1	9.4	15.4	18.2
Number of turns	8	22	39	96	320
Spacing, centimeters	0.8	0.3	0.2	0.2	0.1
Size of wire (high frequency cable)	48x38	48x38	48x38	48x38	32x38
Distributed capacity, micro-microfarads	8	11	11	14	90
Pure inductance, microhenries	9.2	56	382	2439	22880
Equivalent resistance, ohms for the frequency corresponding to a 10° setting of the air condenser	2.4	2.2	6.2	11.3	—
Same for 175° setting of the air condenser	0.4	0.7	2.0	5.1	—
Direct current resistance, ohms	0.27	0.44	1.54	5.1	21.0

TABLE NO 2

RANGES OF VARIOUS COIL AND CONDENSER COMBINATIONS

Coil and Condenser Combinations	Frequency Kilocycles per second 10° setting	175° setting	Wavelength Meters (approximate) 10° setting	175° setting
E	4610	1500	65	200
F	1650	615	180	490
G	700	233	425	1285
G and I	241	172	1240	1740
G and II	174	142	1720	2110
H	280	93	1070	3220
H and I	95	68	3120	4380
H and II	70	57	4300	5280
L	73	29.5	4100	10160
L and I	30.3	22.0	9900	13600
L and II	22.3	18.3	13400	16400

3-millimeter brass rod forming a rectangle 25 by 29 centimeters. Four rods support the connections to the inductor. The two on the insulated side of the condenser are of Pyrex glass. Of those on the grounded side of the condenser, the support nearer the condenser is of brass and connection to the ground is made through its lower extremity. The support nearer the inductor is of laminated phenolic insulating material.

The resonance indicator may be connected either to a model 425 Weston thermogalvanometer or to a crystal rectifier and direct-current milliammeter. The latter combination is much more sensitive than the former and permits much looser coupling between the radio-frequency generating set and wavemeter. The instrument shown in the photograph (Fig. P) has a full-scale range of 2 milliamperes, but when in use the current is usually kept between 0.4 and 0.8 milliampere, which permits extremely loose coupling between the generator and the wavemeter.

The resonance indicator circuit is not grounded or connected to the wave-

THE STANDARD WAVEMETER OF THE BUREAU

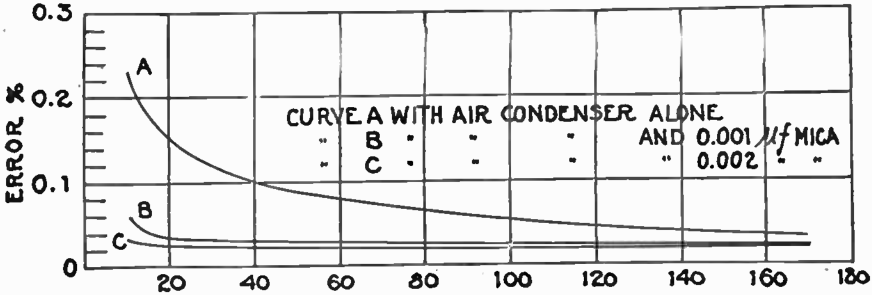
Figure P: Mr. Hall, is shown in the center, explaining the wavemeter to Dr. E. E. Free (at the right). The indicator instruments are shown at the left and the inductor at the right. Mr. O'Keefe (at the left) is adjusting the wavemeter to resonance.

meter circuit in any way. A greater deflection may be obtained by grounding that circuit at certain ranges of frequency, but this is noticed particularly with the crystal rectifier and milliammeter which is more sensitive than the other instrument. The increase in deflection is caused by the apparent increase in coupling with the generator resulting from connecting to the ground connection. This is noticed particularly with the smaller inductors, where there is likely to be a change in the calibration because of the proximity of the two turns of wire which are at ground potential, to the wavemeter inductor.

This method of resonance indication permits of looser coupling than may be obtained with the indicator directly in the wavemeter circuit, except perhaps for the very high frequencies. When a crystal detector and a sensitive wall-galvanometer are used, the wavemeter may be from ten to twenty feet from

HOW WAVEMETERS THEMSELVES ARE STANDARDIZED

Figure Q: To check the readings of wavemeters the Bureau of Standards has devised a method of setting up very short standing waves on parallel wires and measuring these waves with a tapeline. The generator for the short waves is shown at the left. The photograph shows the method of measuring with the tape the position of a resonance point previously determined with the ammeter seen to the right of the operator's hands.

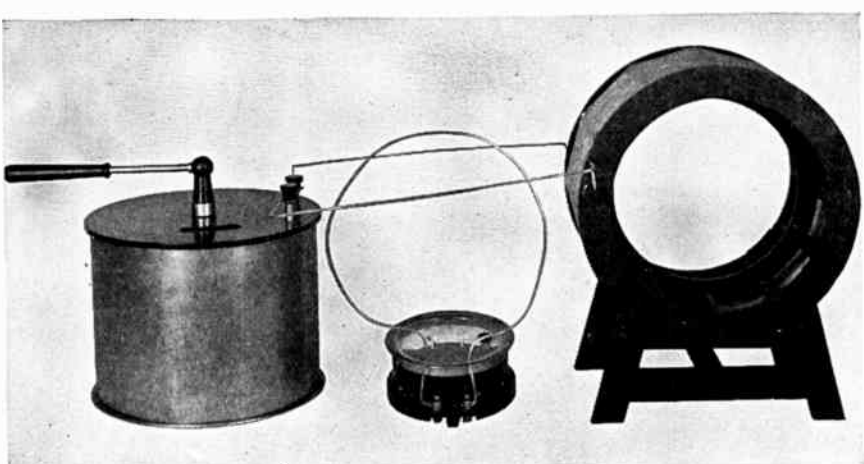


THESE CURVES INDICATE THE ACCURACY OF THE WAVEMETER

Figure R: The percentage error encountered with three condenser combinations is shown by the three curves. Note that the maximum error, at the worst portion of the highest curve, is only a little over two-tenths of a per cent; an error which is altogether negligible in practical work.

the generator, but such a combination is not portable although very accurate results may be obtained in this way. When an indicating device of 4 or 5 ohms resistance is placed in the wavemeter circuit the equivalent resistance of the circuit is considerably increased and closer coupling is necessary.

Another feature of this wavemeter of some interest is the fact that the table is made with two tops separated by pads of sponge rubber about 1½ inches thick. With this device and with the four-inch rubber-tired wheels, the air condenser is kept quite free from jarring when it is moved around the lab-



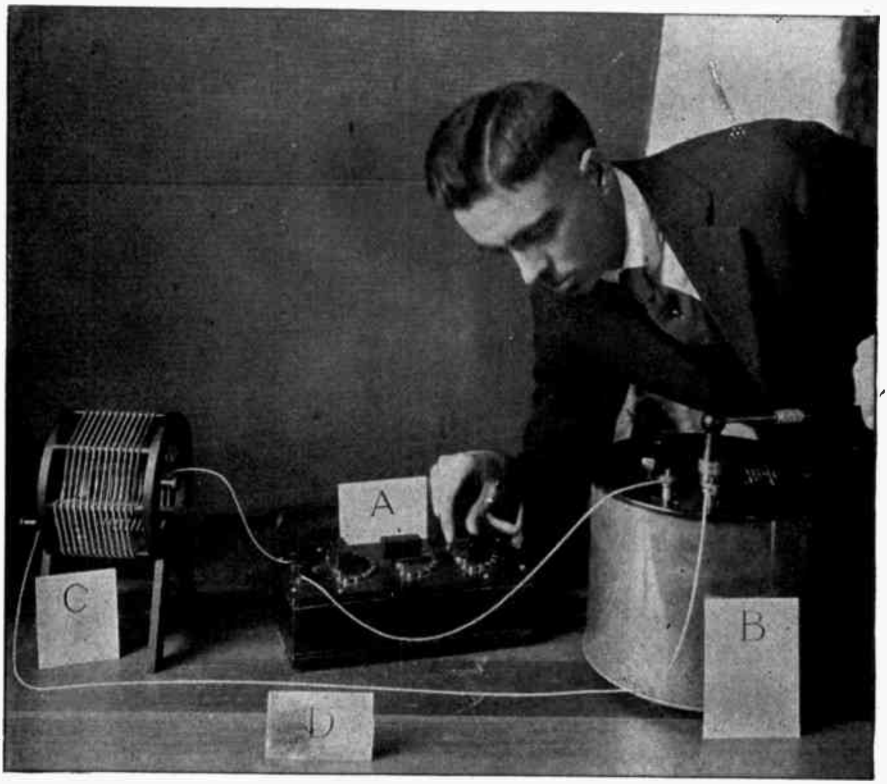
THE MOST IMPORTANT PARTS OF THE WAVEMETER

Figure S: At the left is the cased variable condenser; at the right is one of the inductors, and in the center is the indicating instrument with its loop. Note how the inductor is supported by its rigid frame of phenolic insulating material.

oratory. This precaution is important if the calibration is to be reliable.

The wavemeter is used with a ground wire attached to the shielded side of the air condenser. This reduces the error in noting the resonance point which is likely to be caused by capacity effects between the wavemeter circuit and the body of the operator. When making measurements of frequency the wavemeter is coupled to the radio-frequency generating set as loosely as possible. The distance between the generating set and the wavemeter will vary from a few inches at high frequencies to several feet on lower radio frequencies. The operator always stands on the grounded side of the wavemeter, well away from the inductor.

The constants of the inductor coils and the frequency ranges attainable are given in the accompanying table. The precision of setting the wavemeter to a given frequency is dependent on the



THE "PHANTOM ANTENNA" USED FOR LABORATORY TESTS

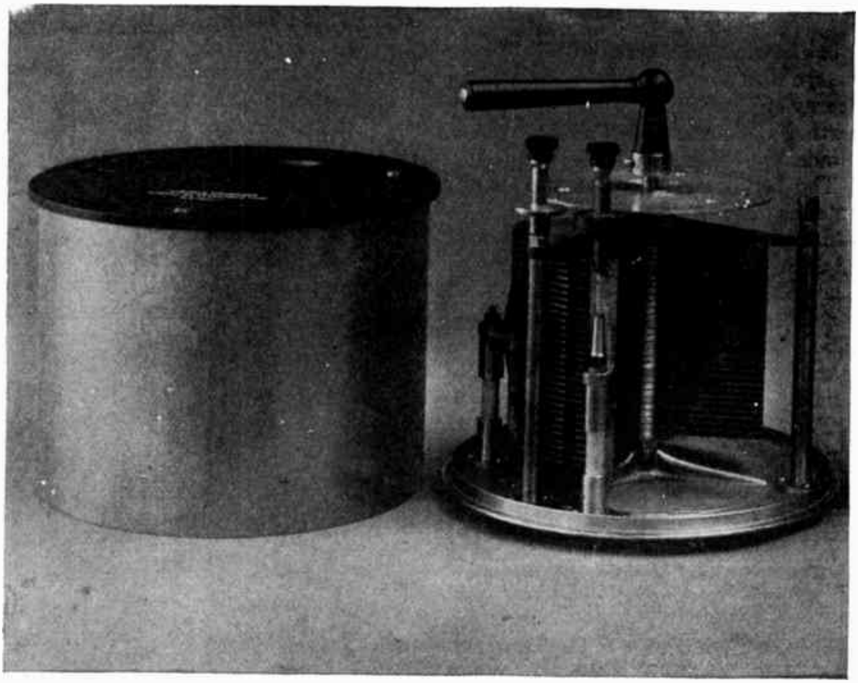
Figure T: One of the authors demonstrates the resistance box, A, which can be set at any value of resistance to be substituted for the resistance of the antenna; B, the variable condenser, which substitutes the capacity; D, the wire substituted for the ground, and C, the coil which furnishes the inductance which would be found in the real antenna.

sharpness of the resonance point as denoted by the resonance indicating instrument, which in turn will vary with the amount of capacity in the wavemeter circuit.

For capacity values such as are in general use at this time the precision varies from 0.2 percent for low condenser settings to about 0.02 percent with fixed condensers of about 0.002 microfarad capacity. In the majority of work with the wavemeter these values will vary between 0.1 percent and 0.03 percent. The precision of measurement may be increased by using more sensitive resonance indicators.

Whether an antenna is a poor or a good receiver of radio waves depends to a great extent upon its constants (electrical properties which can be determined by measurements or sometimes estimated or computed) and by another property of the antenna, "effective height."

The term "constant" is somewhat misleading because some of these electrical properties of an antenna vary greatly with the length of radio waves to which the antenna is tuned. But *at a particular wavelength* the constants of an antenna when used with a ground do remain much the same for a considerable period.



A DELICATELY CALIBRATED VARIABLE CONDENSER

Figure U: Here is shown a standard variable condenser which has been taken out of its protective casing. By rotating the black lever the rotary plates telescope inside of the stationary plates and the capacity of this instrument is varied.

What are the constants of an antenna?

(1) Resistance;
(2) Capacity;
(3) Fundamental wavelength, and,
(4) Inductance.

The resistance of an antenna is the opposition which it offers to the flow of the high-frequency (rapidly reversing) currents induced in it by the radio wave. High-frequency or radio frequency currents flow only on the surface of a conductor. Therefore if the surface area is increased the resistance will be reduced. Antenna resistance is a complex quantity, but it may easily be expressed in ohms.

The capacity of an antenna is a property which enables it to hold a certain electrical charge, and then to discharge this in the form of electrical energy through the receiving set to earth. Capacity is expressed in microfarads.

The fundamental wavelength of an antenna is the length of the wave to which it will respond when it is connected directly to earth. Thus if an antenna has a fundamental wavelength of 290 meters, electrical vibrations or oscillations will be set up in the receiving antenna by a transmitting station that is sending out signals of this wavelength.

The inductance of an antenna is a sort of electrical inertia which retards the changes in the rapidly reversing current induced in the antenna by the incoming radio wave.

On page 28 is shown an artificial antenna in which the required value of resistance is obtained by adjusting the box A and the required value of capacity by adjusting the condenser B; while a fixed value of inductance is obtained in the coil C. The wire D represents the conducting earth under the antenna. The condenser B consists of two sets of overlapping plates which are at all times insulated from each other.

The interior of the condenser is shown in Fig. U. An antenna is a condenser in which the wires and the earth take the place of the two sets of overlapping plates. The coil C has about the same inductance as the average simple receiving antenna. If the wire in the coil is unwound and pulled out straight, its inductance is much less. This explains why the long wire in an antenna has so small an inductance value. In practice no attempt is made to secure a certain value of antenna inductance. The constants in the artificial antenna are "lumped"; in a real antenna they are "distributed."

If the inductance and capacity of an antenna (artificial or real) are increased, its fundamental wavelength is increased. (The capacity is more easily changed than the inductance.) The resistance has no effect on the fundamental wavelength, but if the resistance is increased the current induced by the radio wave is decreased.

Imagine that the inductance of the artificial antenna is "distributed," and that the coil C is the tuning coil of the receiving set. Then we may connect a variable condenser across the terminals of the coil, and thereby increase the wavelength to which the complete antenna system will respond. To decrease the wavelength of the system, we may insert the condenser in the wire leading from the right-hand terminal of the coil to the box A.

The artificial antenna on page 28 is a poor receiver of radio waves because its dimensions are so small that it cannot pick up much energy.

In Fig. V is shown an antenna (erected on the roof of the Radio Building at the Bureau of Standards) which is used for receiving from radio telephone broadcasting stations. The antenna is 115 feet long and 18 feet above the roof. The lead-in wire (shown at the right end) is 45 feet long and passes down the far side of the building, and then through a window. The resistance of this antenna was measured first with a ground connection made to a gas pipe (inside ground), and then with a ground connection made to a pipe driven into the ground (outside ground) directly below the lead-in wire. The measurements were repeated with a single wire in the horizontal part of the antenna. The other constants were measured with the inside ground only as the particular kind of ground connection would make little difference. The results of these measurements are given below:

RESISTANCE WITH INSIDE GROUND

At 1,110 Meters

14 ohms (two-wire antenna)
6 ohms (single-wire antenna)

At 400 Meters

34 ohms (two-wire antenna)
43 ohms (single-wire antenna)

At 360 Meters

45 ohms (two-wire antenna)
37 ohms (single-wire antenna)

RESISTANCE WITH OUTSIDE GROUND

At 1,110 Meters

(Not measured for two-wire antenna)
16 ohms (single-wire antenna)

At 400 Meters

22 ohms (two-wire antenna)
23 ohms (single-wire antenna)

At 360 Meters

23 ohms (two-wire antenna)
17 ohms (single-wire antenna)

CAPACITY WITH INSIDE GROUND

0.00053 microfarad (two-wire antenna)
0.00038 microfarad (single-wire antenna)

FUNDAMENTAL WAVELENGTH

230 meters (two-wire antenna)
190 meters (single-wire antenna)

INDUCTANCE

25 microhenries (two-wire antenna)
22 microhenries (single-wire antenna)

These results show that the resistance of an antenna varies with wavelength, and that at the shorter wavelengths it was reduced by using a single-wire antenna with an outside ground connection. Antenna capacity decreases as the wavelength increases, and then becomes approximately constant. The higher fundamental wavelength of the two-wire antenna is due to higher capacity and inductance as compared with a single wire.

How may one determine the constants of an antenna?

Resistance can only be measured with special apparatus which is elaborate and expensive. It can *not* be computed. The other constants can be measured with less elaborate and, consequently, less expensive apparatus. It is also possible for one who owns a receiving set to measure these other constants with fair accuracy by adding a few simple pieces of apparatus.

Capacity can be computed, although in many cases it is necessary to make allowances for intervening objects, and other factors. On some antennae the computed capacity will check closely with that measured. In other cases the accuracy is not so good. In the formula

$$C = \frac{12.2h\sqrt{A} + 2.7A}{1{,}000{,}000 \times h} \quad \ldots (1)$$

C = capacity in microfarads
h = height of antenna above ground in feet
A = area of horizontal portion of antenna in square feet

To apply this formula to a single-wire antenna, A is obtained by multiplying the length of the nearly horizontal portion of the antenna by 2.5. The result obtained for C must be multiplied by a factor as follows:

LENGTH OF ANTENNA (IN FEET)	FACTOR
30	1.12
40	1.16
50	1.2
60	1.24

70	1.28
80	1.32
90	1.36
100	1.4

Owing to conditions about the average receiving antenna, this result should now be increased by about 20 percent. The factor is not used when the antenna has more than one wire and in addition has a length less than eight times its width.

Fundamental wavelength in meters may often be accurately computed for a single-wire antenna by multiplying the total length of wire in feet by 1.37. Practical allowances can be made for an antenna of several wires close to obstructions, although the result will not be so reliable.

The inductance (L) of an antenna can not be accurately computed by a theoretical formula. It can be computed after one knows the fundamental wavelength (λ_o) and capacity (C), from the formula

$$L = \frac{\lambda_o^2}{3{,}550{,}000 \times C} \quad \ldots\ldots\ldots\ldots (2)$$

If the reader has not the facilities for measuring antenna constants, he may determine them by applying the formula just given.

To illustrate the method some typical antennas will be considered. The preceding formulæ and the following examples apply to "L" antennæ—the type used in the majority of cases. If the lead-in is taken from the center, the capacity remains about the same, but the fundamental wavelength is decreased.

Example 1:

A single wire 80 feet long and 40 feet high; lead-in wire is brought down vertically from one end. The antenna and lead-in are clear of obstructions. If the ground connection is good, the resistance of this antenna at 360 meters should not be more than 15 ohms.

To compute the capacity use formula (1) and let h = 40 and A = 80x2.5 = 200. Substituting these values in formula (1)

$$C = \frac{12.2 \times 40 \sqrt{200} + 2.7 \times 200}{1{,}000{,}000 \times 40}$$

$$= 0.000186$$

This value is multiplied by the factor 1.32 giving

$$C = 0.000245$$

increasing the value 20 percent gives

$$C = 0.000294 \text{ microfarads}$$

If the antenna is close to trees or obstructions, or if the lead-in is closer than one foot from the building, the capacity will be increased still more.

The total length of wire (vertical and horizontal) in this antenna is 120 feet. Multiplying this by 1.37 gives 165 meters as the fundamental wavelength. Add 10 percent to this value if the antenna or lead-in is close to obstructions.

Inductance is computed from formula (2) and is:

$$L = \frac{(165)^2}{3{,}550{,}000 \times 0.000294}$$

$$= 26 \text{ microhenries}$$

The same method of computation may be applied to single-wire antennæ of various heights and lengths.

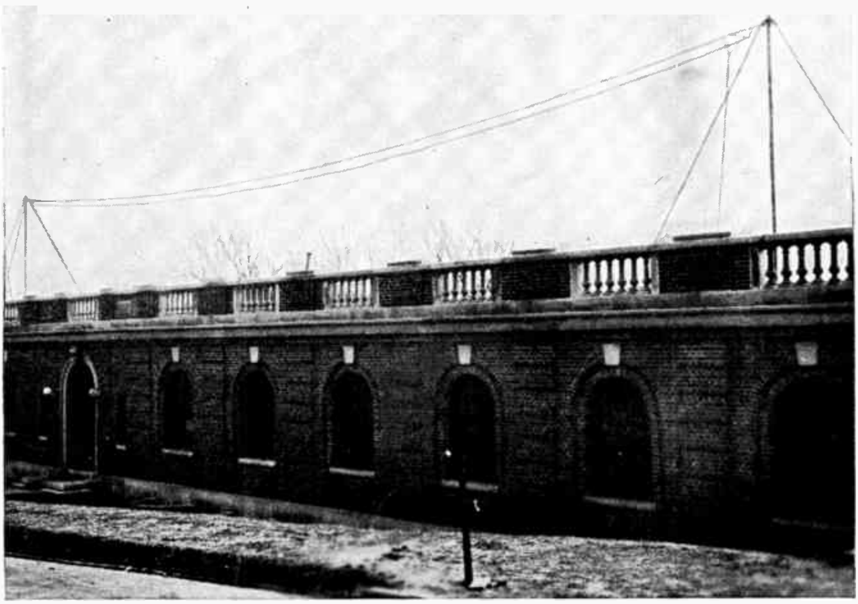
Example 2.

A two-wire antenna 40 feet long and 50 feet high with the wires three feet apart; the lead-in wire is brought down vertically from one end. With a good ground connection the resistance of this antenna, if it hangs clear in space, should not be more than 10 ohms at 360 meters. Because of its comparatively short length this type of antenna is likely to be erected in a restricted space. In this case its resistance may be increased two or three times. The capacity is computed as before, using A = 40x3, and is found to be 0.000192 microfarads. (If the wires are closer than 3 feet, the value of A is the same). Although the antenna has more than one wire, its length is greater than eight times its width; a factor of 1.16 is therefore used in obtaining the result. As before, buildings or obstructions which are very close will increase this capacity.

Multiplying the total length of wire (90 feet) by 1.37 gives 125 meters as the fundamental wavelength. This antenna has a capacity somewhat higher than if a single wire were used. The fundamental wavelength is thereby increased. To allow for this, increase 125 by 15 percent. This gives 145 meters for the fundamental wavelength. Again increase this value by 10 percent if obstructions are near. Inductance, computed as before, is 23 microhenries.

What is the best receiving antenna?

This is not an easy question to answer; in fact it can not be answered at all un-



WHERE UNCLE SAM TESTS AMATEUR AERIALS

Figure V: A special two-wire testing antenna used by the Bureau of Standards in Washington. This is of the inverted L type, and was used for making the determinations explained in this article.

less one knows the location of the antenna and the type of receiving set.

If you have a receiving set with a regenerative tuner or one that employs some kind of radio frequency amplification it is not necessary to have a very high antenna; in some cases a high antenna may be a disadvantage. If you live in a part of the country where static is bad, a high vertical antenna (especially one of several wires) is undesirable. Instead, a single horizontal wire should be used. But if you have a receiving set with a simple (non-regenerative) detector and not more than one step of radio frequency amplification, it is well to have the antenna as high as possible, and also to keep it away from all obstructions. A receiving set connected in the ground lead close to the ground increases the effective height of the antenna and improves reception.

The following points apply irrespective of the kind of receiving set:

(1) Unless you are using an antenna near its fundamental wavelength or one which is exceptionally long compared to its height its directional effect will be slight and not worth considering.

(2) The antenna and lead-in should be kept as free as possible from swaying. The lead-in should be kept as far from obstructions as possible. The vertical part of an antenna is as important as the horizontal part. After the wire has entered the building, it must not be tacked to the wall.

(3) No. 14 copper wire is large enough for any ordinary receiving antenna and ground connection. Larger wire or stranded wire is better because it is mechanically stronger. Of course the greater the surface area, the lower the resistance, but in practice there are so many other features of resistance involved that a larger conductor than No. 14 is not necessary. It makes no difference whether the wire is bare or insulated.

(4) All connections, especially those made outdoors, should be soldered; this insures permanently low resistance. Ground connections to a pipe can best be made with a clamp; a clean surface for contact should be secured. It sometimes happens that a receiving station is situated where the soil is dry and where there is no natural ground connection; in this case a counterpoise (which is nothing but another antenna suspended near the surface of the ground, under the regular antenna) should be substituted. The counterpoise should consist of several parallel wires.

(5) Unless a high antenna is used, natural supports can usually be found. The ropes that support the antenna should have insulators inserted in them. Glazed porcelain is best, but oak blocks boiled in paraffin can be used.

(6) If the fundamental wavelength of the antenna is above 250 meters, a condenser connected in series with the wire leading to the receiving set should be used. If a fixed condenser is used its capacity should be about 0.0003 microfarad. To allow tuning to a wider range of wavelengths a special switch may be used in such a way that a variable condenser may be connected in series with the coil or shunted across the terminals.

(7) It is a good plan to take the lead-in from the center of the antenna instead of the end, when by so doing extra bends can be eliminated.

(8) A water pipe is a better ground connection than a radiator or gas pipe. An iron pipe driven several feet in *moist* earth may be used.

(9) A single wire will usually give as good results as several wires in the hori-

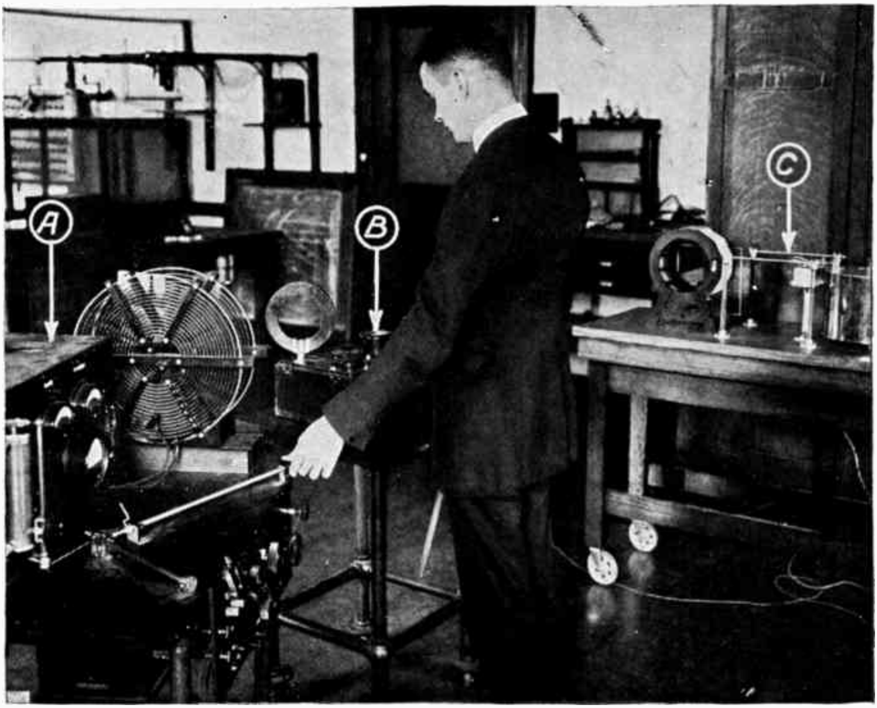
zontal portion of an antenna. If space is limited, two or more wires may be used.

This matter concerns antennas most effective in the reception of wavelengths between 200 to 450 meters.

A wavemeter is one of the most essential instruments used in radio. Now that so many transmitting stations have been given wavelengths close together, the wavemeter assumes even greater importance than formerly.

As its name implies the wavemeter is used to measure the wave emitted by a source of radio frequency oscillations. The most important point to know about this wave is its length—how far it is from the crest of one wave to that of the adjoining wave. This distance is called the wavelength. The wavelength is related directly to the frequencys number of waves or impulses a second, by the relation $\lambda = V/F$ where $\lambda =$ wavelength in meters, $V =$ velocity of electro-magnetic waves (about $3x10^8$) meters a second) and $F =$ frequency of electro-magnetic waves a second.

Radio frequency currents reverse the direction of their flow from (say) 10,000 to 30,000,000 times a second. Audio



TESTING A WAVEMETER IN THE LABORATORY OF THE BUREAU OF STANDARDS

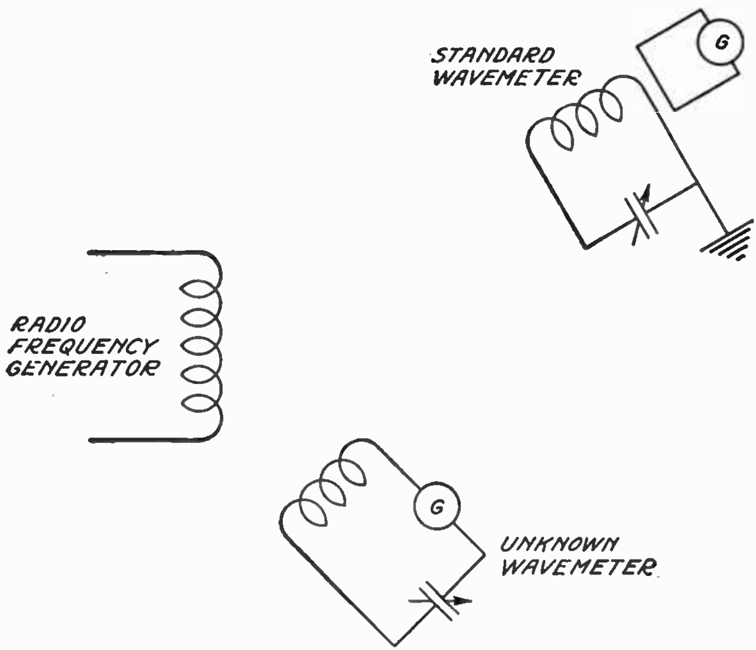
Figure W: To calibrate an unknown wavemeter B, a high-frequency generator A, is used for generating a wave which is accurately measured by the standard wavemeter C. Then the unknown wavemeter B, is tuned to the frequency of the incoming wave and the setting of the instrument checked.

frequency currents reverse the direction of their flow from 16 to 10,000 or 15,000 times a second. It is possible to build a frequency indicator that will respond directly to each alternation up to 500 or 1,000 cycles a second, but beyond that other means for determining the frequency may be employed, such as comparing the audible note produced to that of a known source, such as a tuning fork.

When we consider radio frequency currents we see at once that some other method of determining the extremely rapid alternations is necessary. This is done by employment of the principle of resonance and by taking advantage of the large current which flows in a radio circuit that is in resonance with a "driving" circuit—that is, a circuit that emits waves or impulses of the same frequency.

Wavemeters may be of two types: receiving or transmitting. Both contain an inductance and a capacity. The inductance is usually made up of one or more interchangeable coils of different sizes, and the capacity is a variable air condenser.

The receiving type of wavemeter employs a means for indicating when the maximum current is flowing in the circuit. This is sometimes a visual means (such as a thermal galvanometer of some type, a small battery lamp or a vacuum tube filled with some inert gas



HOW TO CALIBRATE A WAVEMETER BY MEANS OF A HIGH-FREQUENCY GENERATOR

Figure X: Here is a schematic diagram that illustrates the method of calibrating an unknown wavemeter by means of a high-frequency generator and a standard wavemeter as illustrated by the set-up shown in Figure W. Resonance in this case is indicated by a galvanometer in the circuit of the unknown wavemeter.

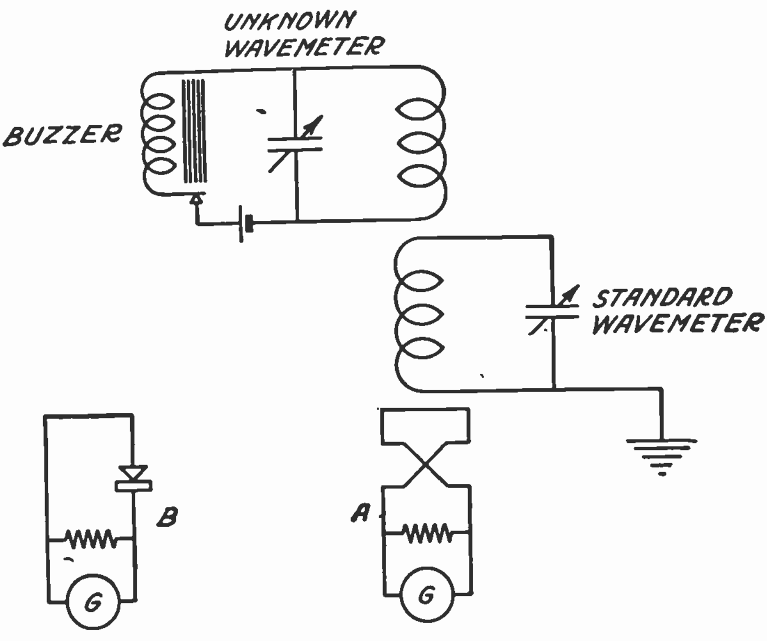
like neon which glows when an electric discharge passes through it), or it may be an audible means, such as a crystal detector and telephone receiver.

The transmitting type of wavemeter usually employs a battery-excited buzzer. The buzzer energizes the wavemeter circuit by impact, and the latter discharges, causing an oscillating current to flow in the wavemeter, the frequency of which is governed by the values of inductance and capacity in the electrical circuit.

There are several methods of connecting the various resonance indicators to the wavemeter; each has its own merits. The purpose of this article, however, is not to discuss the relative merits of the various connections, but to give a general idea of the method of calibrating a wavemeter.

The range of frequencies or wavelengths which a wavemeter will possess can be calculated readily beforehand, but an absolute calibration of the instrument can only be obtained by comparison with a wavemeter which has been calibrated or standardized.

The calibration of a wavemeter should not be considered to be exactly correct without regard to the time when the calibration was made. That this may be assumed was shown by a request received some time ago from a manufacturer of wavemeters, who asked for a copy of the calibration of a certain wavemeter.



HOW TO CALIBRATE A WAVEMETER THAT HAS A UNI-LATERAL CONNECTION

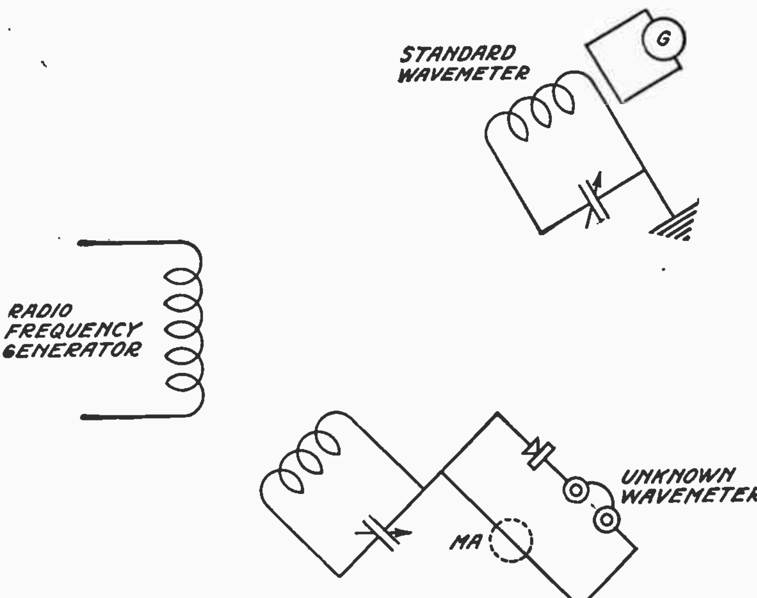
Figure Y: To calibrate an unknown wavemeter employing a uni-lateral connection either a crystal detector may be used or else a milliammeter, as indicated by the dotted circle.

Upon looking up the data for this wavemeter it was found that the calibration had been made six or eight years ago, so that it could not be depended upon after so long a time.

For accuracy, a wavemeter should be checked up at least once a year.

In calibrating a wavemeter the following apparatus is required: a radio frequency generator capable of emitting any desired frequency over the range of wavelengths covered by the wavemeter under test, a standard wavemeter which is calibrated in terms of frequency or wavelength, the wavemeter to be tested, and a sheet of paper upon which to take data.

Five or more points should be selected on the scale of the condenser of the wavemeter under test, at which tests are to be made. In selecting these points the extremes of the scale should be avoided. The lower ten degrees on the scale should not be used (except in extreme cases to obtain an overlap between two coils). This lower portion is avoided because of the small capacity in the wavemeter circuit in this region and the proportionally larger liability of introducing errors by reason of the proximity of other objects. The upper limit of the scale should be avoided because of the chance of error in the resulting calibration curve in case the scale is not set exactly correct with respect to the condenser plates.



HOW TO CALIBRATE A WAVEMETER THAT EMPLOYS BUZZER EXCITATION

Figure Z: In this case no external generator is necessary. The standard wavemeter is moved up close to the generator; sometimes extremely close proximity is necessary on account of the small amount of energy emitted by the buzzer. The settings on the scales of the two instruments are then compared and the unknown meter is corrected to correspond to the standard.

In starting the calibration, the condenser of the wavemeter to be tested is set at the first point and the radio frequency generator is varied until resonance is indicated by the indicating instrument of the wavemeter. The condenser of the latter should then be varied slightly in each direction to determine whether true resonance has been obtained.

At times it is possible to appear to have reached the resonance point by tuning the generator to the wavemeter but if the wavemeter condenser is varied somewhat it may be found that resonance is obtained somewhat away from the desired point. This may be caused by a reaction of the wavemeter upon the generator owing to too close coupling between the two, or it may be due to the capacity existing between the wavemeter and the operator's body. If a wavemeter is properly shielded this latter difficulty will not be observed, except perhaps near the minimum setting of the condenser.

A wavemeter, whether used for measurement purposes or in calibrating, should be coupled as loosely as possible to the source of power. If the wavemeter is coupled too closely to the generator it will react upon the generator.

Pacific and Atlantic

A "PRECISION WAVEMETER"

Figure AA: The Bureau of Standards has done some wonderful development work in designing and constructing standards of measurement. These standards include instruments for exact measurement of length, weight, velocity, pitch, and intensity in practically all fields where measurement can be made.

This condition is more likely to occur on coils of large inductance which have a large distributed capacity and a high resistance. It may be observed on the wavemeter by obtaining two *apparent* resonance points, by turning the condenser in opposite directions. These two points may be a fraction of a degree to several degrees apart. The only thing to be done in such cases is to move the wavemeter away from the generator (loosen the coupling) until but one point is observed.

Another reason for keeping the coupling fairly loose when calibrating the wavemeter is because the power that exists in harmonics of the fundamental frequency may be picked up instead of the fundamental frequency. A radio frequency generator does not have its entire power output at one frequency; it is distributed upon several frequencies which bear certain relations to the fundamental frequency or that obtained from calculations of the inductance and capacity in the circuit. The fundamental frequency has the greater part of the power, but the harmonics may have sufficient power to operate a sensitive detector. Usually no difficulty is experienced from tuning to harmonics when a hot-wire ammeter or thermogalvanometer is used as the resonance indicator.

After the generator is accurately tuned to the wavemeter at the point desired, the wavemeter is detuned and moved away from the generator and the standard wavemeter is brought up and tuned to the generator. The condenser setting of the standard wavemeter is then read and is entered on the data sheet opposite the proper condenser setting of the wavemeter under test. The identification numbers of all apparatus used should be kept so that errors will be avoided in computing results.

The standard wavemeter is next detuned and moved away from the generator and the first one brought up and the generator tuned to the second point. All points throughout the series of coils are obtained in a similar manner. After the first complete test is finished it is repeated and the average of the two values for a given point is taken, unless there is too much of a difference between the values. In such a case a third reading is taken at the doubtful point, and it is likely that two of the three readings will agree sufficiently well. Errors in measurement or calculation are sometimes apparent when the calibration curve is drawn, because one or more points fail to lie on a smooth curve joining the majority of the determined points. The frequency or wavelength for other settings of the condenser than those at which tests are made can be obtained by reference to the calibration curve.

The calibration of a wavemeter that uses a crystal detector and telephone receivers as a resonance indicator is made in the same manner. If an electron tube radio frequency generator is used, undamped waves are produced and a means of modulation must be provided to produce a response in the telephone receivers, such as applying an alternating potential to the grid circuit of the generator. It will often be found that the resonance point is quite broad and that it is difficult to determine the exact point of resonance. Sometimes when the unilateral connection of the detector and telephone receivers is used a sensitive direct current milliammeter may be connected in the circuit (as shown by the dotted circle in Fig. Z) without appreciably altering the resonance point. Then it is possible to obtain a sharp indication of resonance.

Before this method is used, the wavemeter should be tried out both ways to determine if the probable error in using the milliammeter is negligible. If the difference in resonance points by the two methods is significant, the milliammeter should *not* be used.

When calibrating a buzzer-excited wavemeter, the condenser of the latter is set at the desired point and the buzzer started. The standard wavemeter is brought up and tuned to resonance with the buzzer wavemeter. Difficulties are often encountered here owing to the extremely small amount of power emitted by the buzzer wavemeter. Extremely close coupling between the two wavemeters is often necessary. The resonance indicator of the standard wavemeter may be a thermo-element instrument of the crossed-wire type, with a couple of turns of wire connected to two terminals and coupled to the inductance coil of the standard wavemeter, and the other two terminals connected to a galvanometer, as shown at (a) in Fig. Y.

Another indicator that is suitable consists of a coil of a couple of turns, a sensitive crystal detector and a wall galvanometer, all connected in series as shown at (b) in Fig. Y.

Thus it is evident that in calibrating a wavemeter, whether of the receiving or the transmitting type, it is necessary to have a radio frequency current with a frequency or wavelength that corresponds to that of the wavemeter under test for the particular setting under consideration. This frequency will be determined by means of the resonance indicator of the calibrated wavemeter.

Wavemeters should be checked up with an accurately calibrated wavemeter at least once a year to be certain that the calibration has not changed.

One of the most important problems

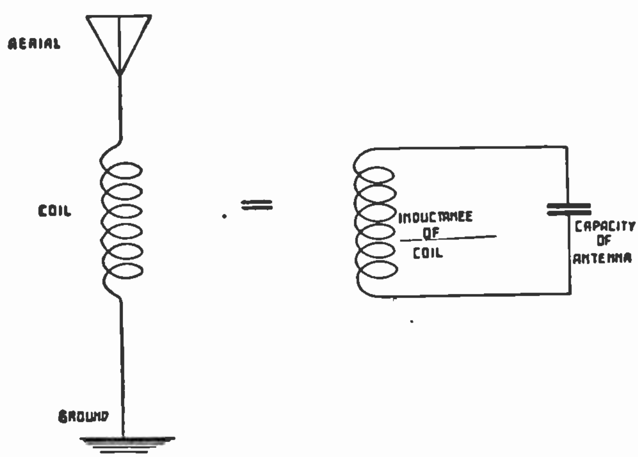
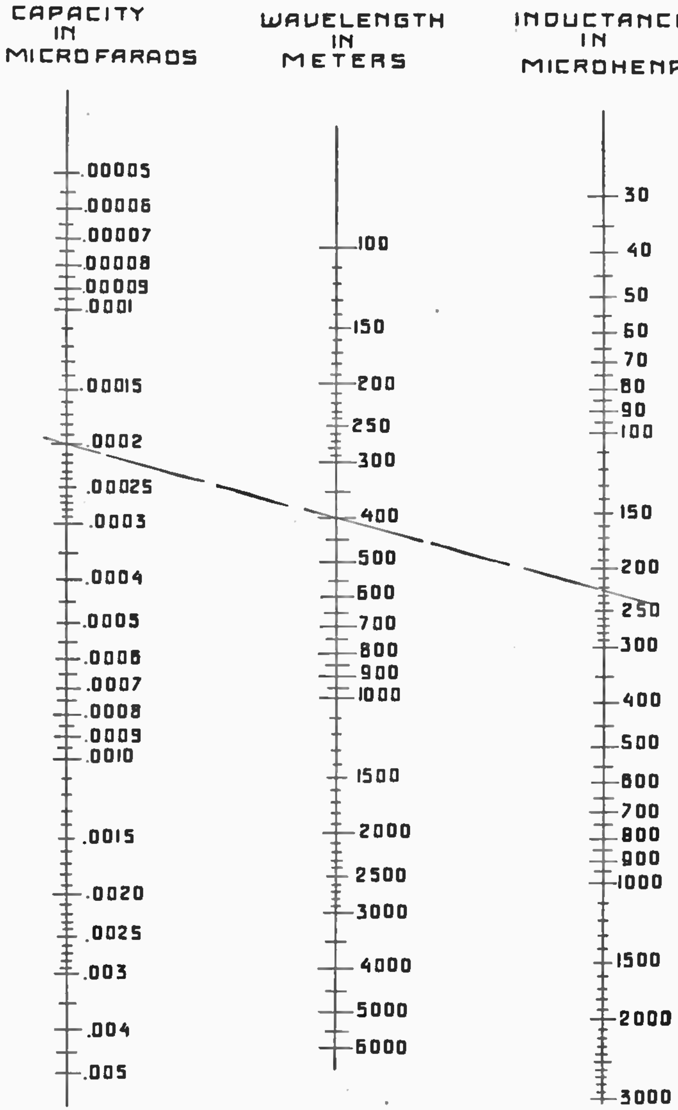


FIGURE BB

Calculations for an antenna circuit with a coil in series resolve themselves into a simple formula for wavelength of a coil with a condenser shunted across it. The condenser in this case represents the capacity between the antenna and the ground.



A CHART FOR DETERMINING THE CONSTANTS FOR YOUR SET

Figure CC: By merely laying his ruler across this chart (in the manner indicated by the diagonal line) the practical amateur may calculate the proper sizes for the condensers and the inductances of the set he proposes to build for use with a certain wavelength range. He need know little or no mathematics; the chart solves the difficult and intricate problems involved. The amateur has only to read from the chart this answer to his particular problem.

to confront the amateur who designs his own radio set is how to calculate the correct sizes of the inductances and the condensers for the various parts of a radio circuit for a given wavelength.

There are several mathematical formulas for determining these "constants" as they are called. But these formulas are usually so complicated that they are not much used by the ordinary amateur.

Most amateurs who design their sets resort to the "cut and try" system; that is, they wind a temporary coil with taps, connect it in the circuit, find the correct tap and then build a permanent coil with a corresponding number of turns on it. Sometimes they build a number of coils and try them all out in order to find the best size to use.

Fairly good results are often obtained in this way, but this method is obviously unscientific. It entails a waste of time, energy and money. It is better and more practical to use standard formulæ that will give the correct sizes for all parts to be built; further, these standard formulæ enable the builder to design his set on paper and then build it according to the recorded specifications; in that way he will know in advance just what the results will be.

For the benefit of the average amateur some of these standard formulæ have been simplified and are represented here in the form of "alignment charts."

These charts offer the most convenient possible way of solving equations which have three or four variables. They make it possible for the ordinary radio fan to use the charts without the aid of anything more than common sense and a ruler.

The prime problem to be dealt with in radio is that of "resonance" in the different circuits. In order to have resonance in a circuit, or in other words, in order to tune a circuit to any particular wavelength, the circuit must contain inductance in the form of a coil, and capacity in the form of a condenser. A certain value of inductance and a certain value of capacity together in a circuit give it a certain wavelength; unless either or both of these values are varied, the circuit will absorb energy of no other wavelength.

The basic formula for the wavelength (W. L.) follows the equation:

$$\text{W.L.} = 1884 \sqrt{\text{LXC}} \quad \ldots\ldots\ldots 1$$

wherein L is the inductance in microhenries and C the capacity in microfarads. The above formula is shown in chart form in Fig. CC.

In order to illustrate the method of using this chart, let us take the following problem: In Fig. BB we have a coil connected in an antenna circuit. This circuit is equivalent to a coil with a condenser connected across it—the condenser in this case being the capacity between the antenna and ground.

The example is this:

To find the proper value of inductance for this coil when used in an antenna circuit that has a capacity of .0002 microfarads, in order to tune up to 400 meters. With a ruler on the chart in Fig. CC, connect the value of capacity (.0002 mfd.) on scale 1, with the wavelength desired (400 meters) on scale 2. The answer will be found at the intersection on scale 3; it is 225 microhenries.

This same example applies to calculations for a secondary circuit in which the capacity will be the variable condenser connected across the coil.

To calculate a circuit that has two capacities (as shown in Fig. BB), we find first the resulting capacity which will follow the relation:

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} \quad \ldots\ldots\ldots\ldots 2$$

wherein c_1, c_2 are the capacities connected in series and c is the resulting capacity. This formula is plotted on a chart shown in Fig. DD.

Let us take another example:

Find the correct value of inductance to use in a circuit shown in Fig. EE in which a condenser is placed in series with the antenna circuit, the antenna having a capacity of .00025 mfd. and the condenser a capacity of .001 mfd. to tune to 400 meters.

The first step is to find the resulting capacity of the two condensers with the aid of the chart in Fig. DD. Connect .001 on scale No. 1 with .0025 on scale No. 2 by a straight line and read at the intersection with scale No. 3 the resulting capacity of .0002 mfd. Having a capacity of .0002 mfd. and a desired wavelength of 400 meters, we find that we will need an inductance of 225 microhenries, as found in the first example we have given.

The chart shown in Fig. CC may also be used to find the wavelength, when the capacity and inductance are known, or to find the capacity when the inductance and wavelength are known. The general rule is this: Connect two known values on any two scales and the unknown will be found where the line crosses on the remaining scale.

The amateur is advised to keep these charts for reference, to be used along with additional charts on the design of coils necessary to get a certain value of inductance, and also with charts that will calculate the capacity of an antenna.

By the use of these charts the amateur may design his set with a definite knowledge of what wavelength range to expect when his set is finally put together and connected up.

When the amateur has finally decided what range of wavelengths he desires to cover in his proposed transmitting or receiving set, and when he has determined the correct electrical constants for the coils which will cover this range, the next step is to construct the coils that will have these constants.

In other words, if the amateur wants to tune to a wavelength of 400 meters and he has an antenna with a capacity of approximately .0002 mfd., his primary coil should have an inductance of 225 microhenries. The question now is: "What size of coil will I make that will give me this value of inductance?"

Of course the answer can be figured out mathematically by an engineer, but the average radio fan would find himself in water too deep for him if he should try to do it himself.

However, the simple alignment charts that accompany this matter have been prepared so that even the novice will find the answer to his problem in a few seconds. These charts are based on mathematical formulas, but all the reader must know is how to draw a straight line and how to read figures.

For the benefit of the more experienced amateur who understands something of mathematics, we will show how the alignment charts for inductance and design of a coil were evolved.

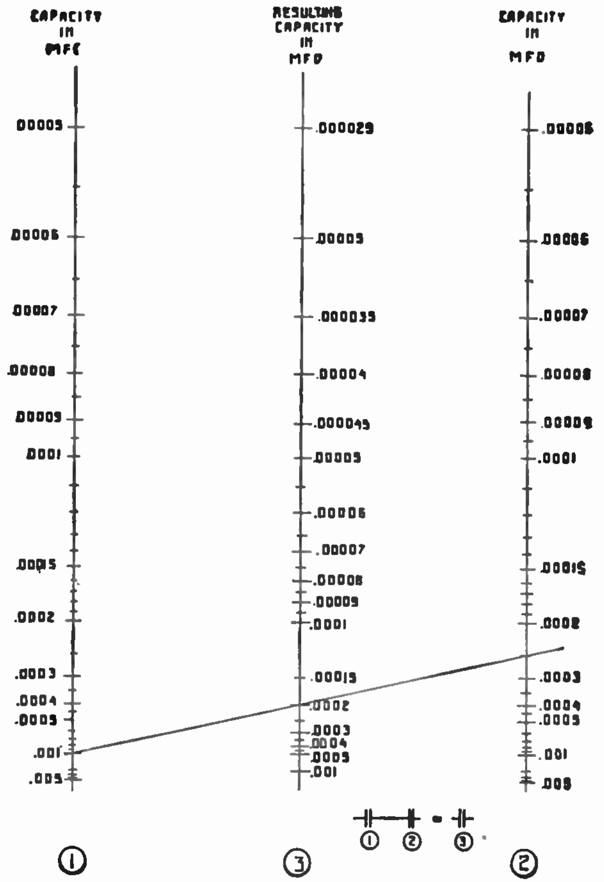
The formula for inductance of a coil follows the equation:

$$L = 4\pi^2 \left(\tfrac{d}{2}\right)^2 n^2 l K \ldots\ldots\ldots\ldots 1$$

wherein

L = the inductance required.
d = the diameter of the coil in centimeters.
l = the length of the coil in centimeters.
n = the number of turns per centimeter.
and k = a constant depending on the ratio d/l

As the correction factor k depends on the relation of the diameter and the



A CHART FOR CALCULATING THE CAPACITY OF CONDENSERS IN SERIES

Figure DD: The capacity of two condensers connected in parallel may be easily found by adding the capacities of each of the condensers together, which will give the capacity of the whole. But to determine the capacity of condensers in series is a more complicated matter. This chart indicates the answer to this problem; by laying a ruler across, as indicated by the diagonal line, calculations may be made.

length of the coil, we cannot, by means of the above formula, calculate directly the dimensions of a coil assuming the other three variables.

Therefore, in order to make the equation No. 1 available for a simple alignment chart, we will have to eliminate the coefficient k. We plot the correction factor against the ratio d /1 on a sheet of logarithmic cross-section paper and substitute a straight line for the curve. By so doing we eliminate this troublesome feature of the formula, with results which will not differ perceptibly from the original values, within the practical limits of a coil design.

The equation for a straight line on logarithmic paper has the form:

$$y = cx^n \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

where y and x are variables and c and n are constants.

One of the most important, but extremely uncertain, of calculations in radio engineering and design is the determination of the constants of the antenna system.

Under the term "antenna system" we understand the total construction outside of the set, connected to it in order to transmit to or receive signals from a distant radio station. These include the antenna proper, grounds, fire-escapes, bedsprings, or any other aerial system used to radiate or collect energy.

Previously, we showed that for a certain wavelength we require a certain amount of capacity and a certain amount of inductance. To use the first

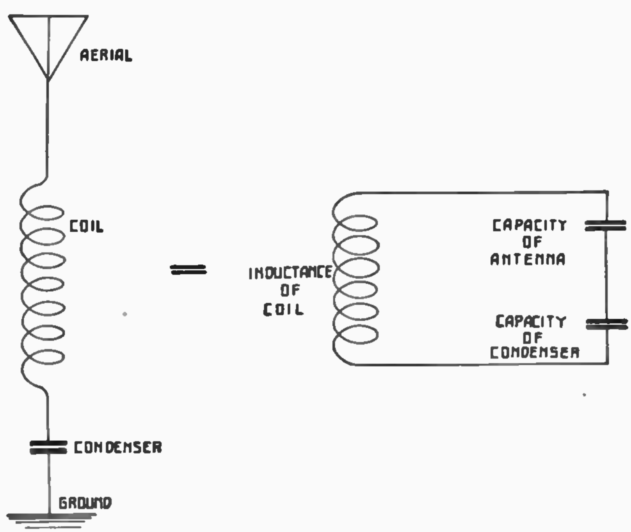


FIGURE EE

To calculate an antenna circuit with a coil and a condenser in series resolves itself into a formula for a coil with two condensers in series with it. One of these capacities is the condenser and the other is that between the antenna and the ground. These are added together by means of the chart in Figure DD.

Figure FF: Lay your ruler across the alignment chart, as described in this article—and read off at a glance the answer to your problems in calculations.

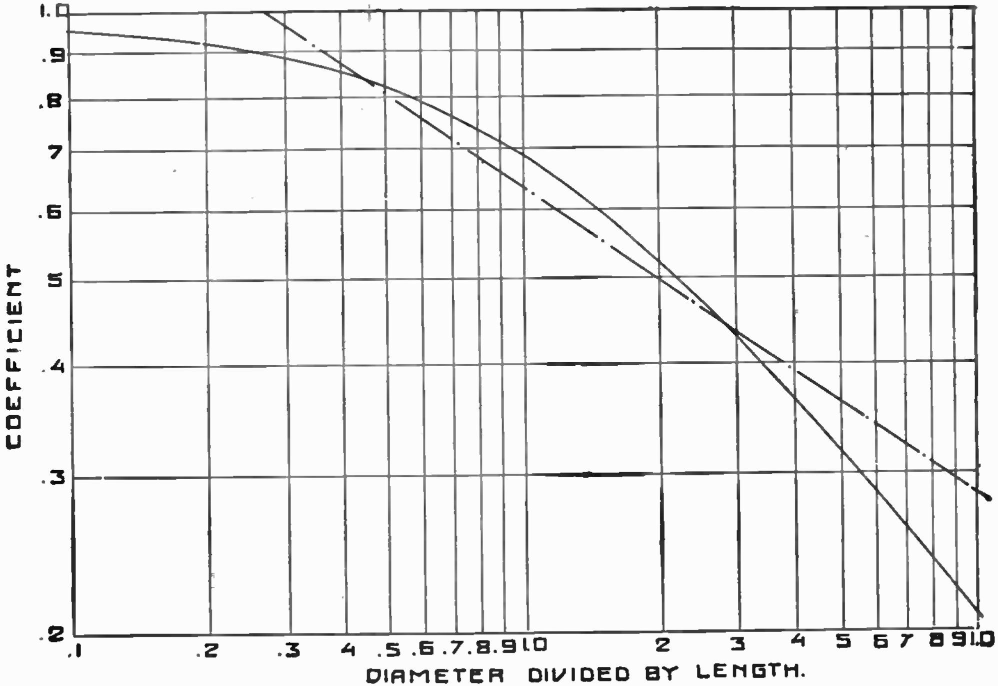
two charts, however, we were required to know the amount of capacity incorporated in the design of our antenna, in order to calculate the correct coil to use with our antenna for a given wavelength.

In this matter, then, we are introducing a chart that gives us the capacity of our antenna, with the requisite amount of accuracy to calculate the proper inductance for the coil to use with it.

To take advantage of simplicity, without deviating from accuracy—and the practical radio engineer always welcomes simplicity—we will neglect the inductance of the antenna, as it is small in comparison with the inductance of the coil to be used with it. This will not materially affect our calculations.

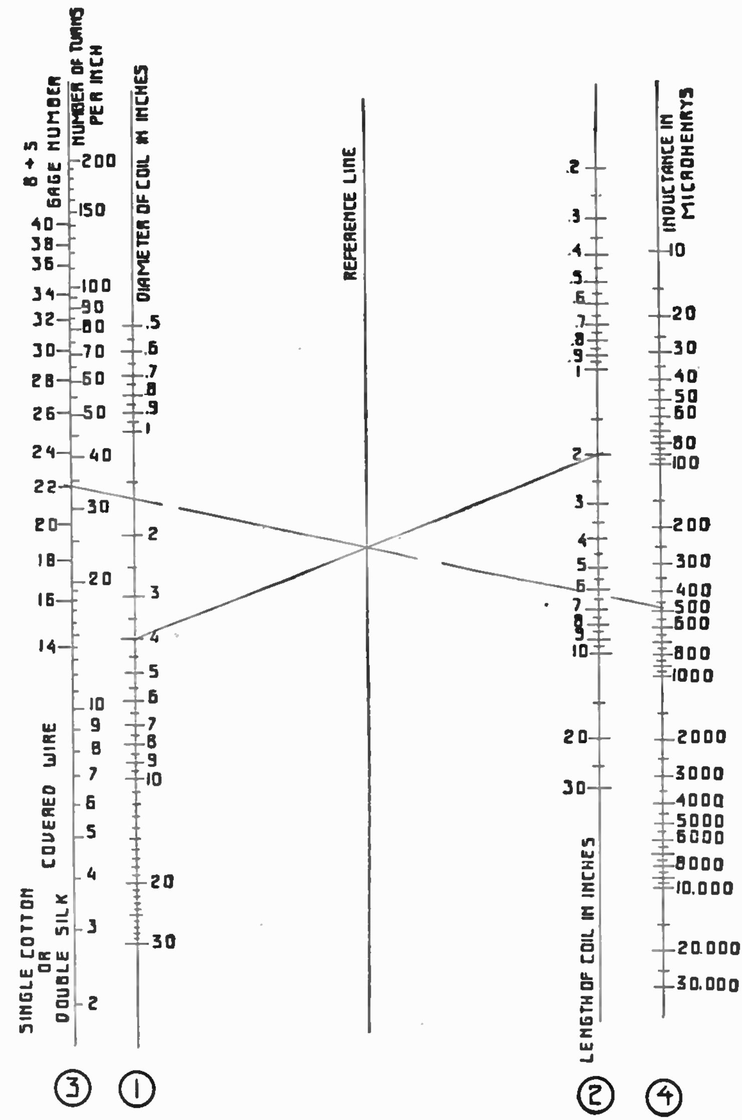
The chart Fig. JJ for calculating the capacity and fundamental wavelength of our antenna system is derived from data obtained from many experimental tests and laboratory experiments on vertical and horizontal antennas.

We will readily see by trying a few calculations on imaginary antennæ (with the aid of the chart) that the longer and wider (or the more wires used) our antenna is constructed, the



A STEP IN THE PREPARATION OF THE CHART

Figure GG: In this diagram we have the correction factor k, plotted against the ratio d—l, which is shown in the form of a curve. In order to eliminate the factor k from the formula used in the charts, this curve has been replaced by a straight line with results that do not differ perceptibly from the original, values in the original curve.



USE YOUR RULER ON THIS CHART—
Figure HH: As described in the accompanying text—to learn the exact dimensions of the coil you need.

more capacity it will have, and the higher up it is suspended the less capacity it will have.

The chart has five scales.

Scale No. 1 indicates the effective length of the antenna (figuring the full length of the horizontal part and half the length of the vertical part.)

Scale No. 2 contains the width of the antenna; (it also indicates the imaginary width to use for the single wire antenna). When more than one wire is used, the width will be the distance between the outer wires. The wires should be spaced not closer than two feet and not farther apart than four feet in order to be effective.

Scale No. 3 indicates the value of the effective height from the ground.

Scale No. 4 gives the resultant capacity in microfarads.

Scale No. 5 gives the approximate natural fundamental wavelength of the antenna, which corresponds to the values on the Scale No. 1, and in accordance with the standard formula:

$\lambda = 1.38\,l$

wherein λ = the natural wavelength of the antenna in meters,
and l = the length of the antenna in feet.

Let us work out the following example in order to understand clearly how to use the chart:

We have an antenna with a 45-foot horizontal, single-wire stretch, a 40-foot vertical lead-in, and a 10-foot ground connection.

Taking the full amount for the horizontal wire (45 feet) and half the amount for the vertical part

$$\frac{(40 + 10)}{2} = 25 \text{ ft.}$$

We will have an effective length of $(45 + 25) = 70$ feet.

Connecting 70 on scale No. 1 with the mark "single wire" on Scale No. 2, and then connecting the point of intersection (of this line we have drawn with the reference line) with the effective height of the antenna $(40 + 10) = 50$ feet, on Scale No. 3, we may read the resulting capacity of the antenna on Scale No. 4.

The approximate natural wavelength of this antenna would be about 97 meters.

In these days of modern radio when the multi-stage radio frequency amplifier, the super-heterodyne receiver, the super-regenerative receiver, and the various reflex circuit receivers have been coming into more or less general use, the loop antenna for receiving has been brought more into prominence.

The three outstanding advantages of the loop type antenna—its directional effect, the simplicity of tuning and the absence of the troublesome and bulky outdoor antenna—are important to the city fan who is interested in receiving only.

There are several standard receiving sets now being placed upon the market that incorporate the loop antenna. However, there are many people who make their own sets, and who are experimenting with radio frequency amplification who have occasion to design and build their own loop antennas.

And the question "How many turns of wire shall I wind on the loop" is not often answered correctly.

For their benefit we have prepared this chart, that tells exactly how many turns of wire to use for a given wavelength range. A loop antenna is almost universally tuned by placing it in shunt to a good variable condenser and this is all that is necessary in the way of tuning.

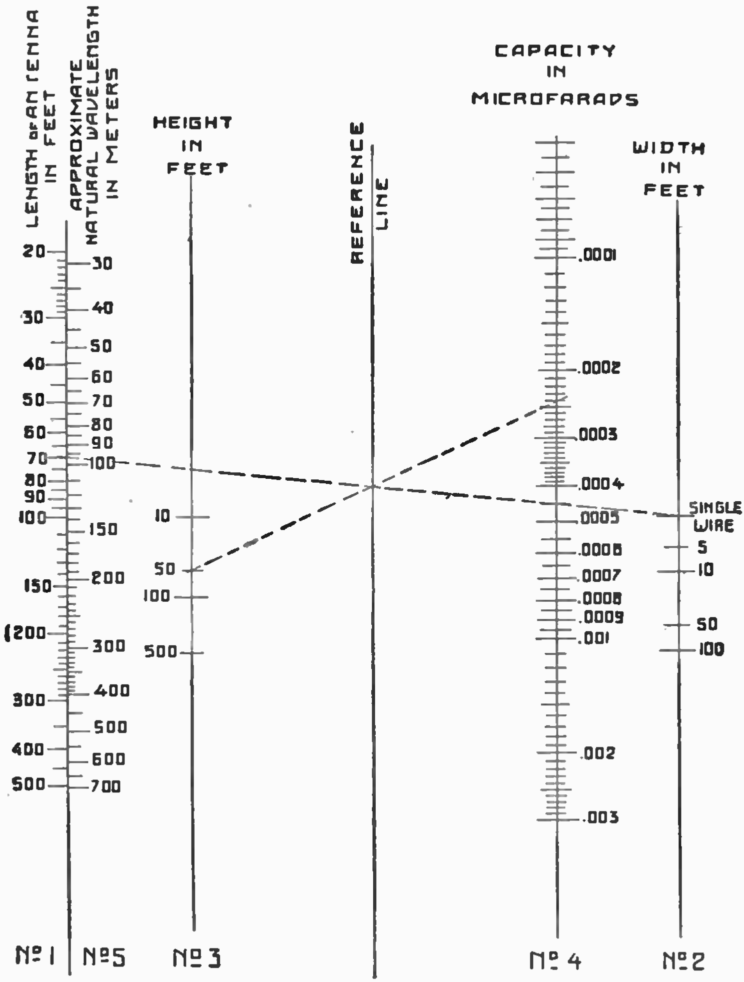
First of all, the wavelength range should be decided upon.

Then the size of variable condenser should be chosen for use with the loop.

With these two points determined the prospective builder may easily calculate

KNOW THE CAPACITY OF YOUR AERIAL!

Figure II: Everyone who uses either a receiving or transmitting set employs an antenna of some kind, and the value of his set is largely dependent upon the efficiency of it.



HOW TO USE THE CHART FOR DETERMINING THE CAPACITY OF YOUR ANTENNA

Figure JJ: With a ruler, connect the effective length of your antenna (scale No. 1) with the width of the antenna (scale No. 2). Then connect the effective height of the antenna (scale No. 3) with the intersection of the first line and the reference line. Carry the line out over scale No. 4—which will indicate the capacity of the antenna.

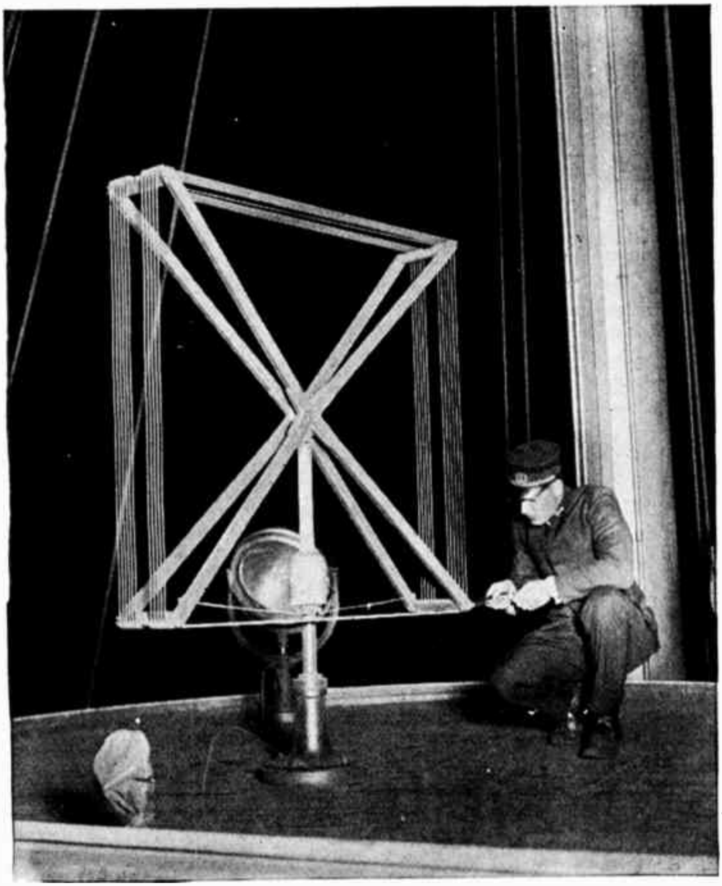
the necessary inductance which must be used in the loop to cover the wavelength range chosen. A previous chart tells you how to do this.

When this inductance is known, you may then use the chart in the present instruction, for calculating the correct number of turns of wire to use to give the required inductance value.

The accompanying chart (Fig. LL) is based on the square form of loop, on which the wires are spaced ½ an inch apart.

This form of loop should not be mistaken for the spiral loop.

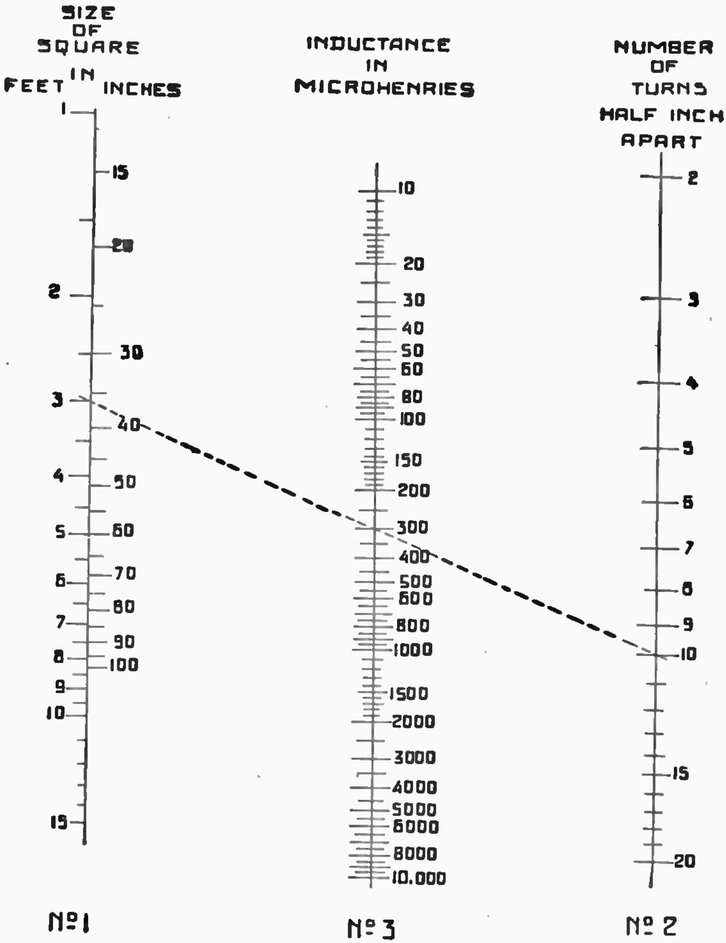
When you use the chart, connect values on scale No. 1, with values on scale No. 3, with a ruler and read the number of turns required on scale No. 2.



Kadel & Herbert

A LOOP ANTENNA INSURES HIGH SELECTIVITY

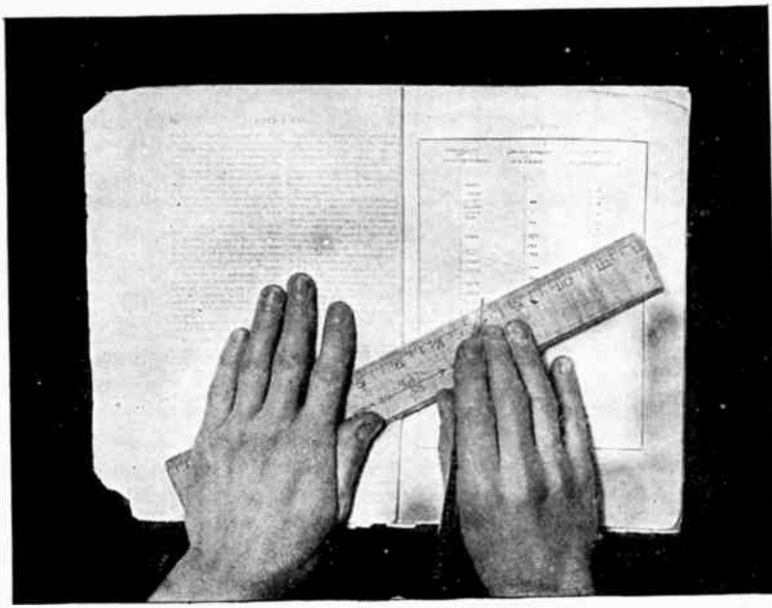
Figure KK: When used with supersensitive amplifying systems it is a valuable aid in doing away with static and interference. The loop shown here is located on the deck of a Navy compass station.



HOW TO USE THE CHART

Figure LL: Problem: If you should want to build a loop antenna that would have a dimension of three feet to a side, and you wanted to incorporate in the loop enough turns of wire to give an inductance of 300 microhenries, how many turns would you wind on it?

Solution: First, connect the value 3 on scale No. 1, with the value 300 on scale No. 3, with a ruler, and carry the line out over scale No. 2. Then observe the value on scale No. 2 where the line crosses the scale—which value would be the correct number of turns of wire to use.



ALL YOU NEED IS A RULER, A PENCIL AND A PAIR OF HANDS

Figure MM: By means of the table on page 59 the amateur who builds his own apparatus may calculate in an instant the design for a condenser that will have a pre-determined capacity, or find out the capacity of a condenser that is already built.

Example:

To build a loop on a square form, 3 feet on each side, with the wires spaced ½ inch apart to have a total inductance value of 300 microhenries. How many turns of wire should be used?

With a ruler, connect the size of the loop (3 feet), on scale No. 1, with the desired inductance value (300 microhenries) on scale No. 3. If this line, connecting the two points is extended over to scale No. 2 it will cross at the correct number of turns (10 turns).

Alternating current may be transformed from one voltage to another by the use of a transformer that consists of a primary and secondary winding wound on an iron core.

The transformers are used to "step up" or to "step down" the voltage of the current.

The "step up" transformer may be used for the CW (continuous wave) transmitting stations; the "step down" transformer may be used for supplying low-voltage current for charging storage batteries. Some form of rectifier must be used in the latter case.

The fundamental formula for the transformer is

$$E = 4.44\, f\, F_m\, n100{,}000{,}000.$$

Where E = the effective value of the impressed voltage.

f = the frequency.

F_m = the maximum value of the magnetic flux.

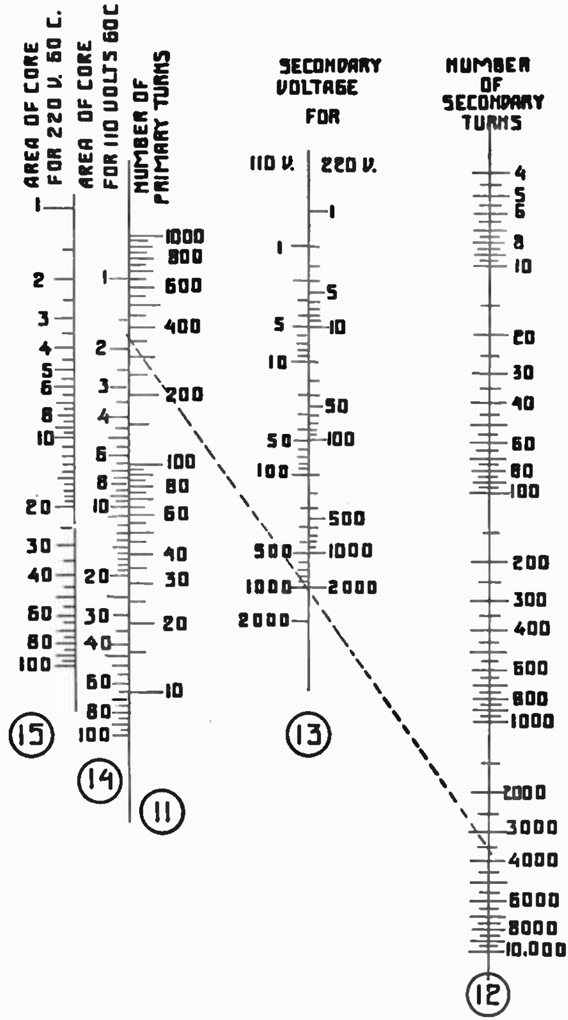
and n = the number of the primary turns.

The magnetic flux is

$F_m = A.\, df$ 2

where A = the area of the cross-section (½ square inch for ½ KW, 1 square inch for 1 KW).

df_a = suitable flux density per square inch to be assumed as 60,000.



THE TRANSFORMER CHART

Figure NN: This mathematical chart enables you to calculate the proper design for your transformer for alternating current work. How to use the chart is fully described in the text.

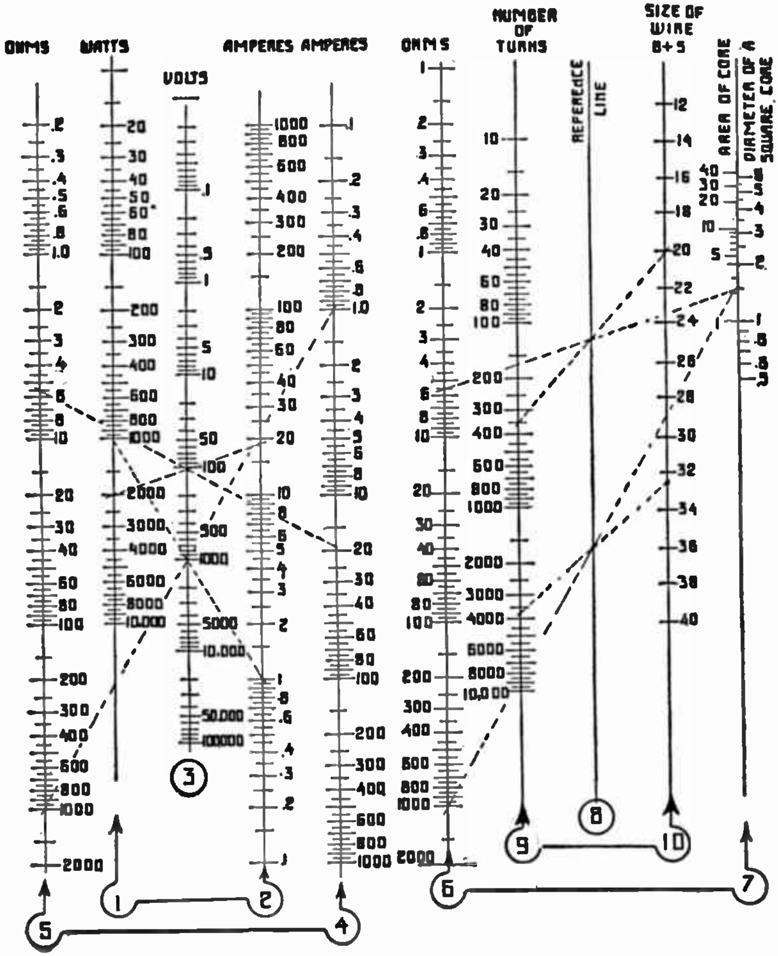

OHMS
WATTS
VOLTS
AMPERES
AMPERES
OHMS
NUMBER OF TURNS
REFERENCE LINE
SIZE OF WIRE B+S
AREA OF CORE
DIAMETER OF A SQUARE CORE

FIGURE OO

From equation (1) and (2) and assuming a frequency of 60, we will have the number of primary turns:

$P_n = 6.3$ Volts/Core Area........3

The efficiency in a well-designed transformer is very high, but for simplicity we will assume a 50 percent efficiency, so that a rheostat can be connected in series with the primary.

The ratio of the secondary voltage and the primary voltage is equal to the ratio of the number of the secondary turns and the primary turns.

In order to simplify the above mathematical operations and the evaluations of the equations, a chart has been substituted and is here illustrated with the aid of an example:

The example is to design a transformer having a 1,000-watt input from a lighting current of 110 volts, 60 cycles, an output of 1,000 volts, at 50 percent efficiency. The area of the core is assumed to be 2 square inches. The current to be calculated for the primary will be then 2,000 watts.

Connect 2,000 on scale No. 1 (Fig. OO) with 110 on scale No. 3 and read at the intersection with scale No. 2 the resulting 18 amperes; then connect 18 on scale No. 4 with 110 on scale No. 3. You will find the line intersecting scale No. 5 at 5.5 ohms which will be the maximum resistance in the primary circuit.

Looking at scale No. 14 (Fig. NN), we find the cross-section of 2 square inches connected with 350 on scale 11, which is the number of the primary turns.

Connect 5.5 on scale No. 6 with 2 on scale No. 7, then connect the intersecting point on the reference line No. 8 with 350 on scale No. 9. We find the line intersecting scale No. 10 at 20 which is the minimum thickness of the wire in B & S gauge to prevent overheating. We can take No. 14 to 16 wire.

The secondary unit will give us 1,000 watts with a voltage of 1,000. Connect 350 on scale No. 14 with 1,000 on scale No. 13; the line will intersect the scale No. 12 at 3,700 which is the number of the secondary turns. Connect 1,000 on scale No. 1 with 1,000 on scale No. 3; (Fig. NN) the line will intersect scale No. 2 on 1; then connect 1 on scale No. 4 with 1,000 on scale No. 3. We find the line intersecting the scale No. 5 at 1,000 which is the resistance permissible in the secondary circuit.

Connecting 2 on scale No. 7 with 1,000 on scale No. 6, the line will intersect the reference line No. 8; this intersecting point connected with 3,700 on scale No. 9 gives us the required wire, No. 33 B & S gauge on scale No. 10. For efficiency a wire of No. 34 to 36 could safely be employed.

For 220 volts read values on scale No. 15, but take point of calculation across to scale No. 14.

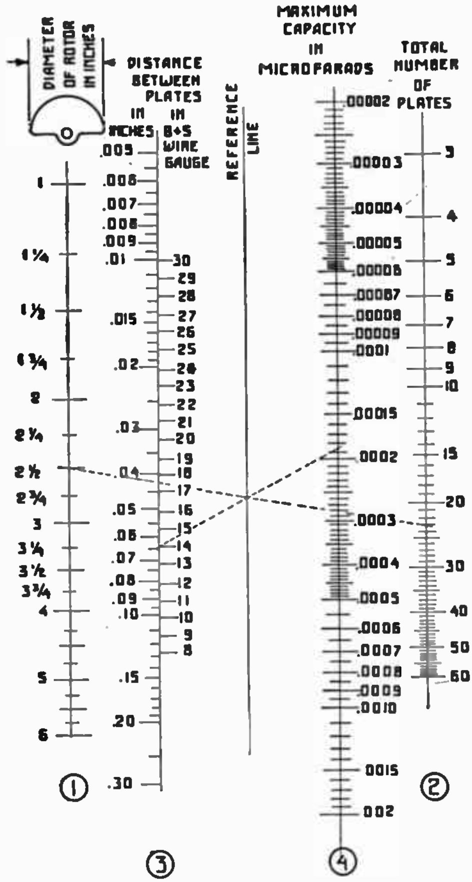
Previously we have given the calculation of a fixed condenser which follows the equation:

$$C = .0000002248\ A\ K/d$$

where C is the capacity in microfarads, A the area of the effective plates in square inches, D the distance between the plates and K the dielectric constant, which in our case—for air—will be 1.

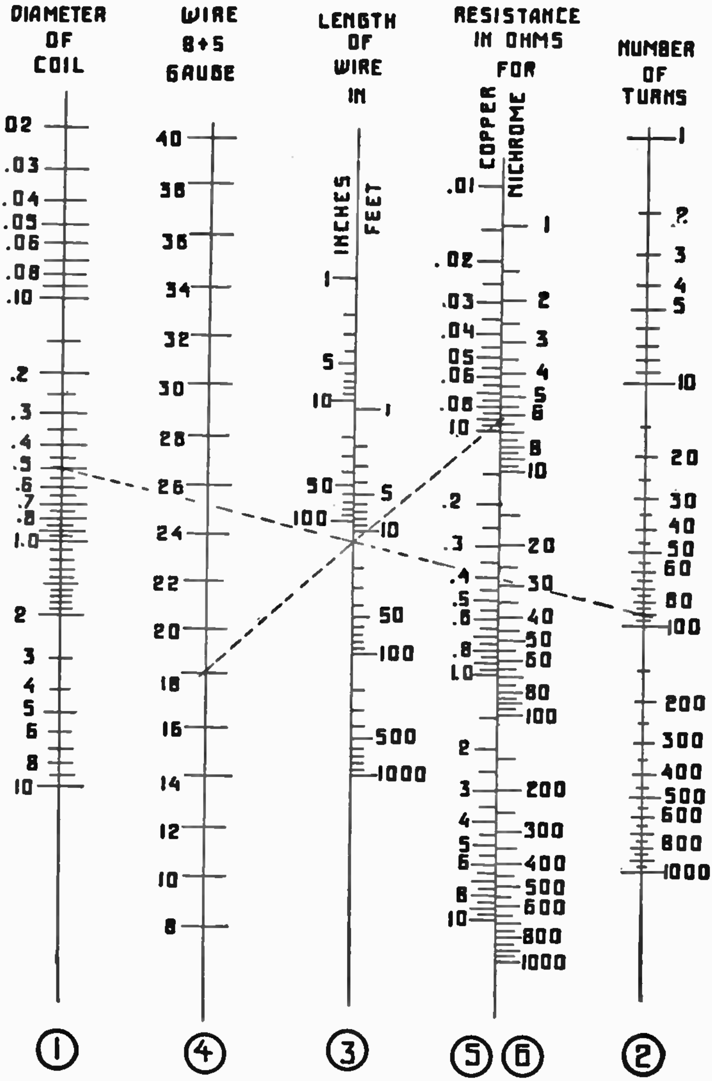
The area of the plates will be very closely figured by taking the area of one rotor plate and multiplying by the number of the plates *less one*, as the capacity effect is accomplished *between* adjacent plates. From an economical standpoint mostly, an odd number of plates is used.

The thickness of the plates is measured with a sheet-metal gauge, the space between the plates may be measured by using various thicknesses of blank wire; the heaviest wire which could be placed



THIS CHART WILL HELP SOLVE YOUR CONDENSER PROBLEMS

Figure PP: This diagrammatic drawing will give you, at a moment's notice, the maximum capacity of any make of variable condenser, whether it contains 11, 17, 23, 26, or 43 plates. It does not matter whether the condenser has a spacing between plates of anywhere between .005 to .3 inch, the chart will tell you the capacity. This is important in buying a new condenser for a given circuit where a given capacity is necessary.



HOW THE RESISTANCE CHART IS USED

Figure QQ: You must first determine the diameter of the coil upon which you are to wind the resistance wire. Then you should decide what size of wire you want to use. The chart will give you the resistance of the wire and the number of turns you should wind on to get any specified resistance.

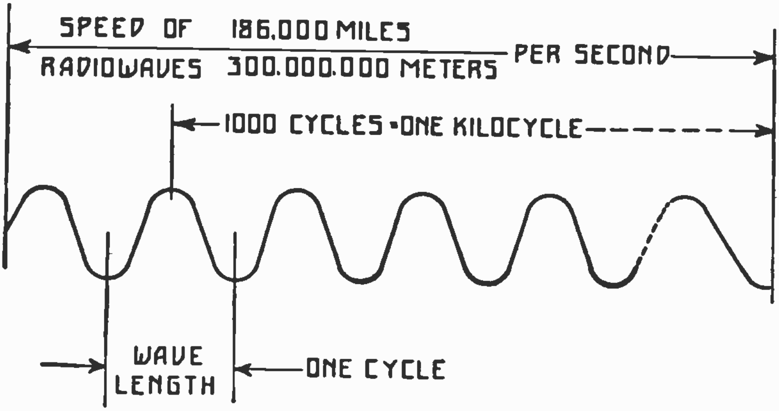


Figure RR: A simple chart that shows the relation between wavelength and frequency. The distance from crest to crest is the wavelength; this corresponds to one cycle, or a complete reversal of the alternating current that produces the wave.

between the plates will be taken as to be equal to the distance between the plates.

Another close method could be used with simplicity to measure the distance between plates by cutting small strips from the middle page of this course and placing them between the plates, multiplying the maximum number thus obtained by .003″ (which is the thickness of the paper), resulting in the distance in inches.

Knowing the distance between the plates and the diameter of the rotor will be sufficient to calculate the maximum capacity of the condenser with the aid of the accompanying chart, Fig. PP.

For example: a condenser has a rotor diameter of 2½ inches, 21 plates and a distance of No. 18 gauge wire between the plates. Connect 2½ on scale No. 1 with 21 on scale No. 2, intersecting at the reference line; then connect the intersection with 14 on scale No. 3 and read the maximum capacity of .00017 microfarads on scale No. 4.

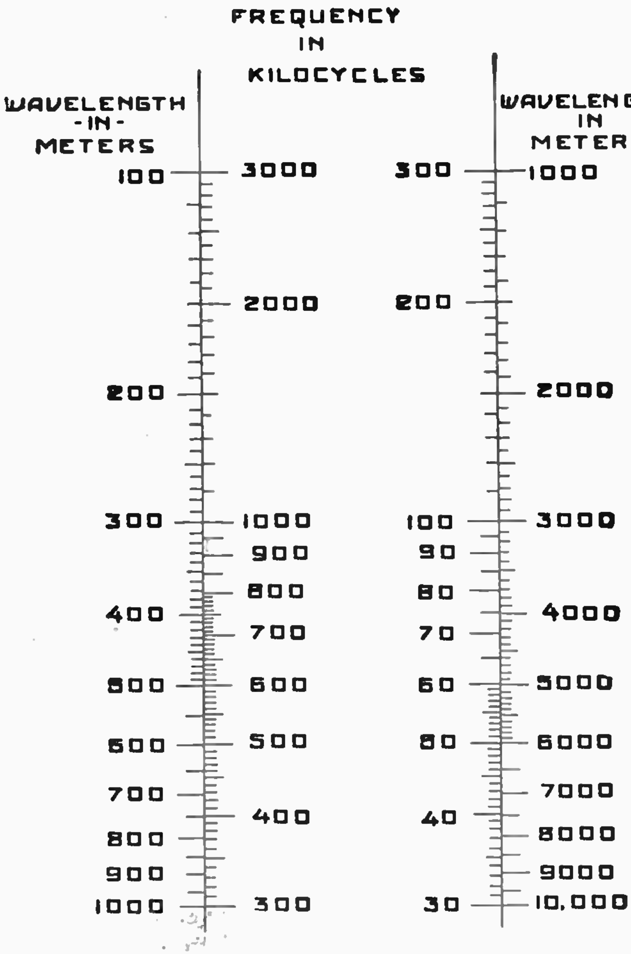
Materials used for transmission and distribution of electric energy are conductors which have a certain resistance. This resistance is measured in ohms. The resistance of a wire is inversely proportional to the cross-section of the wire; that is, the thinner the wire, the higher is the resistance.

The standard thicknesses for wires, in electrical engineering, follows the B. & S. wire gauge and most handbooks have reference tables for the resistance of a standard length of wire.

Copper has almost the lowest resistance of any of the conductive materials. Assuming the resistance for copper as a unit, we can find the resistance for various materials by multiplying the resistance of copper by the following figures, if the same length and thickness is taken:

Silver	by	.94
Copper	"	1.00
Aluminum	"	1.7
German Silver	by about	20
Monel Metal	by	26
Mercury (quicksilver)	"	53
Nichrome Alloy	"	68

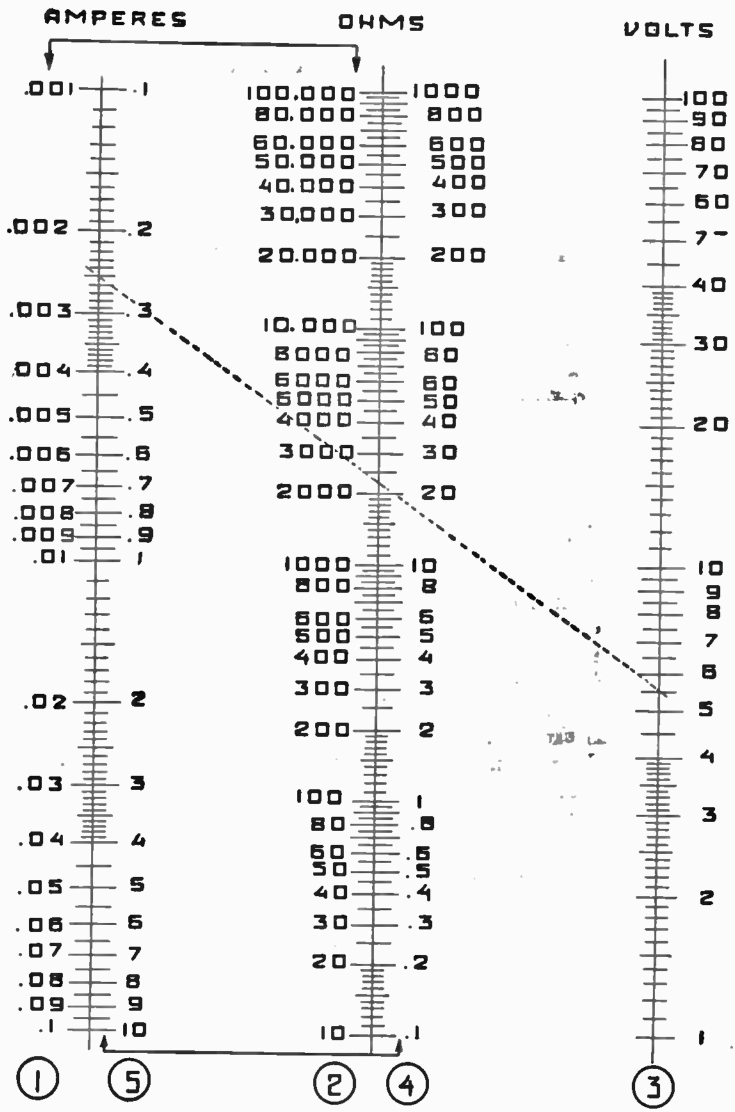
A rheostat is a device for controlling the resistance of a circuit. The rheostat plays a large role in most electrical circuits; especially in radio work. For standard material German silver or



NOTE: ONE KILOCYCLE EQUALS ONE THOUSAND CYCLES

HOW TO USE THE CHART

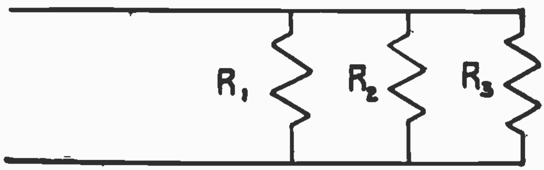
Figure SS: On the outer edges of the two upright lines are given the wavelengths in meters, with their corresponding frequencies denoted opposite them between the two sets of upright lines. Thus, for a wavelength of 300 meters, the corresponding frequency is 1,000 kilocycles a second, and for a wavelength of 3,000 meters, the corresponding frequency is 100 kilocycles a second.



MAKE YOUR CALCULATIONS ON THIS TABLE

Figure TT: The text tells you just how to determine the proper resistance to use with a certain type of vacuum tube and a certain voltage "A" battery. There are a great many other uses that you will find for this handy chart in connection with the calculation of Ohm's Law.

FIG. 1.



TWO WAYS OF CONNECTING UP RESISTANCES

Figure UU: The figure at the top shows resistance in series; the figure at the bottom shows them in parallel—which are often confused in calculating resistances.

nichrome wire is used and wound into the shape of a coil.

The method of calculating the resistance of a rheostat is simplified by the use of the chart illustrated on page 52.

To find the resistance of a No. 18 wire, 12 feet long, connect 18 on scale No. 4 with 12 on scale No. 3 and read, for copper, on scale No. 5. The result is .09 ohms. For nichrome, on scale No. 6 the result would be 6.2 ohms.

To calculate the resistance of a coil rheostat half an inch in diameter, having 90 turns, made of No. 18 B. & S. nichrome wire, connect .5 on scale No. 1 with 90 on scale No. 2 intersecting the reference line on scale No. 3, giving a total length of 12 feet.

Then connect the intersecting point on scale No. 3 with 18 on scale No. 4 and read the resulting resistance of 6.2 ohms on scale No. 6.

This table will help you greatly in the design of special rheostats of various resistances.

The speed of any ether waves is approximately 186,000 miles a second or 300,000,000 meters.

The length from the crest of one wave to the next one (see Fig. RR), completing one cycle, is called the *wavelength*.

The number of waves passing a fixed point in a second is the frequency of the electric oscillations.

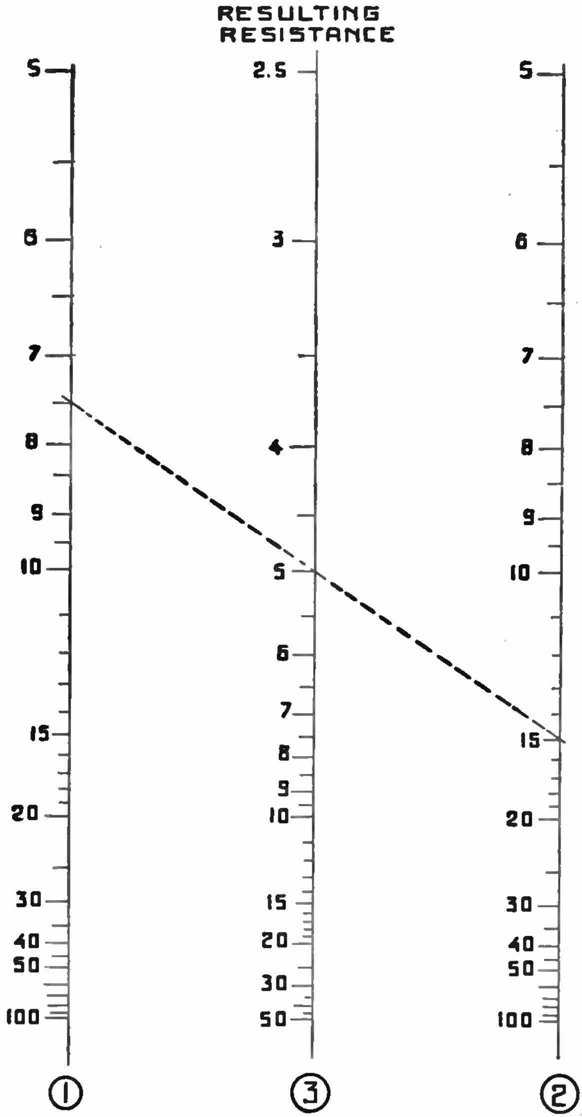
If we take a wavelength of 600 meters, to find the frequency per second we divide 300,000,000 by the wavelength, which in this case is 600. This will give us 500,000 cycles. The amount runs into a high number and, therefore, we can substitute for 1,000 cycles, one kilocycle (as kilo means always thousand in the metric system), giving us 500 kilocycles.

It therefore follows that the multiplication of the wavelength and the number of kilocycles must give us the figure 300,000.

To facilitate the calculation of wavelength and frequency the accompanying chart (Fig. SS) has been prepared.

Simply read the wavelength and corresponding frequency from the same horizontal line crossing the two vertical lines at the desired frequency or wavelength you wish to convert.

The amount of current that flows



HOW TO USE THIS CHART FOR FIGURING YOUR RESISTANCES AT A GLANCE

Figure VV: Put your ruler on line 1 at the number of ohms of one rheostat connected in parallel and join it with the number of ohms of the other rheostat on line 2; then read the effective resistance on line 3. The dotted line shows how it is done.

in a circuit depends upon the voltage of the battery and upon the value of the resistance in the circuit. The equation —called Ohm's Law—applied to above conditions, states that the current is equal to the voltage divided by the resistance or

$$I = E/R$$

wherein I denotes the current measured in amperes, E is the electric pressure (voltage) measured in volts, and R is the resistance, measured in ohms.

Ohm's law is equally applicable to direct current (DC) and alternating current (AC) circuits, but in the latter case the above simple relations must (in general) be modified. Ohm's law is correct only for solid conductors at ordinary temperatures; in radio work it is used to calculate the resistance required, in a rheostat, for the proper operation of a filament for various tubes and the various voltages supplied.

For example:

Using a WD-12 tube, which requires a current of .25 amperes at a filament voltage of 1.1, we can find the necessary resistance by transposing the above formula, so that the resistance is equal to the voltage divided by the current. Substituting the above values, we have:

$$R = \frac{E.}{I} = \frac{1.1}{.25} = 44 \text{ ohms}$$

which is the resistance of the filament.

Using a 6-volt storage battery (6.6) we will have an additional voltage of 5.5 volts, which should pass through a resistance current of .25 amperes.

We therefore divide 5.5 by .25 and find the necessary resistance to be 22.0 ohms, which is the additional resistance required for the circuit. Adding a certain amount of resistance, allowing for filament control, we find we will have to use a 30-ohm rheostat for this purpose.

For handy calculation, a chart is attached (Fig. TT) which can be used in the same manner as any one of the charts previously published.

For the above example, connect 5.5 on scale No. 3 with .25 on scale No. 5 and read (on scale No. 4) the resulting resistance of 22.0 ohms.

The amount of current which will flow in any given electrical circuit can be calculated by the use of Ohm's law, which has been dealt with previously. The equation for this law takes into consideration a single resistance or several resistances connected either in series or in parallel.

The combined resistance of a number of units which are connected in series as shown in Fig. UU, is the sum of the separate values according to the equation:

$$R = R1 + R2 +$$

The effective resistance of a number of units connected in parallel as shown at 1, can be calculated by the equation:

$$1/R = 1/R1 + 1/R2 + 1/R3 +$$

If you use the accompanying chart (Fig. VV), the equation for resistances in parallel may be solved graphically. You need only to draw a straight line from one known resistance picked out on No. 1 scale to the value of the second resistance on No. 2 scale and the resulting resistance value can be read off at the point where the line you have drawn intersects scale No. 3.

For example: Assume that we have two rheostats connected in parallel and the individual resistances of the rheostats are 7½ ohms and 15 ohms respectively. To find the effective resistance of the circuit we connect 7½ on scale No. 1 with 15 on scale No. 2 and we find the effective resistance to be 5 ohms which is the point at which the line will intersect scale No. 3. If these same two rheostats were connected in series the resulting resistance would be 22½ ohms.

To obtain the resistance of a number of units some of which are connected in series and others in parallel in the same circuit, the effective resistance of the parallel portions of the circuit are obtained separately by the use of the chart and then these figures are added directly to the values of the resistance units which are connected in the circuit in series.

END OF SECTION XII

SECTION XIII

Learning the Language of Dots and Dashes

THE student of radio code grows impatient with his perfectly good mind when he tells it again and again that "da de da da" is the letter "Y", and he wonders how any mind can be so stupid. He is too harsh with himself.

Even when the student has progressed more or less steadily, and when he is about fast enough to secure a first grade license, his mind often seems to make no progress for weeks and even months at a time. Some students quit in disgust at such a time, little knowing that success waits just around the corner and that their minds have been working faithfully all the while.

Success does not come by speeding up the progress of copying down the letters as they are sent, but rather by forming new habits of hearing entire words and even phrases without paying specific attention to the individual letters which form them.

The radio code is a foreign language. No one could speak a language fluently if he stopped to spell each word to himself, no matter how fast his mind might work. He must think in phrases which he has heard so often that his mind forms them almost automatically.

The operator who copies forty words a minute usually strains less than the beginner who copies ten. His mind does not work faster than the mind of the beginner; it merely works with fewer acts.

As the experienced operator sits at his typewriter and copies an important message coming, perhaps, from a statesman or a king, he changes the paper in his machine. He even tells a joke to another operator beside him, and maintains his normal rate of speed although he may have been working eight hours. He is at ease, and has none of the worry of the beginner who strains to catch every letter separately as it comes to him.

But he was once a beginner himself, and he strained his mind before he learned a better way. He first learned the dots and dashes which go to make up letters, and he learned them slowly, thinking them over as he went to sleep perhaps, and wondering when he would ever distinguish between Q and Y.

Some schools prefer that the students learn the letters by sound only and ask them never to look at charts which show the dots and dashes used for each letter. They may be in the right, for the sense of hearing is the one which is most concerned, and the sense which must be developed.

Not all minds are alike, however, in their processes of learning. The mind with the strongest visual memory no doubt makes better progress at the start by looking at a chart; such a mind must listen to the buzzer for the auditory sensation of the letter, and then refer to its visual memory to identify the letter by its arrangement of dots and dashes.

The visual process is a roundabout way, of course, and must soon be discarded for the simpler system of auditory memory. The auditory system of teaching, without the chart, is quite likely the best, although there is no way to prove it.

The beginner with a keen visual memory may often startle his friends with his rapid start, but learning the code is a true art which has no short cut, and sooner or later he slackens his pace, and his friends overtake him.

An ordinary mind can remember six figures when they are spoken, and can usually repeat them, both forward and backward. Some minds, of the keen visual type, can retain as many as ten or more figures "in the mind's eye," and repeat them at leisure. If such a mind exists in a class, and the instructor sends ten letters at a time, the student with the unusual mind can retain the letters and set them down at leisure usually to the astonishment of his classmates, most of whom have been unable to receive more than two or three of the letters.

Such a student will stand well in his class always, but if he is to become a fast operator, he must discard the visual processes and learn to write letters, words, and then phrases as he hears them.

Learning the code is much like solving a puzzle. Little Willie in the fourth grade humiliates his venerable old grandfather by learning the trick of it before grandfather, with all his great store of knowledge, has obtained a good start in finding the solution.

The code, in its democratic way, offers the same lengthy task to the old as well as the young and to the quick as well as the slow.

As the long and short buzzes come to the ear in a complex maze, the mind at first strains and can make nothing out of the confusion. It sounds like "oodle oodle de oodle" to the novice. The student in the classroom is almost as much at sea, even though the signals are much slower.

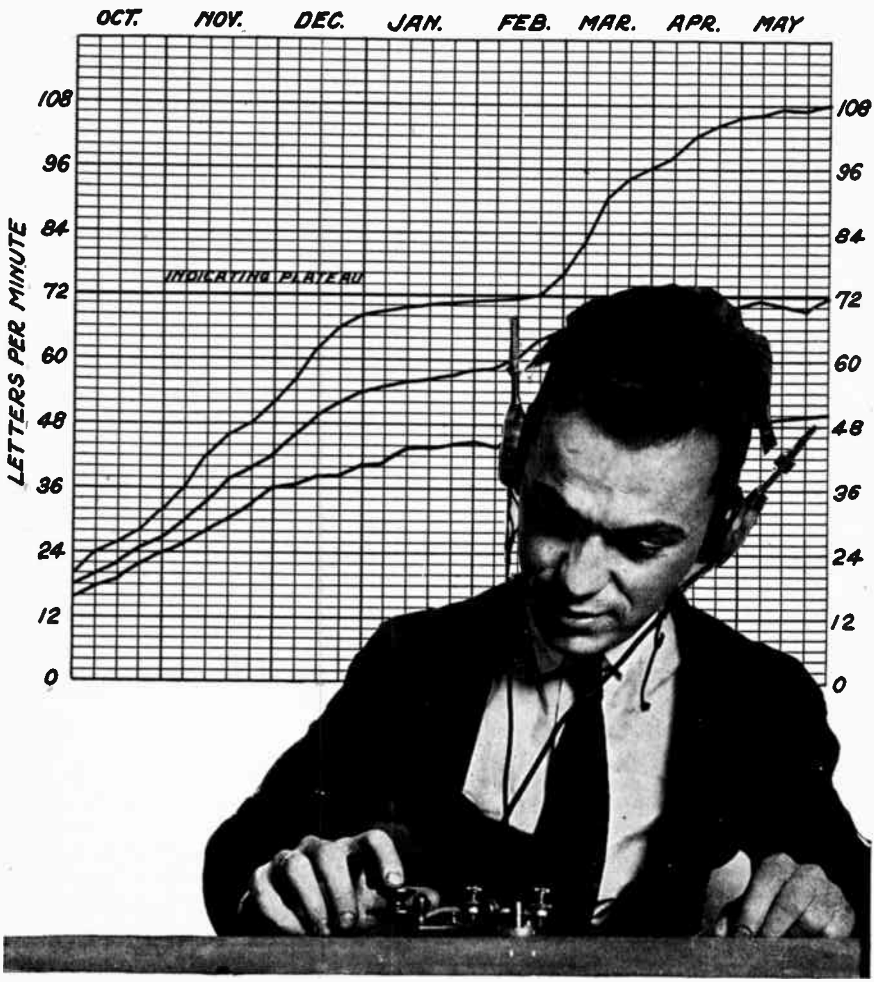
He is unable to distinguish between the letters at all until suddenly some feature catches his ear and helps to fix the signal in his mind. The single dash for T and the single dot for E are distinguished first as a rule, and other letters fix themselves in the mind much more slowly.

Perhaps the beginner discovers that the signal for Q is like the warning whistle of a train as it approaches a crossing; two long notes, a short one and then another long one. Thus, the similarity helps him to recognize Q when it comes to him slowly, but he must forget the similarity later if he is to become a fast operator. He will not have time to think "train whistle" before his pencil writes Q. He must make his actions more simple and automatically write Q just as a German says "*rot*" or a Frenchman says "*rouge*" or a Spaniard says "*roto*" when he speaks of the color red.

He must not be discouraged if his pencil stands still when the buzzes of the letter Q come to him, even though he knows perfectly well, a second later, that the letter was Q. A mother must point many times to a hat or coat and say "red" before her baby finally understands, and the college instructor finds the same difficulty in teaching a foreign language.

If the mind is kept continually open and sensitive to the signals it will after a time eliminate errors and discover short cuts. The beginner who is discouraged needs only to recall his efforts in first learning to put on his collar and tie his necktie. His fingers were slow, and he invented many ways of pushing collar buttons through button holes until he found himself one day doing the trick seemingly without thinking anything about it.

During the process of learning the code, there are dull days, weeks and even months, during which periods the student seems to make no progress at all. Such apparently inactive periods may be caused by discouragement or inattention; perhaps the copying of messages seems too easy. At any rate, there is at least one period in the code student's



HOW THE STUDENT PROGRESSES

The speed of the beginner in learning the code is indicated in this graph. The lower line shows his development in learning it letter by letter, the middle line, word by word, and the top line, phrase by phrase.

progress as shown in the accompanying chart, when his mind seems to be at a standstill.

The curves shown on the chart represent the progress of a group of students who were learning telegraphy. The curves show in a general way how a student can expect his mind to act. In the curve marked "receiving" an inactive period or "mental plateau" is shown to occur during the fourth and fifth months of the student's efforts.

The accepted explanation of the plateau is thus set forth by Prof. R. S. Woodworth, of the Department of Psychology at Columbia University:

"The plateau is the figurative indication of a natural slowing down in the progress of the student during a period of study, and is followed ordinarily by signs of renewed impetus caused by the adoption of improved methods."

To progress from the plateau stage it is necessary not to increase the speed of the acts which the mind has already learned to perform, but to learn new habits of hearing words and even phrases in their entirety. Such new habits can come only from continued practice; while the mind seems to have gone stale, it is really getting a fresh start in a new direction as is shown decidedly by the abrupt upward trend of the curve after five or six months.

The plateau may come at the end of three, four or five months, and it may last much longer than a month or two depending upon the individual's alertness. It is a bugbear to the student who does not understand it, but he should not be discouraged, for it comes to all beginners, regardless of their ability.

The beginner should learn, by all means, to "copy behind," that is, to write down the words several seconds after they are sent. This is the only safe method, for if he tries to keep up with the ticks he is apt to anticipate them and, hearing the first half of a familiar word, write the whole word and thus make mistakes.

Experts can copy from six to ten and even twelve words behind, depending upon their power to remember the words. They find it good practice to keep behind, for the meaning of the sentence may help them to make out a word of which they were not quite certain.

To shift from copying letters to copying words often stumps the student. At first he is sure to miss many of the words and his copy is hopelessly incomplete. He thinks it is better to copy letters, leaving out uncertain ones and trusting that he will catch enough letters to make out most of the words. He hates to miss an entire word. It seems stupid to him.

He should realize that he is starting all over again, in a sense, and that he is learning *words* and *phrases* instead of *letters*. He must think of letters only when they come to him detached or in coded messages. He will find that such "mixed" messages will be easy enough; he will copy the words readily and will have plenty of time to think of the detached letters and figures.

The word-habit will cause many mistakes at first, but after a time it will not only be simpler but superior in accuracy.

Copying with a typewriter is much faster than with a pencil after the operator has learned the keys. A single movement in pressing a typewriter key takes the place of a series of movements in making a letter with a pencil.

To send with a telegraphy key is much easier than to receive at first; that is because the fingers always know just what to do. As the chart indicates, a speed of some twenty words a minute is attained with almost steady progress.

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.

A	. —
B	— . . .
C	— . — .
D	— . .
E	.
F	. . — .
G	— — .
H	. . . .
I	. .
J	. — — —
K	— . —
L	. — . .
M	— —
N	— .
O	— — —
P	. — — .
Q	— — . —
R	. — .
S	. . .
T	—
U	. . —
V	. . . —
W	. — —
X	— . . —
Y	— . — —
Z	— — . .

Ä (German)	. — . —
Á or Å (Spanish-Scandinavian)	. — — . —
CH (German-Spanish)	— — — —
É (French)	. . — . .
Ñ (Spanish)	— — . — —
Ö (German)	— — — .
Ü (German)	. . — —

1	. — — — —
2	. . — — —
3	. . . — —
4	. . . . —
5	. . . . .
6	— . . . .
7	— — . . .
8	— — — . .
9	— — — — .
0	— — — — —

Period	. . . . . .
Semicolon	— . — . — .
Comma	. — . — . —
Colon	— — — . . .
Interrogation	. . — — . .
Exclamation point	— — . . — —
Apostrophe	. — — — — .
Hyphen	— . . . . —
Bar indicating fraction	— . . — .
Parenthesis	— . — — . —
Inverted commas	. — . . — .
Underline	. . — — . —
Double dash	— . . . —
Distress Call	. . . — — — . . .
Attention call to precede every transmission	— . — . —
General inquiry call	— . — . — — . —
From (de)	— . . .
Invitation to transmit (go ahead)	— . —
Warning—high power	— — . . — —
Question (please repeat after......)—interrupting long messages	. . — — . .
Wait	. — . . .
Break (Bk.) (double dash)	— . . . —
Understand	. . . — .
Error	. . . .
Received (O. K.)	. — .
Position report (to precede all position messages)	— . — .
End of each message (cross)	. — . — .
Transmission finished (end of work) (conclusion of correspondence)	. . . — . —

11—6860

THE KEY TO THE INNER CIRCLE OF THE ETHER

Fifteen minutes of study a day for a period of a month will give the average man (or woman) sufficient knowledge of the code to enable him to read most of the amateur signals. A buzzer practice set may be obtained for about two dollars.

The plateau in learning to send is not marked, although the hand can actually be made to think in words instead of letters and can acquire trains of action. A slight plateau is shown in the curve after about two months of practice. It is at this time that the hand is learning to send words instead of letters, and is busy learning the trains of action which form common words.

Perhaps the most obvious train of action in every day life is demonstrated unconsciously when we dress and undress. Almost everyone at some time has started to take off his shoes only and has suddenly awakened from his absent-mindedness to find that he has removed his hose and perhaps other garments as well.

The victim of such absent-mindedness has formed a train of action in undressing. He has followed this train in the same way for years, and when he once starts his mind on the train by removing his shoes, he continues without conscious effort.

In the same way the muscles of the hand learn to send common words in code. The operator has only to think the word; he does not think the letters. And his hand ticks it out. Common words such as "the," "and," "but," and "in" are learned almost at the outset. Endings of words such as "ing" and "ion" become automatic; after long training the hand acquires an extensive vocabulary of words which it sends in trains.

After three or four months the hand has approximately reached its muscular limit in the speed of sending letters and its progress from that time on comes in sending word trains which are not slowed down by the brain that thinks of each letter.

After a certain point in training is reached, sending is learned much more slowly than receiving because the mind can be trained to work much faster than the fingers; if a typewriter is used the operator can receive much faster than he can send. He can eventually find time to correct the sender's mistakes as he writes the message down.

Most beginners have heard of the "glass arm," but most of them do not take proper care to prevent it.

If the key is operated with the fingers or with the muscles of the hand, the continual strain will sooner or later cause temporary paralysis when the operator attempts to send with a key; this condition is known in the trade as the "glass arm." The operator may be able to write and use his hand in any other way, but when he attempts to send a message with a key, his hand and arm become rigid and will not obey him.

Almost any good operator can show the beginner how to place his fingers lightly on the key and make the movements with his wrist in the proper manner.

Progress at first will be much slower than would be the case if the student used his fingers to form the dots and dashes, but in the end the wrist movement is much the speedier. A tired hand or wrist is a danger signal and shows that the method of sending is wrong. A perfect wrist movement will enable an operator to send for hours, causing him little more fatigue than would come from writing a letter or other mild exercise of the hand and forearm.

CODE LEARNING DONT'S

1. Do not let your thoughts divert to other things. Form the habit of concentrating. It is the basis of all success in learning the code.

2. When you memorize the code

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	Have you anything for me?	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?	The tone is bad.
	Is my spark 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.
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. 11—[illegible]

THE NUCLEUS OF A UNIVERSAL LANGUAGE

These abbreviations are observed internationally; they constitute what is, in effect, the beginning of a world tongue. Every amateur who applies for a license to transmit must pass an examination on this list.

make it an "intelligence test" by mastering it in a given length of time.

3. ONCE you have learned the code and you "miss" a character, do not stop and try to think of it. It will come to you the next time. If the group is a word, the character can be filled in; otherwise you have lost the entire group. The habit of holding on to characters, temporarily forgotten, retards the progress in speed.

4. THE beginner who insists on counting the dots and dashes invariably confuses one character with another, particularly when trying to copy speed.

5. GO over the characters in your mind in between times; not by so many dots and dashes but by the sound. For instance Y is—dah-dit-dah-dah.

6. EACH code character is a musical sound. Memorize it in that way. If you must begin by counting the dots and dashes, do so. But save time and acquire speed by reverting to the sound method as soon as possible.

7. Do not attempt to put a character down before it has been completed. Read ahead and write at least one or two characters behind the key.

8. IN copying well behind the key there is ample time to determine doubtful characters before you come to them, to space the groups or words properly and to make a neat copy.

9. THE habit of writing two or more characters behind the sender comes from retaining groups or words in the mind; that is, by having someone send press, word at a time, which must not be written down but connected in the mind and called off as completed. Begin with short words, sent slowly, and increase in length and gradually in speed.

10. THE habit of trying to guess the words and attempting to write them down before they have been completed is a bad one. In many instances the word turns out to be other than that expected and the result is that you become disconcerted and lose the rest of the message.

11. MAKE the characters legible. I's and E's, T's and L's and K's and H's, for instance should not resemble each other. Dot the I's and J's, cross the T's and distinguish M's, N's and U's from each other.

12. WHEN you send, round out the characters properly. Make the dashes of equal length the dots in proportion, and evenly and equally spaced.

13. DON'T try to send fast at first. Learn to form the characters correctly; then send slowly and work up in speed as you grow in proficiency.

14. AVOID jerky sending. This is generally the result of holding the muscles stiff. Let the forearm rest on the table; let the muscles relax and put the movement in the wrist. This rests the arm and makes it easier to form the characters correctly.

15. To send fast is one thing; to send fast correctly is another. Become known for having a good "fist" by first practicing slowly and carefully.

16. THE habit of letting the fingers come in contact with the metal of the key while sending is a bad one. It will eventually result in a shock.

17. WHEN you make an error in transmission make two interrogation marks, instead of series of dots, and then begin the word anew.

18. SEPARATE the heading of the message from its body by a break or double dash; likewise the body and signature.

Every "ham" in the United States is welcome to know how the Signal Corps directs an entire battle by radio with less than a score of characters wrong in the messages exchanged. This is the attitude of Lieutenant Colonel J. E. Hemphill, head of the Signal School at Camp Alfred Vail, New Jersey, where the latest and best methods of instruction are employed.

They know what is the matter with the "fist" of every beginner at the key at the Signal School, and they know just how to go about teaching him to copy at a lively clip and to become practically letter perfect.

The camp literally bristles with antennas, and when there is a sham battle in progress the woods about the camp are alive with messages which are sent with precision and copied in a style which is a distinctive feature of the school's training. Messages are not written, but actually printed by the operator.

To one who is used to copying messages in the usual "long hand," as he would write a letter, any system of printing seems impossible. He realizes how fast he must write to copy at a good speed, and how slow he must go if he prints. He does not take into consideration how many unnecessary movements he makes when writing and how many of these he can eliminate by correct printing.

The Signal School has developed a unique system of printing which is an outstanding monument of efficiency both in saving time and insuring accuracy. The accompanying chart on page 78 shows how few actual strokes need be made in forming the letters of the alphabet and the numerals.

The first letter on the chart is a decided shock to any operator who has been making the letter "u" in the usual way. It requires only one stroke, whereas in ordinary script it would require two or three similar movements, depending upon the position of the operator's pencil at the beginning. The round dot shows the beginning of each stroke, and the arrow shows the direction.

There is no letter on the chart which requires more movement of the fingers in printing than in writing. In actual practice the system is found to be nearly as fast as any method of writing and by far more accurate and legible.

Perhaps the chief advantage of printing lies in the fact that when one char-

LEARNING WITH EXPERT INSTRUCTION

Code learning is largely a matter of becoming familiar with certain combinations of sounds and the student is not always in need of expert instruction.

A GRAPHIC RECORD OF A POOR "FIST"

This record of a student's message is made on an undulator—an apparatus that consists of a paper tape moving at a uniform rate under a pen which is fed with ink by a syphon action. The pen moves back and forth across the tape in perfect time with the student's manipulation of the key and is, therefore, a picture of his message as he sends it.

acter in a word is missed, the remaining characters are formed perfectly enough so that the word can be made out. Although the army is anxious to have all letters perfect because most messages are sent in cipher, tests prove that its method of printing is practical for all purposes.

Just as all soldiers take the same length of step after they have been in service for a while, all army operators have the same handwriting when it comes to copying messages. Any officer can read the penciled message of any private, no matter how fast it has been copied.

There are many operators outside the army, especially the "speed merchants," who can not read their own hasty writing after it "gets cold."

This never happens at the Signal School, because all messages look alike, the old, the new, the hot and the cold. Last year's log is as readable today as ever.

There are a number of script charactters which are easily confused, such as "m," "n" and "i" when they are written together hastily, whereas the same letters written the army way are easily told apart. The letter "n" is printed with one stroke running in three directions only. When the letter is made in this manner it saves the time required to make the final downward movement of the script letter and when it is finished it is easily distinguishable from any other character.

The letter "y" has an unusual form which is the result of long experiments and genuine inventive ability. The first stroke is like the letter "v" and the second completes the character in a way which distinguishes it positively, even though the operator may be somewhat careless in forming it.

An extra stroke is added to the figures 1 and 0, so as to distinguish them from the letters I and O. The 1 is underlined and the 0 has a line drawn through it. The extra strokes do not delay the operator, however, because the code gives him the time of five dashes for the 0 and four dashes and a dot for the 1.

One of the chief arguments for adopting the printing system is that no operator can avoid copying abbreviations and unusual words and combinations of letters which are strange to him and which he must write plainly if he is to make a perfect record.

Europe is now so close to America, from a radio point of view, that almost any American amateur is apt to hear a foreign station sending in a foreign language. When such a thrill comes he is glad to know all the tricks of his trade and to fill his log with the prize. The commercial operator also knows the value of accuracy in messages of importance.

The "fist" of the army operator also receives much consideration at Camp Vail, for there is usually a point in the training of an operator where his ability to receive increases faster than his ability to transmit.

When the operator is struggling to copy ten or fifteen words a minute, he sometimes develops a wrist movement

THE APPROVED METHOD OF WRITING CAPITALS. TRY IT YOURSELF!

Students at Camp Vail are taught to move the pen or pencil in the direction of the arrows shown on each letter. This method of transcribing messages received by radio eliminates mistakes, and it may be faster than ordinary writing which enables him to send twenty or twenty-five words a minute, but as he progresses his hand lags. He may, after some months, be able to copy at the rate of thirty or thirty-five words a minute, but there are few operators who can send well at that rate.

The man in an army class has an advantage over a man who struggles alone at home with PX and with other "hams" who are as slow as he, but the army has rules which will help any beginner, and many who are advanced, if they have the courage to follow them.

It is usually difficult for a man to forsake his speed of nine words a minute because he has a wrong wrist movement and start over again at the rate of three or four, but if he is going to be successful he must treat his arm right. His fingers, which have been trained for many other delicate tasks, perhaps, are little good to him in working a key, and this is the hardest blow to the beginner.

He can seize a key tightly with his fingers and play a lively tune on it after a few days if he is a good mechanic or an artist in any other line where manual skill is required. His wrist movement is too awkward at first to be of any value to him, but if he is to gain any great amount of proficiency, he must forget the nimbleness of his fingers and use them merely as loose and clumsy flappers to rest almost carelessly on his key.

The chief value of his thumb and finger lies in keeping his hand from sliding off the key. The real work, the snappy dots and dashes with which he will soon punctuate the ether are made by his wrist, moved largely by his forearm.

As the radio code is received by way of the ears, it is obvious that the proper way to learn it is by *sound* and not by *sight*.

The best method of learning the code is to have an expert send each letter over and over again until the beginner knows that letter by sound without stopping to think that it is made up of just so many dots and dashes.

Most radio fans are not so fortunate as to have an expert operator at their command to teach them the code.

Here is a novel way to learn the code that will give the proper swing to the letters. By this method you can practice when you are walking to the office or on the stroll after lunch. If you recite a code letter according to this system for every step you take on even one long afternoon walk, you will get a good working knowledge of the code.

To begin with, the number and relation of the dots and dashes that make up each letter of the code alphabet should be memorized until you can give the code equivalent of any letter without looking at the paper. Be sure to consider the dots and dashes as combinations of the words "dit" and "dah" rather than as so many periods and dashes.

In general, consider one step equal to a dash, three dots or a space.

Thus, letter B would be *dah-dit-dit-dit* with the *dah* long enough to last for one step and the three *dits* following evenly during the next step.

There are exceptions, of course, but the chart shows how to time the dots and dashes with your steps.

Remember always to leave a space one step long between letters. And when you get to the point where you are making words and sentences, leave a two-step space between words.

Try it!

Dots are made by raising the wrist with a slight quiver. A series of dots is made by only one upward movement of the wrist, and such movement should require no strain upon any of the

LETTER					
A	DIT-DAH				
B	DAH-	DIT-DIT-DIT			
C	DAH-DIT-	DAH-DIT			
D	DAH-	DIT-DIT			
E	DIT				
F	DIT-DIT-	DAH-DIT			
G	DAH-	DAH-DIT			
H	DIT-DIT-DIT-DIT				
I	DIT-DIT				
J	DIT-DAH-	DAH-	DAH		
K	DAH-DIT-	DAH			
L	DIT-DAH-	DIT-DIT			
M	DAH-	DAH			
N	DAH-DIT				
O	DAH-	DAH-	DAH		
P	DIT-DAH-	DAH-DIT			
Q	DAH-	DAH-	DIT-DAH		
R	DIT-DAH-	DIT			
S	DIT-DIT-DIT				
T	DAH				
U	DIT-DIT-	DAH			
V	DIT-DIT-DIT-	DAH			
W	DIT-DAH-	DAH			
X	DAH-	DIT-DIT-	DAH		
Y	DAH-	DIT-DAH-	DAH		
Z	DAH-	DAH-	DIT-DIT		

LEARNING THE CODE WHILE WALKING

The even swing of march time forces you to recite the code letters properly. The faithful use of this system will help to speed up the recognition of code characters when they are received.

muscles of the arm, the wrist or the fingers. When the proper quiver of the wrist is mastered, five dots can be made with the single upward movement as easily as one.

The dash is made with the downward movement of the wrist. As the dash is longer than the dot, it gives the wrist plenty of time to move downward.

At Camp Vail an undulator can be switched to the key of any pupil whose sending is ragged, and he can see upon a tape just what mistakes he is making. Such a visual record is nothing short of a revelation to many operators, because few can hear themselves as others hear them.

The novice is invariably astounded when he first learns that one operator can know another by his sending just as he would know a voice over the telephone. When he gets farther into the subject of dots and dashes, however, he finds that there are few "fists" which have no foreign accent.

The undulator reveals such a brogue or stuttering on the part of an operator's hand by means of an ink line on a paper tape. The undulator used at Camp Vail feeds ink with a syphon action through a hollow point which is vibrated back and forth across the paper tape as the operator taps the key. As its response is instantaneous, the student's defects are revealed at once when his record is compared with a perfect model.

It has been found that practice with some kind of coded message is more beneficial than with messages which can be understood by the man who copies them. A few press messages are sent occasionally to enliven the lesson.

The amateur who practices with his neighbor often finds it unhandy to plan new code messages constantly, and so he resorts to sending the news of the day from a daily paper. To make a code message out of a newspaper story, however, it is only necessary to send the story backwards. Starting at the end of the story, the operator can send five letters at a time, just as they come, with a pause in between each group of five letters. When he has finished, he can readily check the message by reading it backward.

There are two reasons why men at Camp Vail take pride in being real amateurs. The first is that they cannot tell when an amateur is going to contribute to radio science in a way which will be a valuable aid to his government, and the second is that they are interested in developing amateurs and helping them. The response of "hams" during the war has earned for them a definite place in the activities of the Signal Corps.

The set used for local work at the camp is perhaps more representative of the American "ham" station than any other. It consists of four five-watt tubes, and it is worked with the army call letters, BS6. This little set so far has reached out some 300 miles with only 1.5 amperes in the antenna.

Experiments are constantly made with this little outfit to help the amateur.

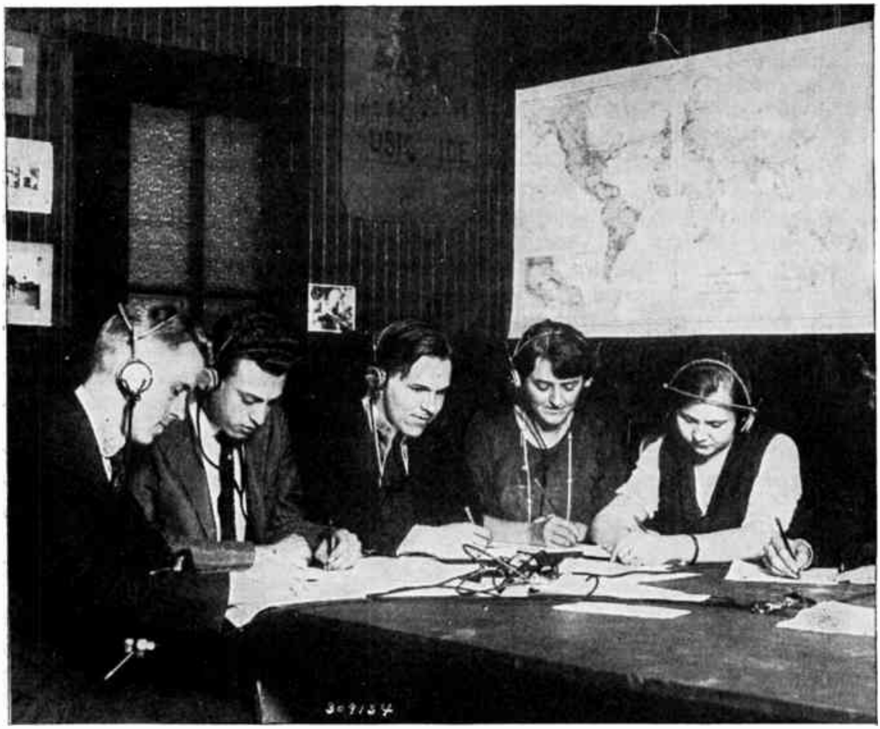
Officers in charge of this development work are among the best technical radio men of the country and they are genuinely interested in amateur radio.

Because of the difficulty of mastering this code language and the necessity of keeping the ether free of inexperienced novices, a license is required before one is permitted to operate a transmitting apparatus. As thousands of radio fans have learned in the last few months, no license of any sort is required by the government for a receiving set in the United States.

Just as the immigrant who comes to this country reads the preamble to the Constitution to prove that he can command the English language sufficiently to make his way about, so there is a minimum speed requirement in the use of the Continental Morse code for passing the amateur's test. The operator must be able to send and receive ten words a minute, and has to understand the international abbreviations, two of which are "SOS," the signal of "distress" and "QRM" meaning "Interference."

But why is a license necessary for operating a radio telephone transmitter? The reason is sufficient.

Sending stations are apt to interfere with one another. The number of wavelength bands is so relatively small for the great amount of traffic that is already being sent over them—that considerable regulation is necessary in order to give an equal chance to all. Of course the control must be centralized in one place, or disputes would arise which would end in the hopeless deadlock of two small boys, one saying, "My mother says I can play in your yard," and the other, "My mother says you can't." In



Underwood & Underwood

A CLASS OF APPLICANTS STUDYING THE CODE

You must be able to receive ten words a minute in order to qualify for the amateur first-grade license. This requirement is not difficult to obtain.

fact, it would be worse, for there would be no strong right arm to settle the matter. So Congress has provided the arm to start with, and power to regulate radio communication has been vested in the Secretary of Commerce, who administers it through the Commissioner of Navigation. The present law makes no difference between radio telegraph and radio telephone.

If you are an American citizen, it is not difficult to get a sending operator's license, provided, of course, that you know the Continental Morse code. The first step is to find out who the district Radio Inspector is and get in touch with him.

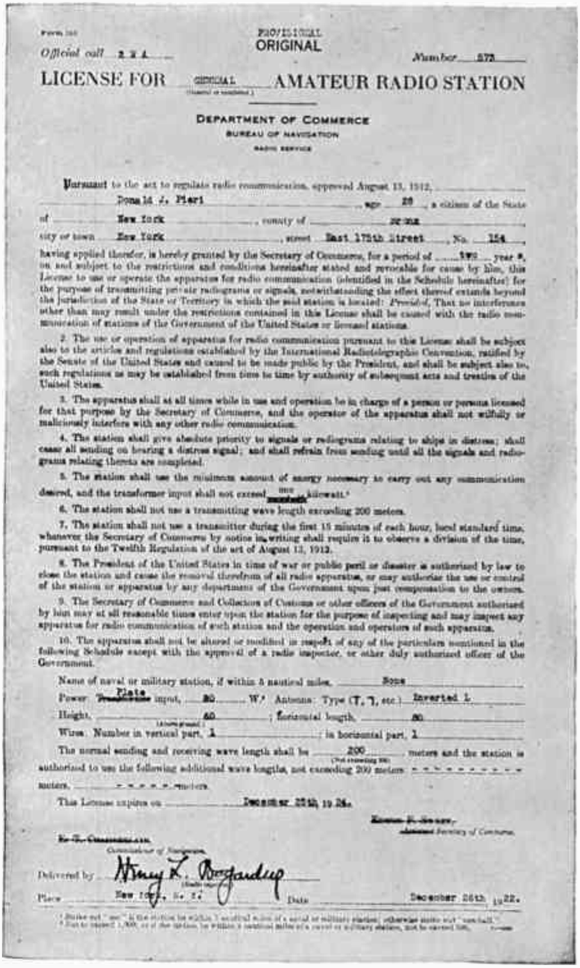
The United States is divided into nine radio districts; the area of each is based upon its population and need for radio supervision.

The First District comprises the New England States, and its Inspector is at the Customs House at Boston. The Second District has its headquarters at the Customs House at New York City and takes in the counties of New York State along the Hudson River, Long Island, and the northern part of New Jersey. The rest of New Jersey, southeastern Pennsylvania, Delaware, Maryland, the District of Columbia, and Virginia are included in the Third District. This Inspector's office is at the Customs House at Baltimore, and he has jurisdiction also, at present, over the Fourth District, which is composed of the southern Atlantic Coast States: North and South Carolina, Georgia and Florida; and the island of Porto Rico. In the near future, the Fourth District will have its own inspector, with headquarters at the Customs House at Savannah.

District Number Five takes in the southern states west of District Four, and extends as far north as the northern boundaries of Tennessee, Arkansas, Oklahoma, and New Mexico. Its Inspector is at the Customs House at New Orleans. The Sixth District takes in the southwestern corner of the United States: Utah, Arizona, Nevada, and California, and also extends itself to take in Hawaii. Its headquarters is at the Customs House at San Francisco. Seattle, Washington, is headquarters for the Seventh District, and its Inspector is to be addressed at 2301 L. C. Smith Building. This district comprises Wyoming, Montana, Idaho, Oregon, Washington, and Alaska. The Eighth District takes in the rest of New York not included in District Two, the rest of Pennsylvania not included in District Three, West Virginia, Ohio, and the lower peninsula of Michigan; its Inspector is at the Federal Building in Detroit. The Ninth District takes in all that is left; its northern boundary follows the Canadian border east from North Dakota through the middle of Lake Superior, then curls down through Lake Michigan to the northern boundary of Illinois. Its Inspector has his headquarters at the Federal Building in Chicago.

Having written to the Radio Inspector of the proper district, the prospective operator receives application blanks for his examination. Examinations are usually held at the offices of the district Radio Inspectors, but Inspectors may arrange examinations at other places in their districts when they deem it necessary.

The examination consists of two parts: A practical test on sending and receiving in the Morse Continental code, at which a speed of ten words a minute must be attained; and a written examination on the adjustment and operation of the prospective operator's apparatus and the regulations of the International Conven-



PROVISIONAL
ORIGINAL

Official call 2 Z L

Number 573

LICENSE FOR GENERAL AMATEUR RADIO STATION

DEPARTMENT OF COMMERCE
BUREAU OF NAVIGATION
RADIO SERVICE

Pursuant to the act to regulate radio communication, approved August 13, 1912, Donald J. Hart, age 20, a citizen of the State of New York, county of Bronx, city or town New York, street East 175th Street, No. 154, having applied therefor, is hereby granted by the Secretary of Commerce, for a period of two years, on and subject to the restrictions and conditions hereinafter stated and revocable for cause by him, this License to use or operate the apparatus for radio communication (identified in the Schedule hereinafter) for the purpose of transmitting private radiograms or signals, notwithstanding the effect thereof extends beyond the jurisdiction of the State or Territory in which the said station is located: *Provided*, That no interference other than may result under the restrictions contained in this License shall be caused with the radio communication of stations of the Government of the United States or licensed stations.

2. The use or operation of apparatus for radio communication pursuant to this License shall be subject also to the articles and regulations established by the International Radiotelegraphic Convention, ratified by the Senate of the United States and caused to be made public by the President, and shall be subject also to, such regulations as may be established from time to time by authority of subsequent acts and treaties of the United States.

3. The apparatus shall at all times while in use and operation be in charge of a person or persons licensed for that purpose by the Secretary of Commerce, and the operator of the apparatus shall not wilfully or maliciously interfere with any other radio communication.

4. The station shall give absolute priority to signals or radiograms relating to ships in distress; shall cease all sending on hearing a distress signal; and shall refrain from sending until all the signals and radiograms relating thereto are completed.

5. The station shall use the minimum amount of energy necessary to carry out any communication desired, and the transformer input shall not exceed one ~~one-half~~ kilowatt.

6. The station shall not use a transmitting wave length exceeding 200 meters.

7. The station shall not use a transmitter during the first 15 minutes of each hour, local standard time, whenever the Secretary of Commerce by notice in writing shall require it to observe a division of the time, pursuant to the Twelfth Regulation of the act of August 13, 1912.

8. The President of the United States in time of war or public peril or disaster is authorized by law to close the station and cause the removal therefrom of all radio apparatus, or may authorize the use or control of the station or apparatus by any department of the Government upon just compensation to the owners.

9. The Secretary of Commerce and Collectors of Customs or other officers of the Government authorized by him may at all reasonable times enter upon the station for the purpose of inspecting and may inspect any apparatus for radio communication of such station and the operation and operators of such apparatus.

10. The apparatus shall not be altered or modified in respect of any of the particulars mentioned in the following Schedule except with the approval of a radio inspector, or other duly authorized officer of the Government.

Name of naval or military station, if within 5 nautical miles, None

Power ~~Transformer~~ Plate input, 20 W. Antenna: Type (T, ⅂, etc.) Inverted L

Height, 60; horizontal length, 80

Wires: Number in vertical part, 1; in horizontal part, 1

The normal sending and receiving wave length shall be 200 meters and the station is authorized to use the following additional wave lengths, not exceeding 200 meters - - - - - - - - - - meters, - - - - - - meters.

This License expires on December 26th, 19 24.

~~[illegible]~~,
~~Assistant~~ Secretary of Commerce.

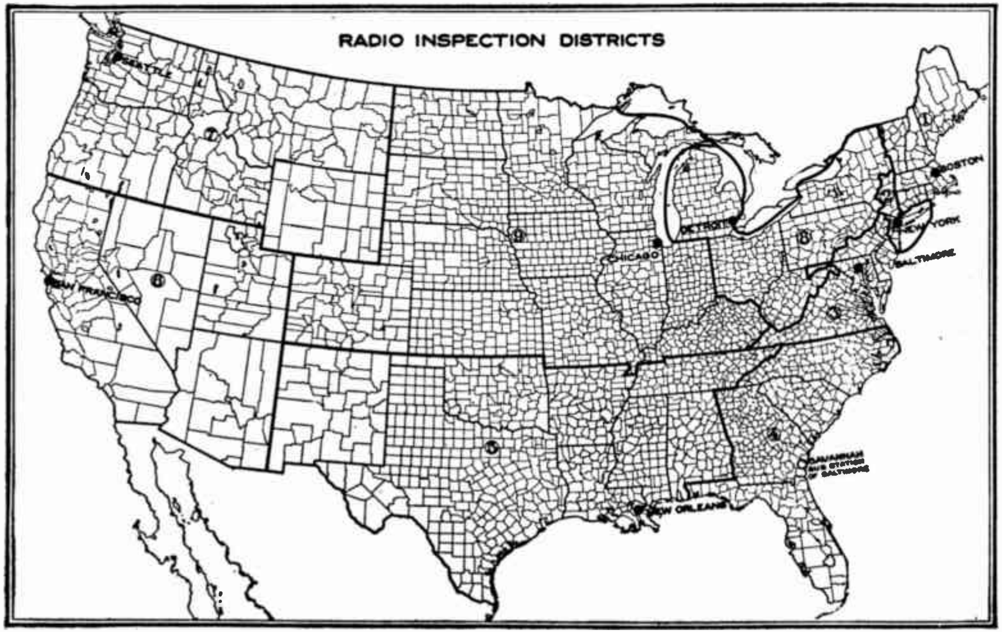
~~[illegible]~~
Commissioner of Navigation.

Delivered by Henry L. Bogardus

Place New York, N. Y. Date December 26th, 19 22.

THE STATION LICENSE

This is the document that permits you to use your amateur transmitting station. It is issued to any American amateur who has already installed his transmitting antenna and planned his set and who can pass the tests that qualify him for the operator's license. This license is good for two years—providing you conform to the rules.



THE NINE "RADIO DISTRICTS" OF THIS COUNTRY

Each district has a Radio Inspector who is in charge of the radio experts who control the operation of all stations, issue licenses to operators and stations and who check up the wavelength of all transmitting stations within their districts.

tion and Acts of Congress "in so far as they relate to interference with other radio communication and impose certain duties on all grades of operators."

The Radio Laws and Regulations of the United States, Part II, Section 121, states:

"Amateurs, before applying for their operators' licenses, should read and understand the essential parts of the International Radiotelegraphic Convention in force and sections 3, 4, 5, and 7, of the Act of August 13, 1912. The Department recognizes that radio communication offers a wholesome form of instructive recreation for amateurs. At the time its use for this purpose must observe strictly the rights of others to the uninterrupted use of apparatus for important public and commercial purposes. The Department will not knowingly issue a license to an amateur who does not recognize and will not obey this principle. To this end the intelligent reading of the International Convention and the Act of Congress is prescribed as the first step to be taken by amateurs. A copy of the radio laws and regulations may be procured for this purpose from the radio inspector or from the Commissioner of Navigation, Department of Commerce, Washington, D. C., but they are not for public distribution. Additional copies may be purchased from the Superintendent of Public Documents, Government Printing Office, Washington, D. C., at a nominal price."

If the applicant is so far away from the district headquarters that the expense of going there for examination would be too great, he may obtain a second-grade amateur operator's license without examination upon submitting evidence that he is qualified to hold a license. To do this, he gets an operator who holds a license to examine him on sending and receiving in code and upon the other requirements, or he may go before a local radio club for such an examination. He sends in the statements of those who have examined him, and, if these are satisfactory, a second-grade license is granted him, subject to later inspection and examination by the Radio Inspector of his district. An amateur second-grade operator's license is usually granted for eight months. It may be revoked if the holder refuses to offer himself for examination when given opportunity to do so.

After receiving his operator's license, the applicant's sending apparatus is inspected and tested, and he is assigned his call and wavelengths. The call consists of a number followed by two, or more, letters. If the Inspector cannot go over his set at once, the amateur receives a temporary station license for use until his apparatus can be inspected.

Most amateur sending stations are classed as "general amateur stations," and their transformer input of power is 1 kilowatt or less. There are, however, "restricted amateur stations" whose input must not exceed one-half kilowatt. This restriction is placed upon stations located within five nautical miles of a naval or military station.

It is interesting to note that in all laws relating to radio supervision, distance is measured in nautical miles. The nautical mile is 6076.1 feet, or about 1⅛ land miles.

Each operator must have two licenses, the operator's license and the station license. These licenses are renewable at their time of expiration. Radio Laws and Regulations, Part III, Section 153 (b) says:

"Operators holding licenses for grades other than commercial, who submit satisfactory evidence to the examining officer showing actual operation of radio apparatus for three months during the last six months of the license term, may be issued new licenses without examination. Otherwise, applicants for renewals will be examined in the usual manner."

No charge is made for any license or examination.

Having received his licenses, it is incumbent upon the operator to keep the rules and regulations which apply to his section of the ether. The first of these, which in these days of broadcasting seems a little bizarre, is secrecy. This is required, in fact, even of those who only listen.

"No person or persons engaged in or having knowledge of the operation of any station or stations shall divulge or publish the contents of any messages transmitted or received by such station, except to the person or persons to whom the same may be directed, or their authorized agent, or to another station employed to forward such message to its destination, unless legally required to do so by the court of competent jurisdiction or other competent authority. Any person guilty of divulging or publishing any message, except as herein provided, shall, on conviction thereof, be punished by a fine of not more than two hundred and fifty dollars or imprisonment for a period of not exceeding three months, or both fine and imprisonment, in the discretion of the court."

But, of course, the rules and regulations were made originally for commercial operators.

Another rule strictly prohibits ship or coast stations from sending unnecessary signals. This applies to amateur as well as commercial operators. Trials and practice are allowed only at times and under conditions that make interference with other stations negligible, and even then the experimenters are cautioned to listen in frequently for distress signals, which have right of way over everything else. Commercial operators not infrequently have their licenses withdrawn for sending unnecessary signals.

Transmission of profane language is forbidden by another rule.

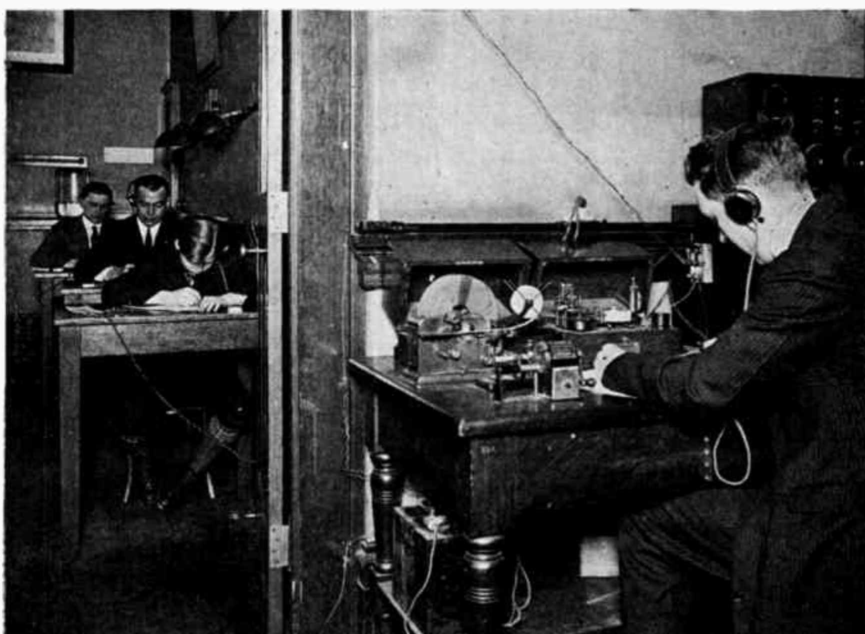
Every licensed operator is assigned a wavelength upon which he must send, and he must be careful not to overstep his limits and interfere with other communication. Willful or malicious interference constitutes a misdemeanor under the law, and is punishable by a fine of not to exceed five hundred dollars or imprisonment not to exceed one year, or both. It is often difficult for amateur operators to be sure that they are sending within their proper wavelengths, and the Bureau of Navigation has recently issued the following warning to them: "The Bureau has received a number of complaints recently of amateur stations using wavelengths in excess of those authorized in their licenses, which has resulted in much unnecessary interference. Amateurs should, if possible, have their wavelengths measured (*with a wavemeter*) to avoid violating the law."

In sending messages, the operator must give his call letter. This gives other operators a chance to take it up with him if his messages are interfering with those of other operators. Little trouble is experienced with operators sending without a license. There is a strong sentiment against such a practice among licensed amateur operators, who are very proud of their licenses, and they are quick to object when messages are sent out under irregular call letters. If such a rebuke does not silence the unofficial sender, and he becomes a pest, complaint may be made to the Radio Inspector of the district. If a reprimand from the district Inspector is not sufficient, the might of the law may be invoked against him, and the case turned over to the District Attorney. But trouble of this kind is rare. The American boy is a law-abiding citizen.

The inspecting force of the Bureau of Navigation for regulation of amateur operators is fast becoming inadequate. The district inspectors' offices being at the seaboard leaves the great interior of the country almost without supervision. The work of inspecting outgoing vessels to see that their radio outfits are in perfect working order is by far the most important duty of the Bureau of Navigation. Vessels upon the high seas are dependent upon their radio sets for all their communication with the rest of the world, and in time of danger it is vital that radio messages can be sent. It is for this reason that inspectors' headquarters must be at the principal harbors of this country.

But since July 1, 1922, when a slightly larger appropriation was made available to the Bureau of Navigation for radio inspection, extension of the service of the district radio inspectors has been increased, and provision has been made to cover fully every large city in the United States. It is, of course, impossible for the Government to place inspectors in every state and every town at the present time.

Eight grades of licenses are issued by the Bureau of Navigation: (1) Commercial extra first grade; (2) commercial first grade; (3) commercial second grade; (4) commercial cargo grade; (5) com-



HOW APPLICANTS FOR A TRANSMITTING LICENSE ARE EXAMINED BY THE RADIO INSPECTOR

A typical scene in the inspector's office. In this case the assistant radio inspector is sending "code" to applicants who are located in the next room with phones on their heads, copying down as much of the test messages as they can. The test papers are then corrected by the inspector and rated for speed in reception.


The United States of America

NUMBER 21538

DEPARTMENT OF COMMERCE
... BUREAU OF NAVIGATION ...

LICENSE
TO
RADIO OPERATOR, AMATEUR FIRST GRADE

This is to certify that Louis Johnson has been examined and shown to have a knowledge of the adjustment and operation of apparatus and of the regulations of the Radiotelegraphic Convention and the Acts of Congress in so far as they relate to interference with radio communication and impose certain duties on all grades of operators sufficient to entitle him to a license, and he is hereby licensed as required by law Radio Operator, Amateur First Grade for two years.

The candidate was examined and shown to have knowledge (excellent or good) in the following additional subjects:

(a) general adjustment, operation and care of apparatus[1] Good
(b) transmitting and sound reading Continental Morse at a speed of[2] 10 words a minute.
(c) general knowledge of international regulations and Acts of Congress to regulate radio communication[1] Good

Herbert Hoover
~~William C. Redfield~~
Secretary of Commerce.

Oath of Secrecy accepted.

U.S. Radio Inspector

Notary Public.

D. B. Carson
~~E. T. Chamberlain~~
Commissioner of Navigation.

Place New York, N.Y. Date November 11th 1922

1 Excellent or good. 2 Insert speed.

THE AMATEUR OPERATOR'S LICENSE

This is the coveted document that is issued to you after you have passed the required examination. It is good for two years and is issued without fee other than the trifling cost of the notary's seal.

mercial temporary permit; (6) experiment and instruction grade; (7) amateur first grade; (8) amateur second grade.

The commercial extra first grade is the highest license granted radio operators by the Government. It is issued to operators whose trustworthiness and efficient service entitle them to extra confidence and recognition. It may be earned by commercial first-grade operators who have put in eighteen months satisfactory service on sea or land during the two preceding years and have not been penalized for violation of the radio laws and regulations, upon passing a special examination. In the examination a speed of at least 30 words a minute, Continental Morse, and 25 words a minute, American Morse, must be attained. The technical questions and the questions on the radio laws and regulations will be considerably wider in scope than those for commercial first grade, and a higher percentage is required, 80 or better on a score of 100.

The commercial first-grade applicant must know how to adjust, operate and care for his apparatus, correct its faults and change from one wavelength to another. He is required to transmit and receive by ear at a speed of not less than 20 words a minute in Continental Morse. For these tests a word is agreed to consist of five letters. He must also know how to care for a storage battery and other auxiliary power apparatus, and he will be examined upon his knowledge of international regulations of radio communication and the requirements of the Acts of Congress to regulate radio communication. An operator who holds a commercial first-grade license or a commercial extra first-grade license is qualified for employment at any ship or land station.

The commercial second-grade examination covers the subjects given for the first grade, but the questions asked are not as comprehensive in character. To operate in this class, a speed of only twelve words per minute is required.

All American steamers carrying radio outfits must keep a continuous watch for distress signals. On cargo vessels, one first or second-grade operator is required, but the man to relieve him may be any member of the crew or other person qualified to recognize the distress signal when it is included with other words and to recognize the call signal of his own ship. He must also be able to test the apparatus with a buzzer to determine whether it is properly adjusted to receive signals.

All the foregoing are licenses granted to commercial radio operators. There is another license which, while classed as a "commercial grade," may be issued to amateurs. It is known as the Experiment and Instruction grade. It has, however, no reference to the instruction of radio operators as such, but is required by those who operate stations carrying on scientific experiments but are unable to obtain commercial operators' licenses. To obtain this license the operator need know only the essential parts of the radio laws and regulations and be able to recognize distress and "keep out" signals, but he has to satisfy the Radio Inspector that his scientific attainments warrant his receiving a license of this class.

END OF SECTION XIII

SECTION XIV

Batteries, Battery Eliminators and Chargers

A STORAGE battery is really not a battery but a container for electric current—a sort of electrical receptacle which will hold and deliver a definite quantity of electric current. It differs from the ordinary chemical battery or cell (a battery is a group of cells) in that no destructive chemical action takes place between its elements. Take the ordinary dry cell as an example for illustration. The dry cell is not rechargeable and its metallic element (zinc) is consumed in the generation of current. The generation of current not only gradually exhausts the zinc but the active chemical agent (sal ammoniac) as well.

In a storage battery or cell nothing is consumed but certain chemical changes take place every time a battery is charged and discharged. When a cell is charged, electric energy is stored as chemical energy and when the cell is discharged this chemical energy is converted back into electric current and is available as such at the terminals of the device.

In radio reception, storage batteries are used both to light the filaments of the vacuum tubes and to place the proper electrical charge upon the plates. When used to light the filaments, the storage battery is referred to as an "A" battery and when used to place the correct charge upon the plates of vacuum tubes, it is called the "B" battery. In the former case the terminal voltage of the battery is six and in the latter it may run anywhere from 22½ to 100 or even 150 volts.

The six volt storage battery is always made up of three cells connected in series so that their voltages will be added. When fully charged, a single cell will deliver current at a voltage of 2.2. Thus a 22½ battery would have about 11 cells.

The lead-plate storage battery, is made up of electrodes that contain active elements of lead peroxide and sponge lead as the positive and negative materials respectively, immersed in a dilute solution of sulphuric acid.

When fully charged and in good condition, the positive plates have a dark reddish-brown or chocolate color, while the negative plates are gray or slate colored. The plates may be readily distinguished by their color and also by the character of the active material on them. The lead peroxide is hard, like soapstone, while the negative material is soft and can be readily cut into with the finger-nail. The negative material is pure lead which has been reduced to a sponge-like form.

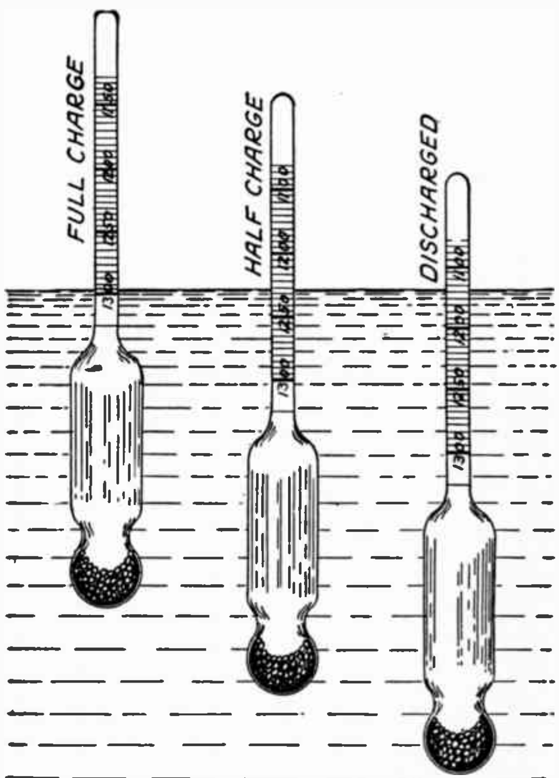
On discharge, the electrolyte (the solution) combines with the active materials of the electrodes and, on charge, the active materials are reduced to their original condition. The chemicals extracted from the electrolyte are released and returned to the electrolyte. It follows then, that the density of the electrolyte is greater at the end of charge than at the end of discharge, and also that the active material on the plates expands as discharge proceeds.

The unit of capacity of any storage battery is the *ampere-hour*. This is generally based on an eight-hour rate of discharge.

Thus a 100 ampere-hour battery will give a continuous discharge of 12½ amperes for eight hours. Theoretically it should give a discharge of 25 amperes continuously for four hours, or 50 amperes for two hours. As a matter of fact, however, the ampere-hour capacity *decreases* with an *increase* of discharge rate.

The capacity of a cell is proportional to the exposed area of the plates to which the electrolyte has access, and depends on the quantity of active material on these plates.

The capacity of batteries depends, therefore, on the size and number of plates in parallel, their character, the rate of discharge and also the tempera-



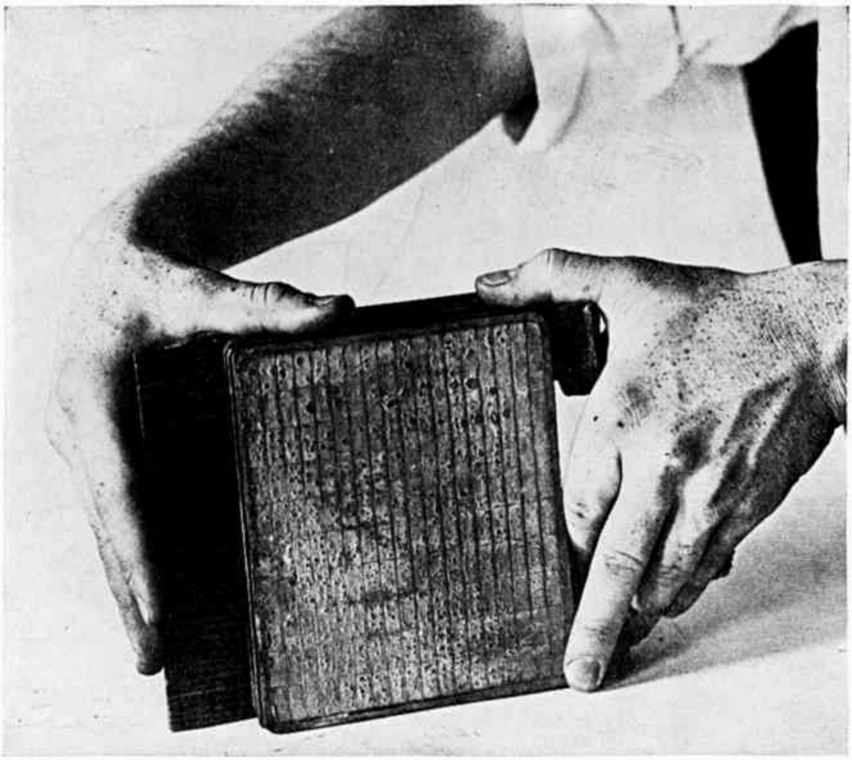
WHAT THE HYDROMETER READINGS MEAN

Figure A: When the hydrometer sinks down so that the level of the top of the solution is near 1,100, as shown at the right, the battery is practically discharged and should be recharged at once until the hydrometer floats up to nearly 1,300 as shown at the left

ture. Taking the eight-hour rate of discharge and temperature of 60 degrees F. as standard, the capacities which obtain in American practice are from 40 to 60 ampere-hours a square foot of positive plate surface (equals number of positive plates in parallel multiplied by the length by the breadth and by 2). If the capacity under the above conditions is taken at the eight-hour rate as normal, the table below shows the decrease in capacity with increase in discharge rate for average plates of American manufacturers:

	8-hour rate
8-hour	100 percent
6-hour	96 "
4-hour	88 "
2-hour	70 "
1-hour	48 "

The voltage of any storage cell depends only on the character of the electrodes, the electrolyte density, and the condition of the cell, and is *independent* of the size of the cell. The voltage of the lead sulphuric-acid cell, while on



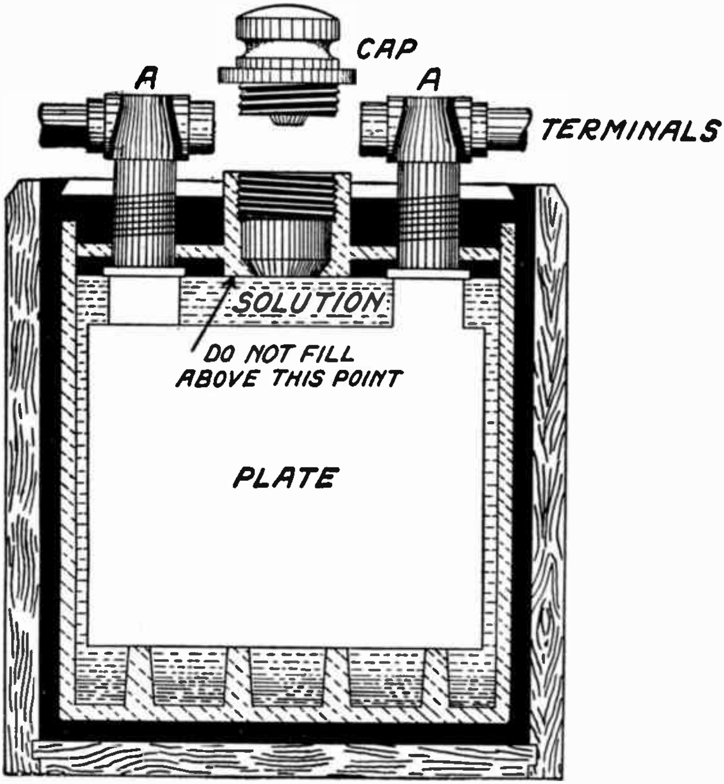
INSERTING THE SEPARATORS BETWEEN THE PLATES

Figure B: A thin sheet of wood or perforated rubber is used as insulation between each positive and negative plate to prevent them from making contact with each other and thus cause an internal short-circuit.

charge is from 2 to 2.5 colts, while on discharge it varies from 2.0 down to 1.7 volts.

The density of the electrolyte is measured with an instrument called a hydrometer (Fig. A and J), which is immersed in the liquid and floats with a greater or less amount projecting above the surface of the liquid according to the density or dilution of the liquid. It has a scale on the upwardly projecting portion, on which the degree of density may be read. Where cells are so small that the hydrometer cannot be immersed in the electrolyte, it is customary to use a combination syringe and hydrometer which draws up into itself some of the liquid from the cell.

In addition to an effect on the voltage and electrolyte density, the temperature also influences the capacity and efficiency. The capacity of a cell, at discharge rates of eight hours or less, increases with the temperature. If the capacity at 60 degrees F. is taken as normal, the increase of capacity will be



HOW THE STORAGE BATTERY IS PUT TOGETHER

Figure C: Inside the outer wooden case is the rubber jar that contains the plates and solution. The black area is the pitch composition that is run in between the case and the jars. Note the ridges in the bottom of the jar that support the plates and provide room below them for the sediment to collect without causing a short-circuit.

about one percent for discharges at four-hour rate, and at the two-hour rate the increase is about two percent, for each degree increase in temperature.

The electrolytic action seldom penetrates to a depth greater than 1/16 of an inch at ordinary discharge rates, so that where the thickness of the active material, measured from the surface of the electrolyte to the conducting plate, exceeds this amount, the portion in excess of this thickness is practically useless.

In order to obtain any desired capacity, the proper number of plates are assembled in a cell, all the plates in one cell being necessarily in parallel, the positives being joined together in one group and the negatives in another group, interleaved with the positives. Customarily, the number of negative plates exceeds the number of positive plates in each cell by one, so that the extreme end plates of each cell are negative plates. The plates of similar character in a cell are joined together by so-called burning the plate terminals to a common bus-bar, which is also lead. The burning is in reality a lead-welding process, in which the heat of an oxy-hydrogen blow-pipe is used to melt the parts together. This is the universal method of joining up the lead work in battery installations.

The plates are assembled in containing cells usually made of hard rubber. The cells are, in most cases, provided with upwardly projecting ribs and on these ribs the plates are supported. As the alternate electrodes are at opposite potentials they must not come in contact with each other, otherwise an internal short-circuit will result which will discharge the cell and injure the plates. In order to prevent this, some spacing arrangement or method of separation is necessary. The separators are made of specially treated pieces of wood or rubber. The illustration in Fig. B shows one of these spacers as well as the method of inserting it between the plates.

The troubles to which batteries are most commonly subject are:

First; loss of capacity;

Second; loss of voltage;

Third; corrosion of electrodes;

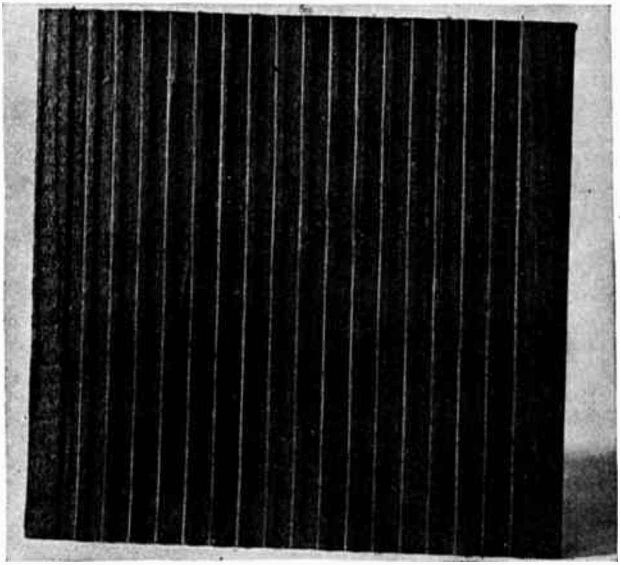
Fourth; distortion and fracture;

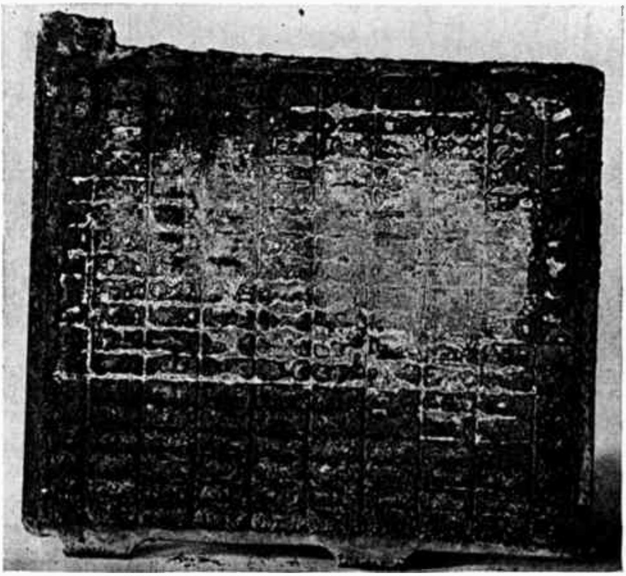
Fifth; shedding of acting material.

Nearly all these except the third are directly traceable to over-discharge, although overcharge and impurities in the electrolyte are important factors.

It has been shown on discharge, that a portion of the active material which enters into the chemical combination with the electrolyte is reduced to lead sulphate. Since this sulphate is mixed with the uncombined active material, the whole mass retains its conductivity to a large extent and does not expand to a harmful degree if provision is made for a reasonable amount of expansion in the plate. If discharge be prolonged, however, beyond the proper point, it produces an over sulphation which manifests itself in a variety of ways. The lead sulphate deposits in white crystals on the surface of the plates. Its excessive increase in volume closes up the pores in the plates, thus reducing the true active surface. The expansion either causes the active material to loosen and fall from the supporting grid, or with certain types of plates, it will distort the electrode, and in some cases fracture it. The distortion usually takes the form of a warped surface and is known as "buckling."

Over-discharge may be caused by the prolonging of the current from the battery on discharge; by internal discharge, produced by impurities in the electrolyte, and by accidental short-circuiting





A SPOILED PLATE AND A SEPARATOR

Figs. D and E: Above is shown a wood separate, while the picture below shows a badly sulphated plate caused by over discharge.

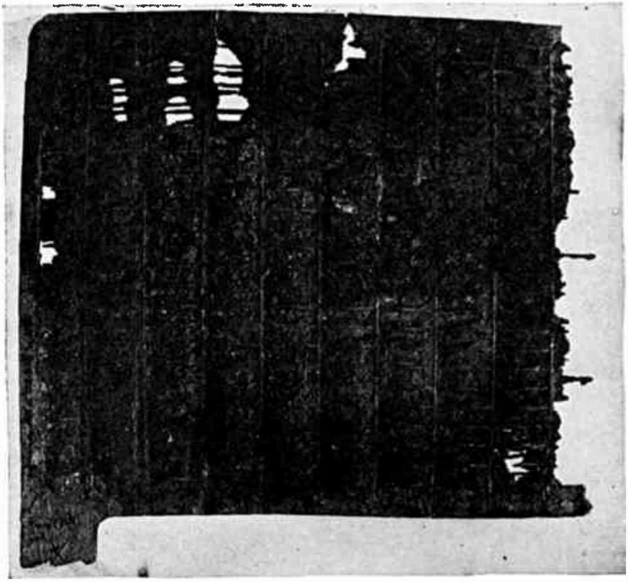
of the plates, which last frequently occurs inside the cell. Internal short-circuiting may be caused by buckled plates which are so far distorted as to crack the wood separators and come in contact with each other, but it is most likely to be caused by active material deposits which accumulate in the bottom of the cell. When this sediment has reached such a thickness that it touches two electrodes of opposite polarity it will short-circuit the plates to a greater or lesser degree and cause over-discharge with the attendant troubles above named.

A little care will greatly prolong the life of a storage battery. A few random hints may not come amiss.

For purposes of illustration let us consider a six volt, sixty-ampere-hour battery of the lead-acid type, which has been discharged and needs recharging.

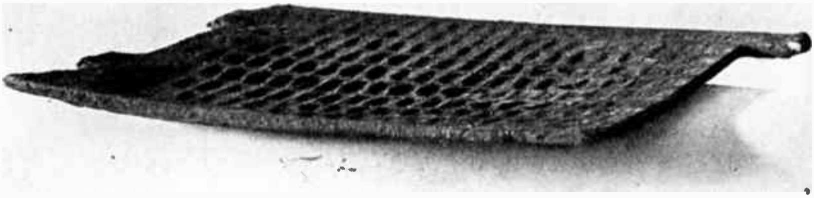
Such a battery may be recharged in several ways. If you have direct current, you may use a few thirty-two candle power lamps, connected in multiple as shown in Fig. I. If you have alternating current, a number of rectifiers that are on the market will serve the purpose, such as the Tungar bulb rectifier or the magnetic rectifiers. These rectify the alternating current and turn it into direct current, as all storage batteries must be charged with the direct current.

Before you put the battery on charge. make sure which is the positive and which is the negative terminal of the battery. The positive is marked "Pos." or + or is painted red; the negative is



TOO HIGH CHARGING CURRENT RUINED THIS PLATE

Figure F: After years of service, the positive plates gradually go to pieces. This plate gave out long before its time because of excessively high charging rates and prolonged over-charging. The large amount of gas produced under these conditions loosens the active material and it drops out.



THE RESULT OF OVER-DISCHARGING

Figure G: When current is drawn from the storage battery, the acid in the solution combines with the plates and increases the volume of the material in them. When carried beyond the proper limit, this causes the plates to swell and buckle.

marked "Neg." or —, or is painted black. The polarity of the charging wires (if they are not marked), may be determined by placing them in a glass of water to which a teaspoonful of salt has been added; if you do this make sure that the wires are not too close together. Fine bubbles of colorless gas will collect on the negative wire under water.

The positive terminal of the battery must connect with the positive wire of the charging circuit and the negative terminal of the battery must connect with the negative wire of the charging circuit.

The battery is now on charge. The direct current flows through the plates and the solution, causing a chemical action which takes off that part of the solution that had combined with the material in the plates during the discharge and returns it to the solution again. Great care should be taken that the charging rate is not greater than the correct charging rate of the battery. (This is usually shown on the manufacturer's nameplate).

Let us assume that the charging rate of the battery is five amperes and the battery is a sixty ampere hour type. Therefore we will charge it for twelve hours. For example: 5 amperes $\times$ 12 hours = 60 ampere hours. However, this should be determined by means of a hydrometer or hydrometer syringe. By inserting the end of the syringe in the filling holes of the battery and by drawing up enough solution to float the glass bulb inside of the instrument, the reading of the scale at the surface of the liquid gives the strength of the solution which must be between 1.250 and 1.350 when the battery is fully charged.

Another way of making sure that a battery is fully charged is to leave it on charge for two or three hours after each cell has started to gas or bubble. However, everyone should have a battery hydrometer to test his battery.

Upon discharging the battery, let us assume that we are using a detector and one step of amplification. The two vacuum tubes used are drawing about two amperes between them. The battery has but sixty ampere hours of current; therefore $60 \div 2 = 30$ ampere hours. This means that we can only draw two amperes for thirty hours.

The battery is now fully discharged and must be recharged immediately. However, a battery of sixty ampere hours' capacity that has two amperes drawn out of it should never be discharged for more than twenty-five hours. This leaves some life in the battery, which lengthens the total life of it.

Hydrometer readings should be taken

at least once every week and pure distilled water should be added to the solution at least once every week, so that the plates are always covered. The full charge hydrometer reading of a lead-acid cell should be between 1.250 and 1.300 and the battery should never be discharged below a hydrometer reading of 1.18. The lead-acid cell has a fully charged voltage of 2.2 volts and discharged voltage of 1.8 volts.

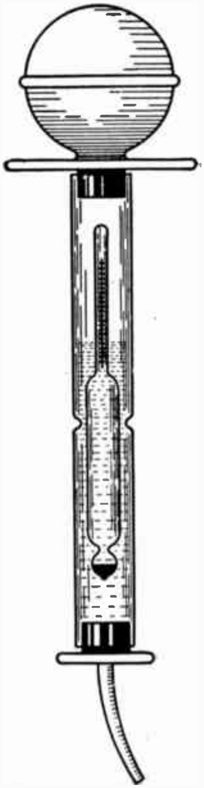
Another type of battery is the Edison cell battery. The positive or nickel plate consists of one or more perforated steel tubes, heavily nickel plated and filled with alternate layers of nickel hydroxide and pure metallic nickel in thin flakes. The tube is drawn from a perforated ribbon of steel, nickel plated, and reinforced with eight steel bands, equidistant apart, which prevent the tube from expanding away from and breaking contact with its contents.

The negative or iron plate consists of a grid of cold rolled steel, nickel plated, that holds a number of rectangular pockets filled with powdered iron oxide. These pockets are made up of a finely perforated steel, nickel plated. After the pockets are filled, they are inserted in the grid and subjected to great pressure between dies which corrugate the surface of pockets and force them into good contact with the grid. The elec-

TAKE YOUR HYDROMETER READING ONCE A WEEK

Figure H: The full charge hydrometer reading of a lead acid cell should be between 1,250 and 1,300, and the battery should never be discharged below a reading of 1.18.

trolyte consists of a 21 percent solution of potash in distilled water with a small percent of lithia. The density of the electrolyte does not change on charge or discharge. The Edison cell has a fully charged voltage of 1.2 volts and a discharge voltage of .9 volt. The Edison cell may be overcharged or over-discharged, or even short-circuited, without injury to the plates. The lead cell, if allowed to remain idle, will lose its charge, and if left in a discharged or a partially discharged condition for any length of time, deterioration of the plates will take place. The Edison cell will retain its charge for a long time and is not damaged by being left in a discharged condition.



A SPECIAL RADIO HYDROMETER

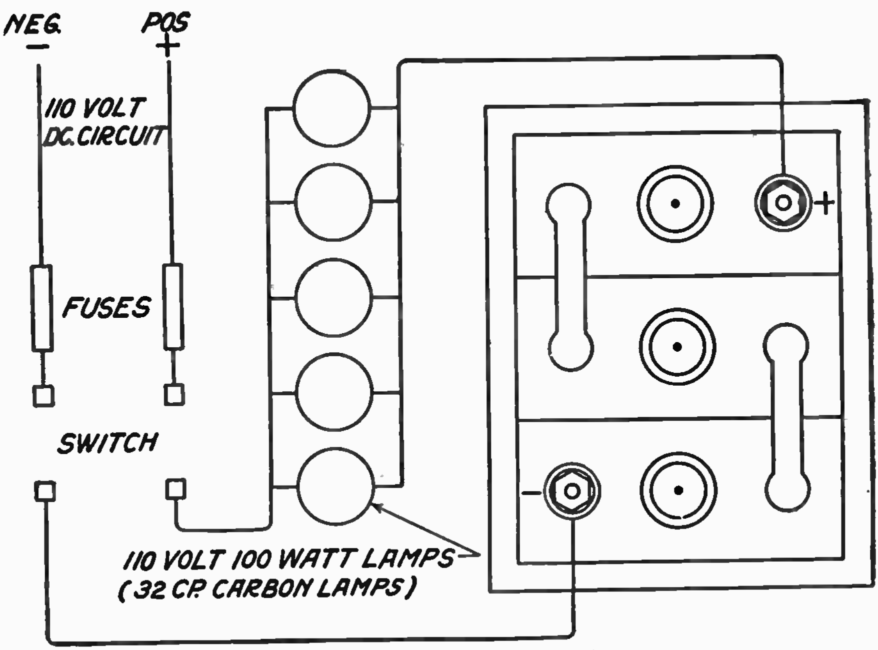
Figure J: The battery solution is drawn up into the outer glass tube of the hydrometer syringe by means of the rubber bulb at the upper end. The narrow part of the floating indicator is graduated, much like a thermometer, to read in "specific gravity." The point where the surface of the liquid crosses the scale on the float gives the correct reading.

Never leave your storage battery discharged for any length of time, and do not try to use it when it is run down, or it will become permanently injured.

Data for the construction and operation of home battery charging equipment has been included in the following paragraphs for those who care to assemble their own devices at low cost. The reader who is not interested in home-made equipment will also gain a more practical knowledge of battery operation and maintenance if he reads through the following instructions:

The charging of a storage battery is a problem that has to be solved by every radio enthusiast who operates a vacuum tube set. A storage battery may well be compared to a living organism, which soon dies and must be discarded if it is neglected. On the other hand, a little regular care, water and food—which in the case of the storage battery is water and charging—prolongs its life over a long period.

When a storage battery is discharging, the acid in the electrolyte (liquid) mixes and combines with the active material of the plates. For this reason the specific gravity of the electrolyte, which depends entirely upon the ratio of acid to water, varies as the battery becomes charged and discharged. When the battery has completely discharged



A CIRCUIT FOR CHARGING YOUR BATTERIES FROM THE D. C. LIGHTING MAINS

Figure I: This diagram illustrates the connections that should be used with a 110-volt D.C. lighting circuit through a bank of lamps. Be sure that the positive terminal of the lighting main is connected to the positive terminal of your battery most of the acid has gone from the water and combined with the plates, leaving an electrolyte that consists largely of water.

When the battery is charged the reverse action takes place; the acid is driven out of the plates back into the water. If all of the acid is not thus driven out, the battery is not completely charged. If this happens a number of times the acid tends to clog up the porous active material (spongy lead) of the plates and the battery become sulphated.

It is seen that the route taken by the acid is either into or out of the plates and that this direction of movement is controlled by the direction in which current flows in the battery. When a battery is discharging, the direction of the internal e.m.f. between the plates is from negative to positive as shown in Fig. K, and that during charge the flow is in the opposite direction. It is necessary, therefore, that the charging current flow in one direction only; in other words, that direct current be used. An alternating current cannot be used because the direction of flow changes periodically. This is shown in the oscillogram in Fig. L.

In this diagram the electromotive force takes a positive direction for 1/20th of a second and a negative direction the next 1/120th of a second; 1/60th of a second is necessary for a complete reversal of current. Such a current is a 60-cycle current; it is the kind supplied to most lighting circuits.

If a rectifier or some other method of eliminating one direction of flow is introduced in the circuit the pulsating direct current that is shown in Figure M results. The lower or negative side of the curve shown by dotted lines is the flow eliminated by the rectifier.

While it is true that the rectified current does not maintain a steady value while flowing, it is uni-directional and therefore suitable for the charging of storage cells.

There are many ways of rectifying an alternating current. Some of the most commonly used and efficient pieces of apparatus are the mercury-arc lamp rectifier, the Kenotron and the Tungar rectifiers, the mechanical rectifier, and the type of rectifier to be described in this part, called the electrolytic rectifier.

The electrolytic rectifier is perhaps the one most easily made by an experimenter who has only a few tools. A photograph of the completed rectifier and resistance is shown in Fig. N. The following materials are necessary:

2 mason fruit jars—pint size;
2 strips of aluminum; size—6 inches by 1 inch by ⅛ inch;
2 strips of lead, size—6 inches by 1 inch by ⅛ inch thick;
A few ounces of borax;
4 terminal posts.

The construction is so simple that a lengthy explanation is unnecessary. A close study of the photograph will show that the two strips are bent and hung over the edge of the jar into the electrolyte.

The electrodes as noted in the list above are of lead and aluminum, cut to the sizes given in the list.

The electrolyte consists of two pints of water to which has been added about three heaping teaspoonfuls of borax. A new electrolyte should be prepared and substituted every few weeks. This is necessary because the electrolyte becomes saturated with aluminum particles which come off the positive plate and mix with the electrolyte, thereby lowering its resistance. The lead plate does not wear away.

The jars used are the pint size mason fruit jars which may be purchased in any hardware or grocery store.

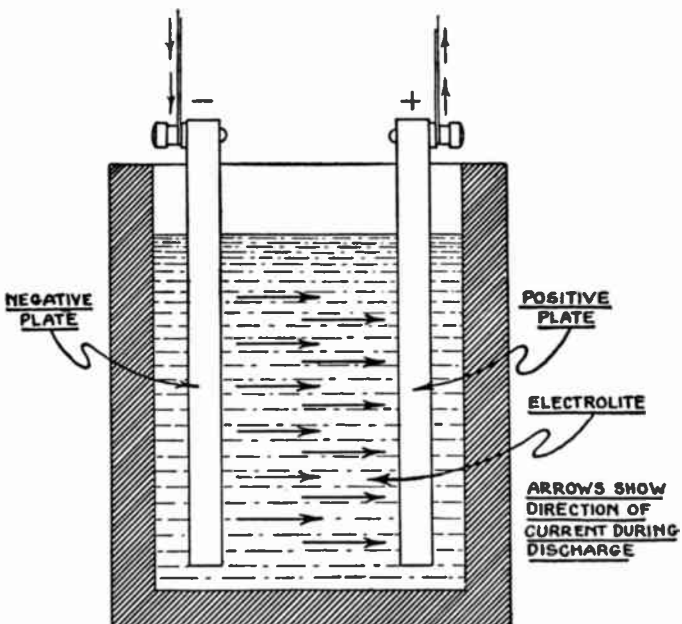
The terminal posts should be one-inch round head brass machine screws with two nuts. Their size should be 8/32 or 10/32 thread.

The jars should be set into a wooden rack as shown in the photograph. A rack such as the one shown can be made of whitewood and stained any desired color. The electrical terminals used should be heavy enough to form low-resistance paths for the large current.

While in operation the rectifier "boils" due to the heat produced by the current that flows through the electrolyte between the lead and aluminum electrodes. The water is therefore evaporated and it is necessary to add water to take the place of that lost by evaporation. It is not necessary to add more borax; this element does not reduce itself by evaporation.

A connecting lead-wire to hook the rectifier up to the lighting circuit is necessary. This should be as long as required and should have a screw plug fitted to one end so that it may be screwed into a light socket. Spring clips should be soldered to the other ends for clipping it onto the rectifier and resistance terminals as indicated in Fig. O.

A double-pole double-throw switch to



HOW A BATTERY DISCHARGES

Figure K: When a battery discharges the current flows outside the battery, through the circuit, from the positive terminal to the negative terminal. The flow inside the battery is from the negative to the positive, through the electrolyte, as indicated by the arrows.

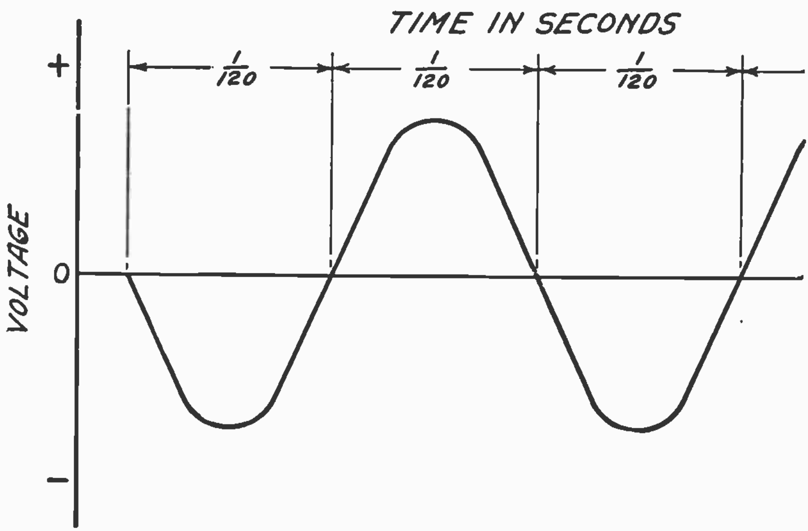
change the battery from charge to discharge will be found convenient and may be connected as in Fig. O.

It is important that the two sets of aluminum plates and the two sets of lead plates be connected together, with the jars paralleled and also that the aluminum strip electrode of the rectifier be connected to the positive terminal of the storage battery. If the polarity is not marked on the battery it may be determined in any of the following ways:

1. Cut a potato in half, and insert the two leads from the battery; a green formation will take place around the positive terminal.
2. A direct current voltmeter will read correctly only if connected positive to positive and negative to negative. Get a reading on the voltmeter and note the markings on the connecting posts.
3. Dip the terminals of the battery into a glass of water into which a little salt has been dropped, being careful not to let them touch; bubbles will appear at the negative terminal.
4. Use a polarity indicator; this may be purchased in any electrical supply store.

The rectifier and storage battery should be installed in the cellar near the electric meter. This, of course, will necessitate running two wires up to the radio set but it removes the possibility of any of the sulphuric acid coming in contact with furniture and carpets.

If the battery is installed in any place



AN ALTERNATING CURRENT WAVE BEFORE RECTIFICATION

Figure L: The ordinary lighting current in most homes is 110 volts, 60 cycles, A. C. This means that the current reverses its direction of flow 120 times a second. In this form the current is useless for charging a battery where it may injure fabrics or furniture, it should be kept scrupulously clean. It is well, any way, to keep the lead connectors and terminals coated with vaseline. Always unscrew the caps while the battery is on charge so as to allow the gases which are generated to escape.

The generation of gas (shown by bubbling) in the electrolyte while the battery is being charged indicates that the battery is nearing the full-charge point. After this has been going on for four hours it is safe to assume that the battery is fully charged. Providing the capacity of the charger matches the battery.

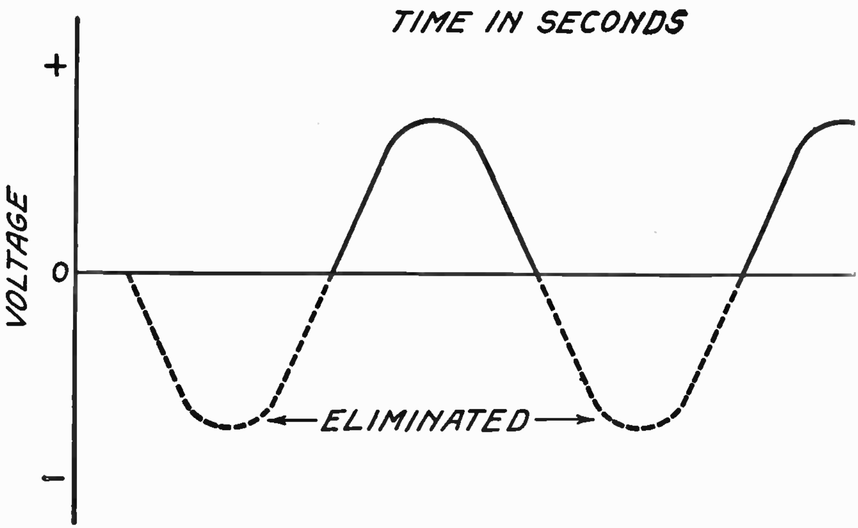
It is necessary to insert a resistance in the line; such a resistance may be a 100-watt lamp or a water rheostat, made as shown in Figure P.

The jar for this should be 6 inches by 8 inches in size. The electrodes should be lead and carbon. Connect the lead to the negative side of the line. The electrolyte should consist of pure water to which has been added a half tesspoonful of salt.

Practical application has shown that only two rectifying jars are necessary for the ordinary 40 or 60 ampere-hour battery. If, however, a battery of larger capacity is to be charged, three jars in parallel may be used to cut down the time necessary for charging. Two jars may be used in any case, but the higher the capacity of the battery the longer the time that is necessary for charging.

Before the completed rectifier is put into use it should be connected across the lighting circuit line for several hours until the plates have taken on a crust or deposit. The plates are then said to be "formed."

This is necessary because the rectifier. when it is first connected to an alter-



AN ALTERNATING CURRENT WAVE AFTER RECTIFICATION

Figure M: After passing an alternating current (such as indicated in Figure L) through a battery charging rectifier, which "cuts out" one-half of the alternations, a pulsating direct current is left which can be used to charge a storage cell.

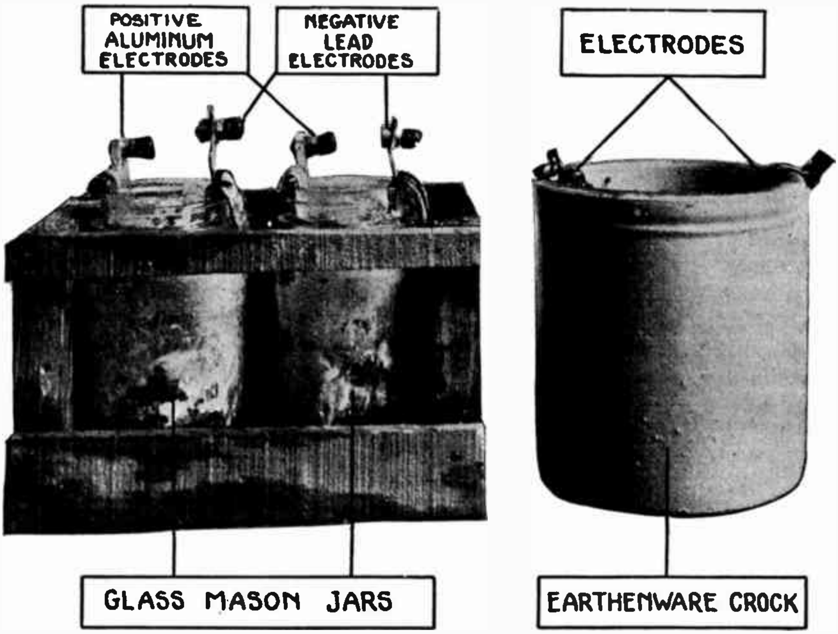
nating current line, acts only as a resistance, and if it were connected to the battery without first having the plates formed, it would allow alternating current to flow through the battery.

In other words, the rectifying action of this type of cell depends on the chemical action which takes place in the thin crust or deposit on the aluminum plates, and if the plates are not first formed they will not rectify efficiently.

The only part that has to be replaced in the cell is the aluminum plate, which eats away after a period of usage.

The above type of rectifier has been used for many months by the designer, and it has given him uniformly excellent results and the cost per charge has been extremely low.

There are many different types of battery chargers on the market and some of them are designed to charge direct from the direct current mains while others are constructed to operate on alternating current circuits. It is easy to see that it is only necessary to reduce the voltage when a battery is to be charged on a 110 volt D.C. circuit. Charging the battery by connecting it directly to a circuit of this voltage would overcharge the device so rapidly that it would soon succumb to the mistreatment. Direct-current charging devices are usually made up of a series of resistance coils so arranged as to get the proper voltage drop when they are used in connection with direct-current circuits. Sometimes a number of electric lights are used in place of the resistance

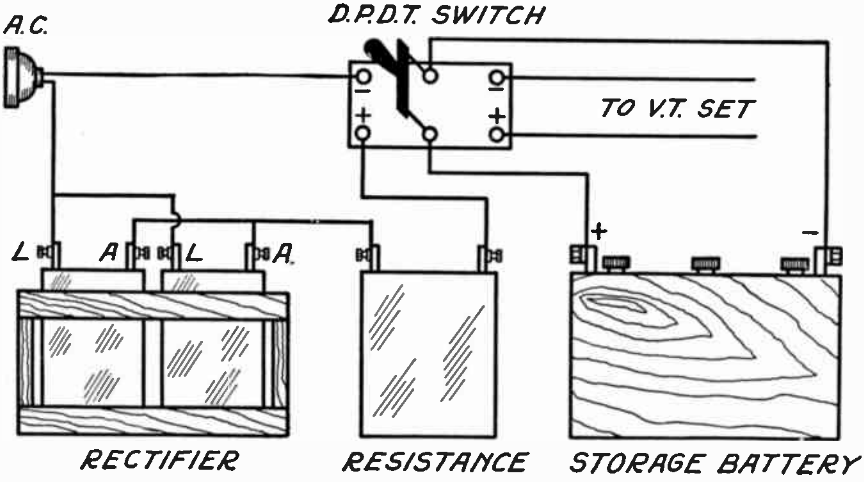


A COMPLETE CHEMICAL RECTIFIER AND WATER RHEOSTAT

Figure N: The rectifier jars are set up in a woo den rack, and an earthenware crock is used to hold the electrodes of the water rheostat. With these two u nits the radio fan may charge his own batteries at home from the A.C. lighting mains at small cost.

but this is really a wasteful method since the lights must be kept burning while the battery is charging. It is easy to see that something more than a resistance must be placed between a lighting circuit carrying alternating current and a storage battery to be charged. A mere resistance will not suffice because the alternating current will have no charging effect whatever on the battery. This is so because the current has no definite polarity. One instant one side is negative and the next instant it is positive. The charging apparatus must not only reduce the potential of the circuit but it must also rectify the alternating current; that is, change it to a unidirectional pulsating current with the positive and negative polarity. Rectification for purposes of battery charging may be carried out in a number of different ways. There is what is known as a magnetic or vibrating rectifier. This is really mechanical rectification brought about by means of a vibrating armature. This vibrating armature which is caused to vibrate by the alternating current impulses, is arranged with a system of contacts so that when it is in motion it functions as a polarity changing switch. It is by so changing the path of the electric current that the current is kept going in a single direction. It will be seen that a vibrator would not have to operate very rapidly to keep pace with a 60-cycle current.

We see in Fig. Q a sketch representing a well-known type of vibrating rectifier. In this instrument the current is allowed to pass only in one direction. When it reverses itself it is prevented from entering the terminals of the battery. The voltage is brought down to the proper level by a small step-down transformer which we see illustrated diagrammatically in connec-

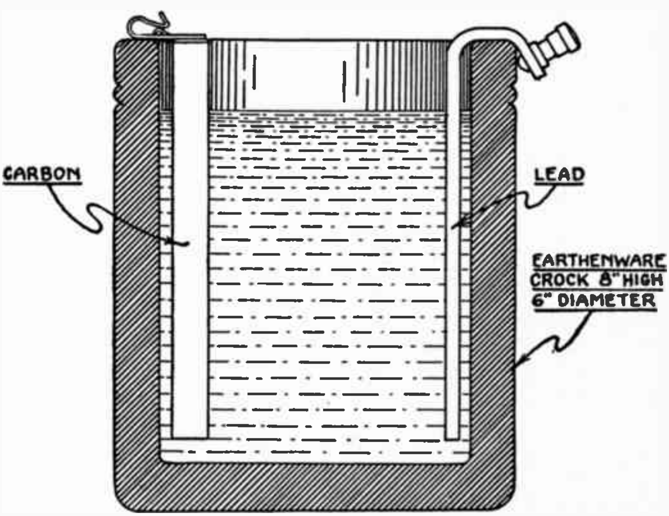


HOW TO WIRE UP A CHARGER

Figure O: The circuit diagram for connecting up a rectifier, the rheostat, the storage battery and the change-over switch. By throwing the switch to the left the battery is put on charge and by throwing it to the right the battery is connected to the vacuum tube receiving set.

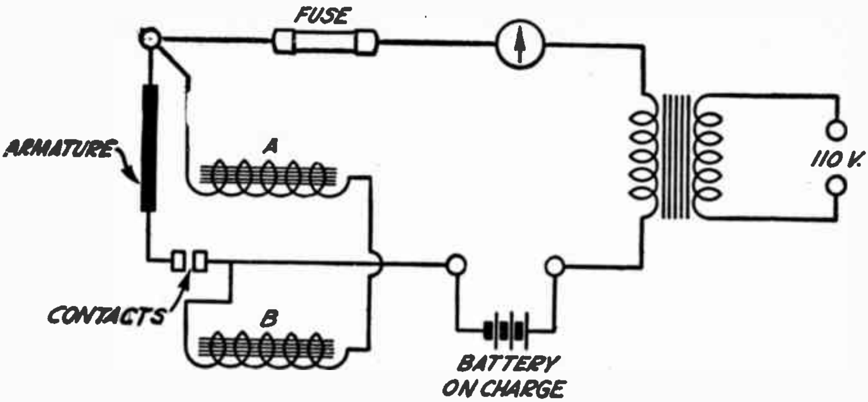
tion with the sketch. A fuse is inserted in series with the ammeter so that the circuit will be protected should a "short" develop on the secondary side of the transformer. The two coils A and B function to operate the armature. When the device is in use the ammeter will register the number of amperes that the battery on charge is taking. If the charger is operating efficiently this charging rate will taper off as the battery becomes filled. It may start at 5 or 6 amperes and taper down to 1.

Here it might be helpful to say something about the indications that a healthy battery will give while it is being charged. It is advisable to remove the filling caps from the cells so that the battery will gas freely for this is one of the indications of successful charging. If the battery is not gassing freely or does not gas at all, it is probably not charging. In the case of a magnetic type of rectifier, the trouble may be traced to a number of things. The fuse may be blown and in such a case the ammeter would register zero current. It may be also that the clips on the charging wires have not made proper contact with the terminals of the storage battery. Storage battery terminals are very difficult to establish connection with due to extreme corrosion of the metal that is brought in contact with them. Sometimes the filing of the clips on the end of the charging wires and on the battery terminals will overcome this trouble. Although it is not necessary to constantly adjust the contact points of vibrating rectifiers, they do in time become misplaced and it is necessary to move the adjusting screw or screws until a point is reached where the ammeter indicates that the battery



HOW A WATER RHEOSTAT IS PUT TOGETHER

Figure P: The rheostat consists of an old earthenware crock which is filled with water to which has been added a half-teaspoonful of salt. The lead and the carbon electrodes are then immersed in the liquid on opposite sides of the crock.



CONNECTIONS OF A BATTERY CHARGER

Figure Q: One of the schemes of connection used in a conventional magnetic charger for storage batteries. The small transformer at the right is of the step down type, bringing the voltage from 110 down to approximately six. Practically all magnetic battery chargers on the market are operated on this principle.

is receiving its normal charging current. Contacts on these devices also burn and it is necessary to eventually replace them with new ones that may be supplied by the manufacturer.

The cautious student will see that when two or more batteries are charged at one time the method of connecting them is important. Since the voltage of the rectifier is usually in the neighborhood of six and since the voltage of a storage cell is about 2.2 more than three cells in series could not be charged. All radio A batteries are made up of three cells connected in series and when it is desired to charge more than one A battery the batteries must be connected in parallel as will be seen by reference to the sketch Fig. R. These parallel connections leave the voltage of the entire battery still six but the current consuming capacity of the system is doubled providing the two batteries are of the same ampere hour capacity. Hence it will take twice as long to charge the two cells. More than two batteries in parallel is not advisable and as a matter of fact is quite beyond the capacity of the average type of magnetic rectifier. Some of them will "carry on" but they become dangerously hot and might cause trouble unless watched very carefully.

Since radio broadcasting has been commercialized, storage battery manufacturers have accommodated radio users with storage B batteries that may be charged and recharged many times before they are finally exhausted. These batteries are usually put out in 22½, 45, 90 and 100 volt capacities. By dividing every one of these figures by two we arrive at the number of cells in each battery. The cells are sometimes in glass containers and sometimes in rubber containers.

It is impossible to charge radio B batteries with a magnetic charger or any other type of charger used in the conventional way. It is evident that we cannot hope to charge a 45-volt producer with a 6-volt source. That would be like trying to force a 6-lb. stream of water against a 45-lb. stream. By following out certain directions however, simple provisions may be made so that B batteries can be charged from a vibrating rectifier.

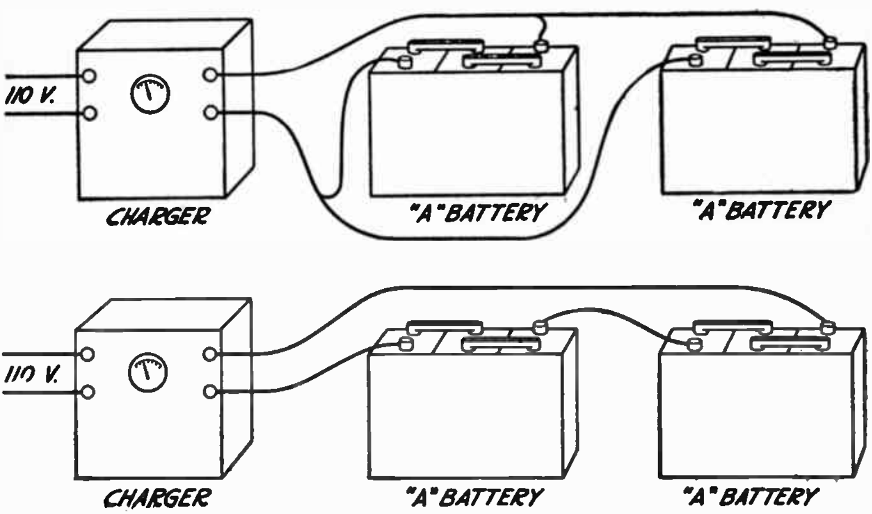
We have shown in Fig. S how such connections are made. The accessories necessary follow.

1 2-socket plug.
1 porcelain socket.
1 60-volt lamp.
3 standard attachment plugs.

These plugs are connected up with standard flexible lighting cord as shown in Fig. S. Since the fuses used in magnetic rectifiers are usually of the plug type it is only necessary to remove the fuse and insert the plug as shown. This system works only when the A battery is being charged at the same time. Omission of the A battery will unbalance the whole system and make it impossible to charge B batteries.

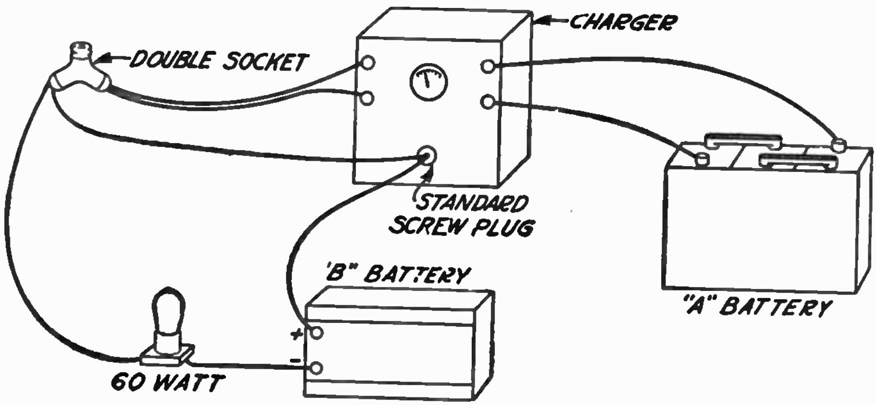
It is a comparatively easy matter to charge an A or B battery from a direct-current circuit since it is only necessary to insert the proper regulating resistances. Such resistance units are available on the open market and they may be connected with a switch as illustrated (Fig. T). In this way it is only necessary to throw the switch over to change the battery connections from the radio set to the charger. All of the connections can be permanently made.

Unless a voltmeter is available it is difficult to determine when a battery is completely recharged. When a battery has been successfully recharged it should cease to gas freely and its temperature may go up considerably. The sides of a battery will always be slightly



RIGHT AND WRONG METHODS OF CONNECTING BATTERIES

Figure R: The diagram above shows the correct method of connecting two six-volt storage batteries to a six-volt magnetic or vacuum tube charger. The method illustrated at the bottom should never be employed unless a twelve-volt charger is available.



HOW TO CHARGE A B BATTERY

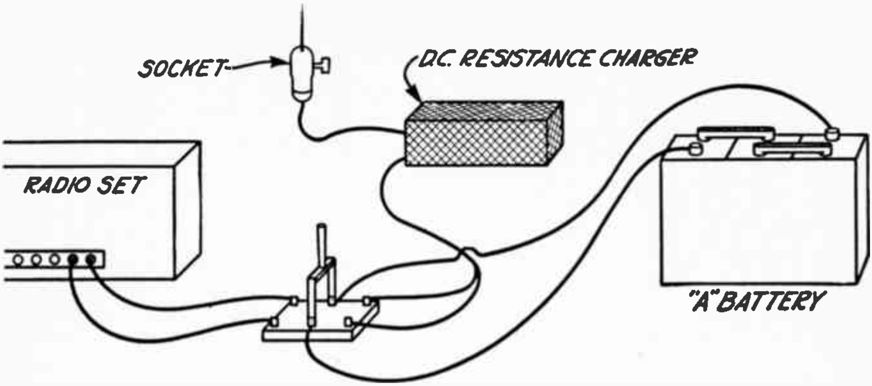
Figure S: How a B battery is charged with a magnetic charger. This must be done while a six-volt A battery is on charge. The connections shown must be slightly different for the different makes of chargers on the market.

warm after it has been charging for some time. The safest practice is that of applying the voltmeter.

It is not wise to leave batteries in an uncharged condition for any great length of time. In the case of the ordinary lead plate battery this is very dangerous practice and usually results in permanent injury to the cells. If batteries are to be left for a long period (two or three months) unused it is advisable to first give them a good charging. They may then be left either in the wet or dry state. That is, the electrolyte may be poured off or it may be left in. If the electrolyte should be poured off and replaced, chemically pure water, which is available at every battery charging store for 25 cents a bottle, should be used. Water from the city source always contains a sufficient quantity of certain chemicals to destroy storage batteries even when introduced in small amounts. This is especially true of B batteries where the plates are smaller and more delicate and consequently more susceptible to abuse, either chemical, mechanical or electrical.

Those who object to the hum of the magnetic type of rectifier may desire to invest in the tube type of rectifier. This is more quiet in operation and charges a battery just as thoroughly as the types dealt with previously. In this type of rectifier an exceptionally heavy two element vacuum tube of special construction is used to rectify the 110-volts of alternating current. Of course a step-down transformer is employed in connection with the tube so that the proper voltage will be available at the terminals. Such chargers are used in exactly the same way as the magnetic chargers and all connections save those for charging B batteries are the same.

There has recently come to the American market numerous devices called B battery eliminators. It is the function of such equipment to take current from the lighting circuit for the purpose of placing the requisite charge upon the plate of vacuum tubes, a function heretofore performed by storage



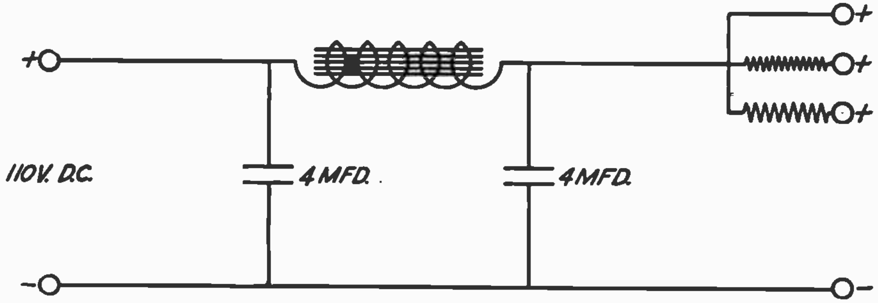
CHARGING FROM THE D. C. MAINS

Figure T: It is only necessary to use a small resistance unit in connection with a D. C. circuit when storage batteries are charged. This illustrates the method of connecting it to the line.

B or dry-cell B batteries. It should be plain to the student that we could not take the raw direct or alternating current from a socket and place it upon the plate without producing distortion in the music. For this purpose we must employ an absolutely unvarying and uniform source of voltage. Even a direct current taken from the lighting socket will be unsuited because of the very considerable commutator ripple. This commutator ripple causes a hum which is quite noticeable in the loud speaker. It stands to reason that alternating current without being rectified and smoothed out would be hopelessly unsatisfactory because of its constant reversals. At one instant there would be a negative charge on the plate and at the next instant a positive charge, while we know from experience that an unvarying positive charge is necessary.

What B battery eliminators do then is to take 110 volts of direct current or alternating current and doctor it up so that it is available for plate use instead of A and B batteries. Of course no rectification is necessary in the direct current types as we shall see by referring to Fig. V. Here we will find pictured a choke coil, two 4-mfd. condensers and two resistances. The heavy paper condenser and the choke coil are used in connection with this set to "iron out the ripples" as engineers put it. The tendency of the condensers and the choke coil to eliminate the depressions or the variations in voltage, thereby cutting out the hum that would be present if the 110 volts should be connected directly to the plate. The object of the resistances is simply that of permitting the user to tap off different voltages. It is evident that 110 volts is the maximum amount that could be used with this sort of equipment. As a matter of fact it is really a little less than this for the choke coil has an appreciable resistance which must be overcome at a sacrifice in potential.

The device just described is so simple and functions so beautifully in connection with direct current circuits that the more ambitious reader may wish to



THE PRINCIPLE OF THE B BATTERY ELIMINATOR

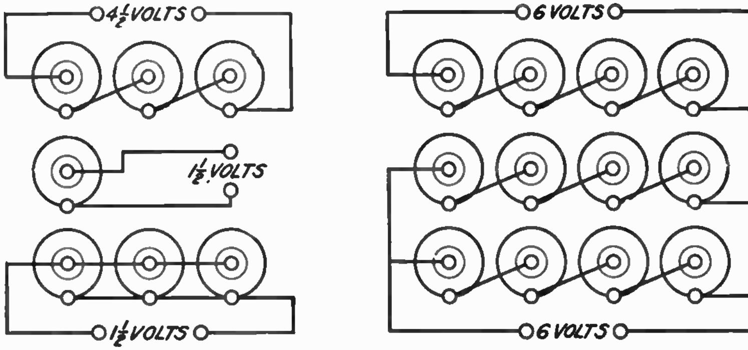
Figure U: Here the connections used in a simple type of B battery eliminator are given. This type, however, is designed only for use in connection with a 110-volt direct current circuit.

construct it. The 4 mfd. condensers are available in any large radio shop and the choke coil may be the primary of an ordinary audio-frequency transformer. The secondary connections of the transformer are not used. The two resistances shown are No. 10 Bradley-ohms.

Alternating-current B-battery eliminators are of necessity much more involved than the type just described. Two different types are available. One is a chemical type in which rectification is brought about by a chemical cell similar to that described in the earlier part of this particular portion of the course. After the current is rectified it is put through a circuit similar to the one just described, in which the ripples and irregularities of the line voltage are smoothed out. The other type of alternating-current B-battery eliminator employs a special type of rectifier tube in place of the chemical cell just mentioned. This tube has a filament and a plate and is usually constructed along the lines of the original Fleming valve save that it is capable of handling a large volume of current and is built along modern lines. The filter circuit, which is the smoothing out circuit, contains inductances and condensers arranged in some fashion similar to that employed in connection with the direct current B battery eliminator which was described previously.

Dry cells intended for B battery use do not need to have a very great current capacity and consequently they may be very small in size. This makes it possible to mount a large number of them in a small space so that a battery giving the required voltage does not take up much more space than an ordinary heavy duty dry cell of the type employed for door bells. B batteries are usually made in two voltages 22½ and 45. These classifications are further divided into two sizes, the small and large 22½ and the small and large 45. Of course, the larger sizes last longer because the cells are larger and are able to deliver a greater volume of current over a greater period.

There is really little that a user of B batteries can do in the way of proper care save refraining from short circuiting the terminals. Due to the small cells it is a very easy matter to permanently injure a B battery by allowing it to remain upon a short circuit for only a short time. Batteries should also be



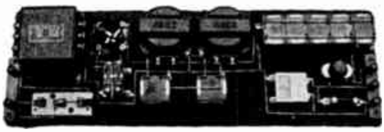
HOW TO CONNECT BATTERIES

Figure V: How batteries are connected to obtain various degrees of voltage and current.

kept in as cool a place as possible for they rapidly deteriorate in an abnormal temperature. Extreme deterioration can usually be detected by blisters that rise on the surface of the sealing wax. The battery may also bulge at other points and if tested under these conditions with a voltmeter it will be found that the voltage has dropped considerably. There is no practical way of reviving B batteries although many radio fans may feel that some of the various chemical treatments do some good. The trouble, expense and muss caused is entirely out of proportion to the results achieved.

The failure of B batteries is indicated in radio sets by a reduction in volume and if the batteries are in a very bad condition by noises caused by extreme chemical action. It is, of course, advisable to have a small pocket voltmeter on hand to test the batteries when it is felt that trouble is arising from this source. Such voltmeters can be placed directly across the terminals of the large and small batteries without any danger to the instrument. If the hands are sensitive a small shock may be felt from the 45-volt size, but it is usually nothing more than a tingle. However, people sensitive to shock and especially children should not permit their fingers to come across the terminals of two of the 45-volt size connected in series. Such a combination will deliver quite a substantial jolt.

Since ordinary dry cells of the heavy duty type are being used so much nowadays with the dry cell tube the reader may find something of value by referring to Fig. V. Here he will find diagrams showing the different ways in which dry cells are connected for different voltages.



Acme B-Eliminator

Specifications

Type; vacuum tube
Tube; gaseous, no filament
Voltage; up to 180 volts
Input; 110 to 115 volts A.C.
Size; 10½ x 8½ x 3½ ins.
Supply; for detector and amplifier

Balkite B-Eliminator

Specifications

Type; chemical
Voltage; 90 volts
Input; 110 to 115 volts, A. C.
Current output; 20 milliamperes
Size; 8 3/16 x 8 x 3¼ ins.
Supply; for detector and amplifier. Will handle six tubes

Dubilier B-Eliminator

Specifications

Type; vacuum tube
Tube; filament
Voltage; 10 to 50 for detector. Amplifier voltage 100
Input; 110 to 115 volts A.C.
Size; 9¾ x 8 x 5½ ins.
Supply; for detector and amplifier
Input power; 12 watts

Epom B-Eliminator

Specifications

Type; tube
Tube; gaseous
Amplifier Voltage; 150 (adjustable)
Input; 110 to 115 volts A.C. .3 amp.
Size; 6 5/16 x 10¾ x 4 13/16 ins.
Supply; for detector or amplifier

Ferbend B-Eliminator

Specifications

Type; chemical
Voltage; 100
Line voltage; 110 to 115 A.C.
Supply; for amplifier and detector
Case; wooden

Mu-Rad B Battery Eliminator

Specifications

Type; tube
Voltage; 20 and 90
Line voltage; 110 to 115, 60 cycle
Supply; for amplifier and detector
Tube; filament type
Size; 6 x 4½ x 10 ins.
Case; metal

Mayolian B-Eliminator

Specifications

Type; vacuum tube
Tube; filament
Output voltage; 50 to 150
Current output; 70 milliamperes
Input; 110 volts A.C.
Supply; for detector or amplifier

Rhamstine B-Eliminator

Specifications

Type; vacuum tube
Tube; filament
Detector voltage; 0 to 150
Amplifier voltage; 0 to 110
Input; 110 to 115 volts A.C.
Size; 6 inches square
Supply; will handle up to 8 tubes

Timmons B-Eliminator

Specifications

Type; vacuum tube
Tube; filament
Amplifier voltage; 0 to 120
Detector voltage; 16 to 45
Input; 110 to 115 volts A.C.
Size; 7 x 3 x 8¼ ins.
Supply; will handle 6 tube receiver

Glenn Martin B-Eliminator

Specifications

Type; tube
Tube; UV201A or C301A
Detector voltage; 0 to 75
Amplifier voltage; 135 to 150
Input voltage; 110 to 115 A.C.
Supply; for detector and amplifier
Current output; 20 milliamperes
Number of tubes; will supply voltage for 5 tube set
Size; 5⅞ x 4¾ x 8¼ ins.

RCA B-Eliminator

Specifications

Type; tube
Tube; double rectifier filament
Line voltage; 110 to 115 A.C.
Output voltage; 22½ to 135
Output current; for all ordinary receivers
Supply; for detector and amplifier

RCA B-Eliminator

Specifications

Type; tube
Tube; double rectifier filament
Line voltage; 110-115 A.C.
Output voltage; 22½ to 135
Output current; for all ordinary receivers
Supply; for detector and amplifier

Valley B-Eliminator

Specifications

Type; tube
Tube; filament
Detector voltage; 0 to 45
Amplifier voltage; 65 to 140
Input; 110 to 115 A.C.
Output current; 35 milliamperes
Supply; up to 8 tubes

Exide Storage B Battery

Specifications

Type; 1 lr. tube
Voltage; 24
Capacity; 6000 m.a.h.
Size; 7¼ x 9 7/16 x 7 ins.
Containers; round glass jars

Exide Storage B Battery

Specifications

Type; 24 lr. tube
Voltage; 48
Capacity; 6000 m.a.h.
Size; 7½ x 13 1/16 x 9 3/16 ins.
Containers; round glass jars

Exide Storage A Battery

Specifications

Type; 3 LXL 5-1
Voltage; 6
Capacity; made in sizes from 50 a.h. to 150 a.h.
Size; 6½ to 13¼ long x 9 inches
Weight; 24½ pounds to 59½ pounds
Container; moulded composition

Edison A Battery with Charger

Specifications

Voltage; supplied in all sizes from 1½ volts
Capacity; from 18.75 a.h. to 75 a.h.
Size; varies from 7¼ x 4¾ x 12½ to 18 ins.
Charging equipment included in wooden case

Edison B Battery

Specifications

Type; 36
Voltage; 45
Capacity; 25 m.a.h.
Size; 10 x 7 3/16 x 5¾ ins.
Case; moulded composition

Exide Power Unit

Specifications

Type; 6 volt A.
Voltage; 6 v.
Capacity; in sizes up to 100 amp. hours
Charger; trickle type
Case; pressed metal

Gould B Battery

Specifications

Voltage; 24
Capacity; 2,000 m.a.h.
Size; $6\frac{3}{4}$ x $3\frac{7}{8}$ x 5 3/16 ins.
Case; moulded composition

Gould Power Unit

Specifications

Type; A.C. 30
Line voltage; 110 to 125 v. 60 cycle
Voltage; 6
Capacity; 120 a.h.
Charging rectifier; chemical
Size; $21\frac{3}{4}$ x $7\frac{1}{2}$ x 9 3/16 ins.

Philco Power Unit

Specifications

Type; A 60
Line voltage; 105 to 125, 60 cycle
Voltage; 6
Charger; tungar type, bulb
Capacity; made in various sizes
Size; 12⅞ x 9½ x 8 9/16 ins.

U.S.L. Storage B Battery

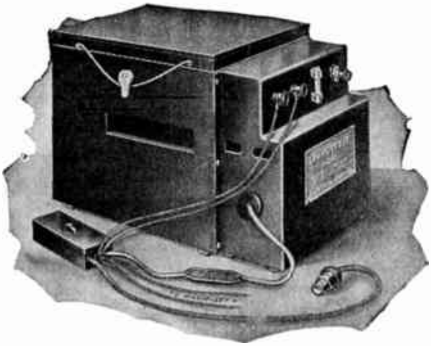
Specifications

Type; DXS 2402
Voltage; 48
Capacity; 4,500 m.a.h.
Size; 12 3/16 x 8 5/16 x 7½ ins.
Case; wooden
Containers; glass jars

Gould Storage B Battery

Specifications

Voltage; 96
Capacity; 2,000 m.a.h.
Case; wooden
Containers; moulded composition
Size; 18 x 8 x 6¼ ins.



Gould Power Unit

Specifications

Type; A.C. 6
Line voltage; 100 to 125 v. 60 cycle
Voltage; 6
Capacity; made in various sizes.
Size; 9½ x 7 11/16 x 11⅞ ins.

Philco Power Unit

Specifications

Type; A.B.
Line voltage; 105 to 125. 60 cycle
(special types made for 25, 30 and 40 cycle)
Charger; trickle type
A battery voltage; 6
Amplifier voltage; 130
Detector voltage; fixed
Case; wooden
Size; 12¼ x 11½ x 9⅜ ins.

Philco B Battery and Charger

Specifications

Type; B 60
Line voltage; 105 to 125 A.C.
Charger; chemical type
Voltage; 130
Supply; for detector and amplifier
Case; sheet metal
Size; 8⅞ x 8½ x 7⅞ ins.

Willard Storage B Battery

Specifications

Type; WTAM 127
Voltage; 48
Capacity; 6,000 m.a.h. at 25 m.a. rate
Case; wooden
Containers; glass jars

Willard Storage B Battery

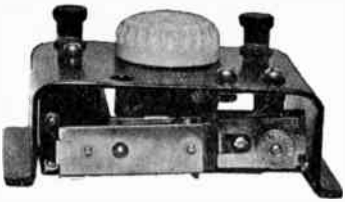
Specifications

Type; H.R. 127
Voltage; 48
Capacity; 300 m.a.h.
Case; wooden
Containers; glass jars

Wilson Power Unit

Specifications

Voltage; 72
Case; wooden with cover
Size; 25 x 10½ x 7 ins.
Weight; 50 pounds
Charger; chemical type
Cell containers; glass jars
Line voltage; 110 to 120 A.C.



Apco B Battery Charger

Specifications

Type; 89
Type; self-polarizing vibrator
Line voltage; 110 to 115
Capacity; will charge 24 to 100 v. B batteries in 10 hours; 1/10 to ¼ amp.
Case; semi-covered

Balkite Charger

Specifications

Type; chemical
Charging rate; 2.5 amps.
Line voltage; 110 to 120, 60 cycles current
Size; 6 x 10¼ x 6½ ins.
Case; sheet metal

Dynamik Charger

Specifications

Type; tube
Tube; tungar filament bulb
Current; 2 and 5 amp. sizes
Line voltage; 110 to 115 A.C.
Container; pressed metal

Exide B Battery Charger

Specifications

Type; chemical
Line voltage; 125 A. C.
Capacity; sufficient to charge radio B batteries up to 100 volts
Container; glass jar
Cover; moulded composition

Eclipse Charger

Specifications

Type; vibrating rectifier
Line voltage; 110-125 volts
Charging current; 2 amps.
Charging voltage; 6 to 96
Container; metal case

Kodel Charger

Specifications

Type; vibrating rectifier
Line voltage; 125 v.
Charging current; 5 amps.
Charging voltage; 6 v. (also adjustments for B batteries)
Container; metal case

Kodel Charger

Specifications

Type; tube
Tube; tungar
Line voltage; 125 volts A. C.
Capacity; 2 amps.
Charging voltage; 6 v. (also adjustments for B batteries)
Case; uncovered

Sterling Battery Charger

Specifications

Type; vibrating rectifier
Line voltage; 110 to 115 v. A. C.
Charging voltage; 6 (also accommodations for B batteries)
Charging current; 5 amps.
Case; pressed metal

Valley Charger

Specifications

Type; vibrating magnetic
Line voltage; 110 to 115 v. A. C.
Charging voltage; 2 to 96 v.
Charging current; .1 to 5 amps.
Container; pressed metal case with glass cover
Size; 6 x 6¾ x 7½ ins.

Tungar Charger

Specifications

Type; tube
Tube; tungar filament tube
Current; sufficient for all A-batteries
Line voltage; 110 115 A. C.
Container; pressed metal
Output voltage; 6 volts

Tungar Charger

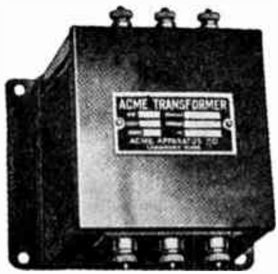
Specifications

Type; tube
Tube; tungar filament bulb
Current; sufficient for all A-batteries
Line voltage; 110 to 115 A.C.
Output voltage; 6
Container; pressed metal

American Choke Coil

Specifications

Use; choke for elimination of hum in B-battery devices
Current rating; 60 milliamperes
Terminals; binding posts
Case; uncovered type. Arranged for base mounting



Acme B-Eliminator Transformer

Specifications

Input voltage; 110 to 115 A. C.
Output voltage;
Output current;
Case; pressed metal
Terminals; binding posts
Use; for double rectifier tubes

American B-Eliminator Transformer

Specifications

Input voltage; 110 to 115 A. C.
Output voltage;
Output current;
Case; cast metal
Terminals; pigtails
Provided with voltage graduating switch

Jefferson B-Eliminator Transformer

Specifications

Line voltage; 110 to 115 A.C.
Current output;
Voltage output;
Case; pressed metal
Terminals; binding posts
Finish; black enamel

Precise A-Battery Circuit Breaker

Specifications

Use; to open A battery circuit in case of short circuits
Type; solenoid magnetic
Case; pressed metal
Setting; may be set for operation at varying current strengths. When the device trips the circuit is again closed by outside button

SECTION XV

The Different Types of Receivers

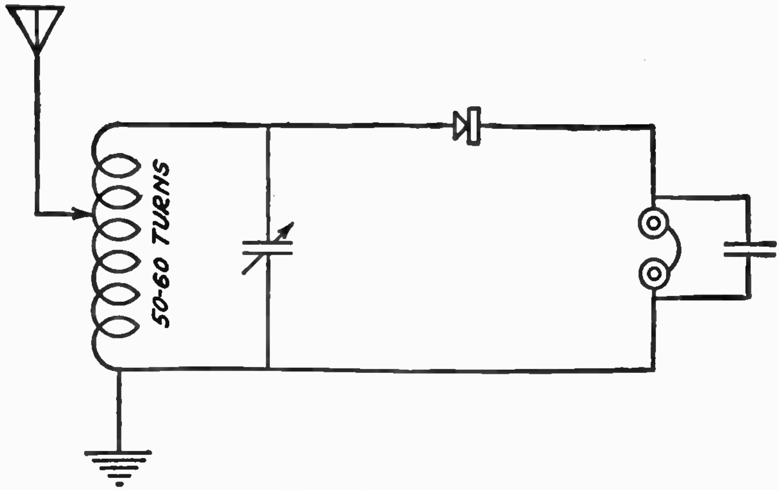
SINCE broadcasting has come into its own our research workers, under the impetus of competition, have added many new types of receivers to the list of those available for public use. Some of these outfits have represented distinct new departures in principle while others have been mere adaptations of the standard circuits. It is a very easy thing to disguise a radio circuit so that the novice cannot identify it, and many youngsters have gained considerable notoriety through the newspapers in developing circuits with new names and old principles.

In this work of classifying radio receivers we had best start at the very bottom of the ladder and give our first attention to the crystal set. In Fig. A we have what is known as a single circuit crystal receiver. By single circuit we mean that we have but one tuned circuit which is the antenna circuit. In reality this is a two-circuit receiver, although for practical purposes it is said to have one circuit. The two circuits that we refer to are the open circuit (aerial circuit) and the closed circuit (tuning coil, detector, and 'phones.) Sometimes this is referred to as a close-coupled circuit because the circuit involving the 'phones, tuning coil and detector are connected directly to the aerial circuit.

An improvement over this single circuit receiver can be made by replacing the single slide tuning coil with a loose coupler, that is a two-coil tuner with the coils inductively arranged, one within the other. It is plain that we have two circuits here, the aerial circuit which is sometimes called the primary circuit and the circuit involving the 'phones and detector which is sometimes called the secondary circuit. The coil in this circuit is also called the secondary coil. The advantage of this two-circuit crystal receiver lies in its ability to tune more sharply and to give a greater signal strength.

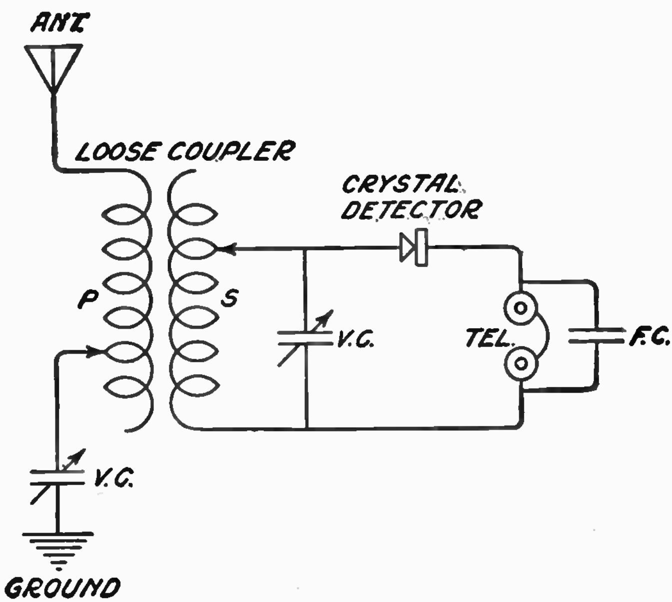
Crystal receivers may be elaborated upon by introducing more circuits and by adding variable condensers and fixed condensers, but the money that would be necessary to increase the efficiency of a crystal receiver would be so great an amount that it could be used in the purchase of a vacuum tube outfit. Consequently it would be folly to launch off into an extended discussion of this subject.

If we will refer to Fig. C we shall be given an opportunity to study the various circuits involved in a single vacuum tube receiver containing but one tube which, naturally, is the detector tube. Here we have first the grid circuit. The grid is always connected directly to the



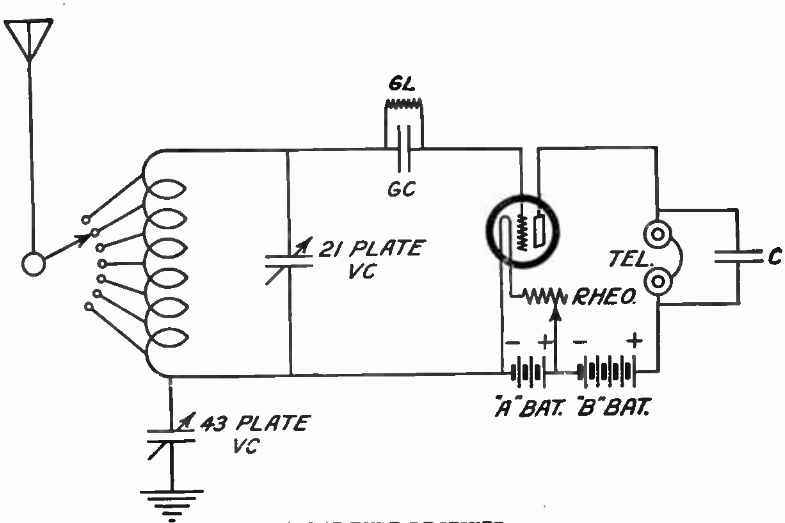
THE SINGLE-SLIDE TUNER

Figure A: This is one of the most simple radio sets that could possibly be assembled. By leaving the system untuned the tuning coil could be eliminated but the aerial would have to be of the correct size for the wave to be received.



A LOOSE-COUPLED CRYSTAL RECEIVER

Figure B: Here we have a more complicated type of crystal receiver employing two coils inductively related to each other. Louder signals and greater selectivity is claimed for this type of receiver.



A ONE-TUBE RECEIVER

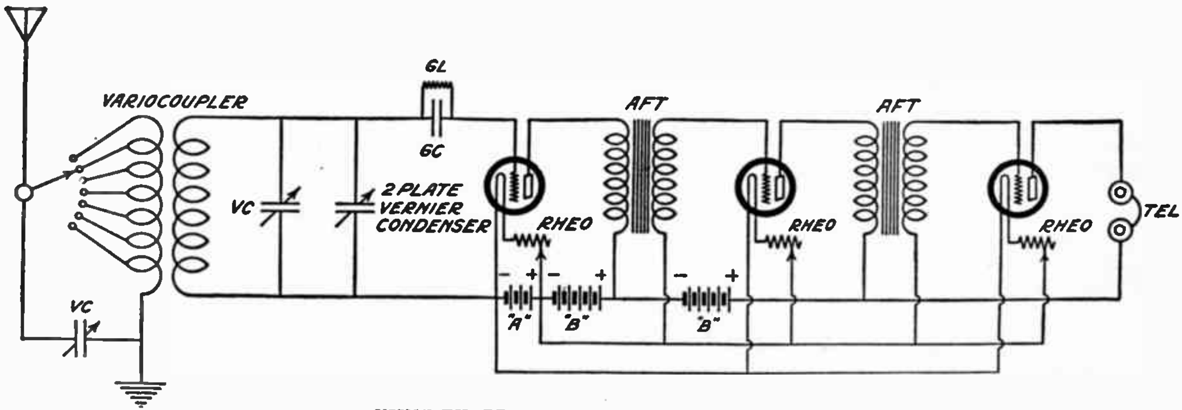
Figure C: Here is perhaps one of the most practical and simple single tube receivers that could be assembled. The receiver could be made more sensitive by using the regenerative principal.

tuning device. Next we have the filament circuit which involves the rheostat for the control of the A battery current, the A battery itself and the filament of the vacuum tube. It will be noticed that this A battery circuit forms part of the grid circuit as a unit. The third circuit is the plate circuit which is often referred to as the output circuit. This involves the plate of the vacuum tube, the B battery and the telephones or loud speaker. It will also be seen that this plate circuit makes connection with the filament circuit.

In Fig. D we have added two amplifying tubes to the simple circuit shown and it will be seen that we have added several more circuits to the layout illustrated in Fig. C. We have added two more grid circuits, two filament circuits and two more plate circuits. It will also be noticed that we have added another B battery, since a single battery cannot be used for detector and amplifying tubes working together. The detector must always maintain its own private source of plate-current supply. It is good practice however, to use but a single 45-volt B battery on a two-stage amplifier.

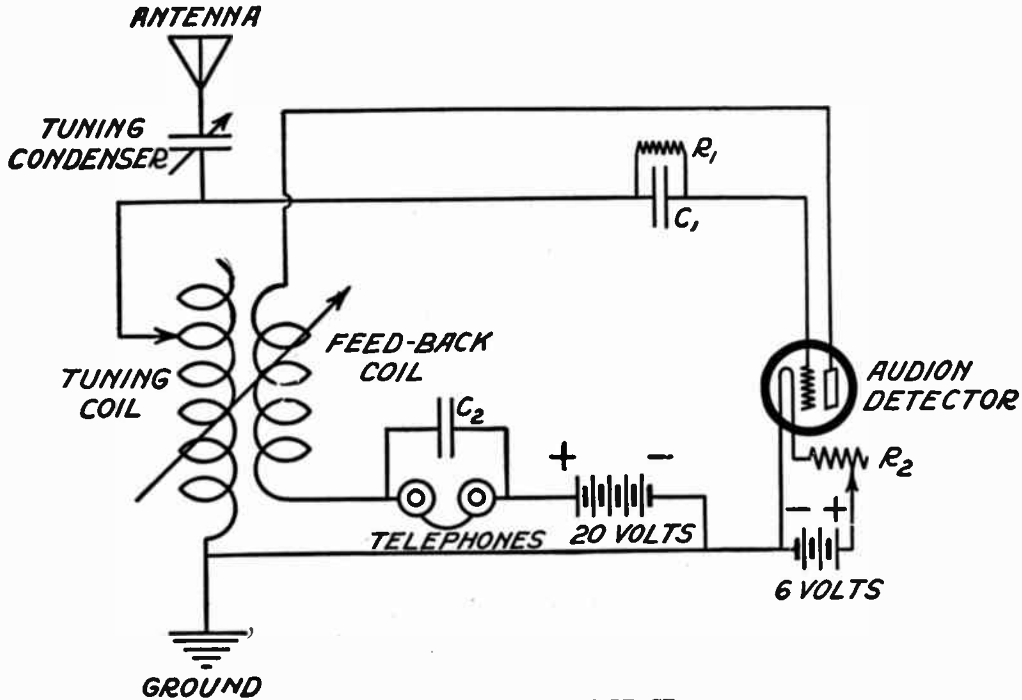
In Fig. E we will find a single tube receiver which is called a single circuit receiver because only the antenna circuit is tuned. This is really not a single circuit receiver because it has the plate. filament and grid circuits. It is only because but one circuit is capable of being tuned that it has been mis-named the single circuit receiver. It might be well to point out here that it is the single circuit receiver that causes so much annoyance by interference in neighborhoods where it is used. It is a prolific producer of squeals and squawks and every squawk and squeal produced is radiated into space to be picked up by perhaps hundreds of receivers in the neighborhood.

Before going further with our discussion of radio receiver types let us for



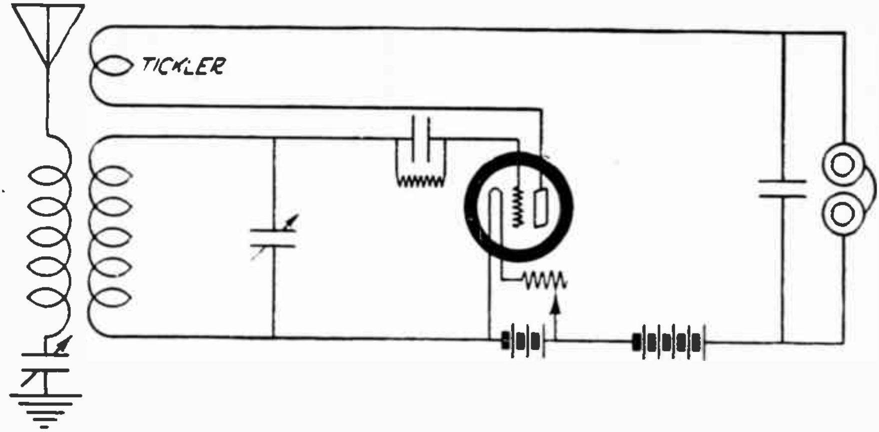
USING THREE TUBES AND REGENERATION

Figure D: Here we have the regeneration or feed-back principle of Armstrong used in a three-tube receiver of conventional design. Many modifications of the Armstrong principle have been used.



A DISTURBER OF RADIO PEACE

Figure E: Here is a single-circuit regenerative receiver which causes so much interference with reception. This combination is at once a receiver and a transmitter and causes squeaks and howls in neighboring receiving sets. It is a good circuit to avoid.

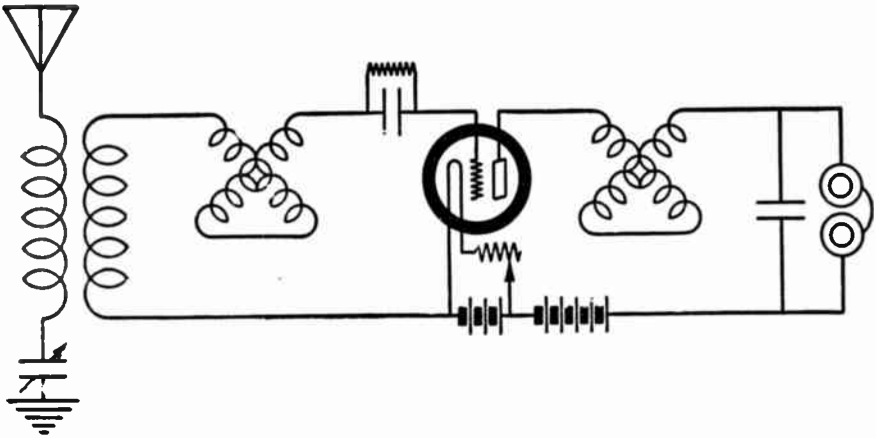


THE TICKLER THAT CAUSES REGENERATION

Figure F: Here a small coil is inserted in the plate circuit and placed in inductive relationship to the secondary of the tuning device. Thus energy is fed back from the plate circuit to the grid circuit.

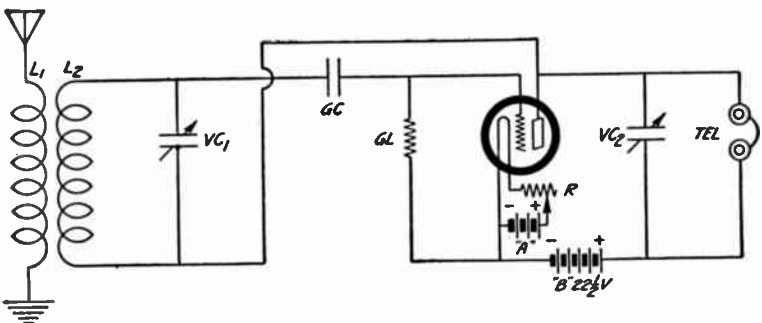
a moment take up the subject of the regenerative receiver. The single circuit receiver which was depicted in Fig. E was regenerative and very similar to the one shown in Fig. F, which represents the conventional Armstrong hookup. If we study Fig. F closely we shall see that we have nothing more or less than a regular detector and tuner, the only difference between it and a non-regenerative circuit being that a small coil is inserted in the plate circuit and that this coil (which is called a tickler) is brought up so that it is in line with the secondary of the loose coupler. In this system part of the output current passing through the telephones and plate circuit is re-impressed upon the grid of the vacuum tube and re-amplified. This results in a great reinforcement of the signal strength, and the process is sometimes referred to as "feedback", and such circuits are sometimes called self-amplifying circuits, since the vacuum tube is made to serve as a detector and an amplifier. Regenerative or feed-back circuits may be adjusted by changing the position of the tickler coil in relation to the secondary coil of the loose coupler. When the coupling is made too close an audio-frequency squeal which results in impressing too much energy upon the grid circuit takes place which makes reception impossible. The position of the tickler is simply changed until this squeal disappears and normal reception is secured.

There is another much used method of securing this regeneration or feed-back effect, and this is done with a double circuit receiver shown in Fig. G. Here two variometers, one in the grid circuit and one in the plate circuit, are used. The energy transfer is brought about by adjusting the variometer until the grid circuit is resonant with the plate circuit. When both circuits are in tune, the feed-back effect will take place and greater amplification will be produced. While this circuit is exceptionally sensitive it is at the same time difficult to control and unless controlled intelli-



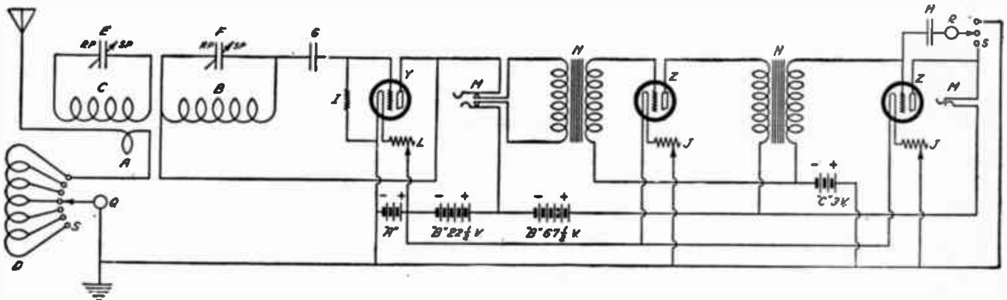
THE TWO-VARIOMETER REGENERATOR

Figure G: Here regeneration is produced by tuning the plate circuit to the grid circuit using the two variometers illustrated.



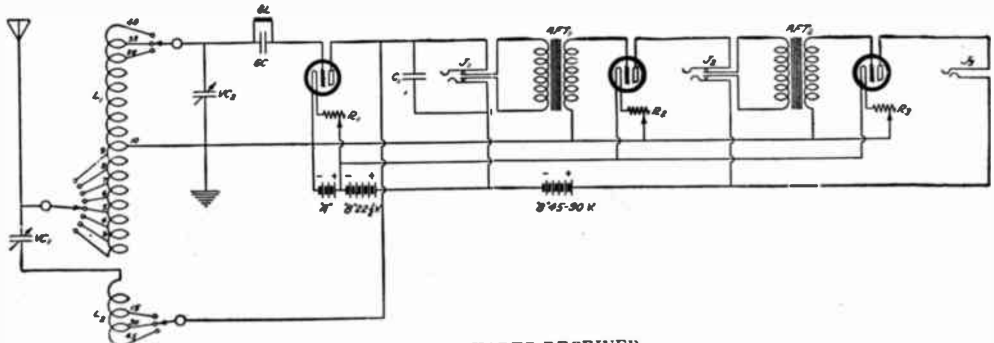
REGENERATION WITH CAPACITY FEED BACK

Figure H: In this case regeneration takes place not inductively but capacitatively through the natural capacity of the vacuum tube used in the circuit. This principle is little used however.



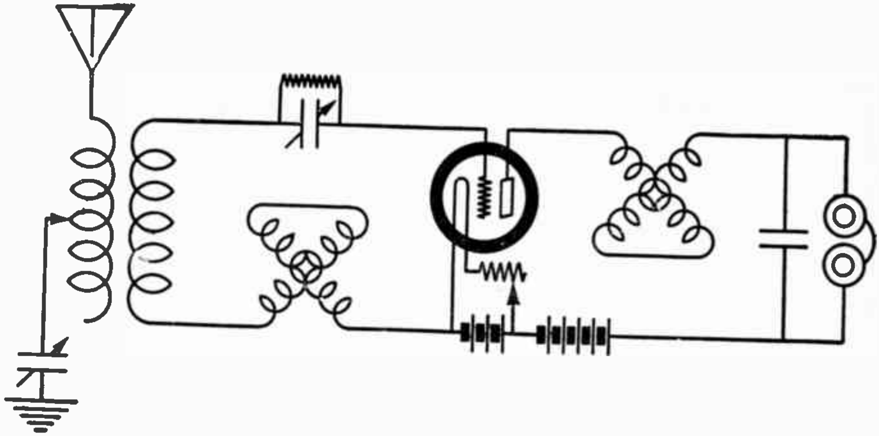
THE COCKADAY FOUR-CIRCUIT, A GOOD MODIFICATION OF THE REGENERATIVE PRINCIPLE

Figure I: Here is a regenerative set constructed along original lines. Four independent circuits are used and exceptional results in selectivity are accomplished.



THE RHEINHARTZ RECEIVER

Figure J: Here we have still another modification of the regenerative principle of reception. The Rheinhartz receiver has been vastly popular with the transmitting amateurs.



ANOTHER TWO-VARIOMETER RECEIVER

Figure K: This receiver is exactly the same as that illustrated in Figure G save that one variometer is connected in a different position. This is included to show that, although the instruments of a radio set may be connected in slightly different position, the operating principles may remain the same.

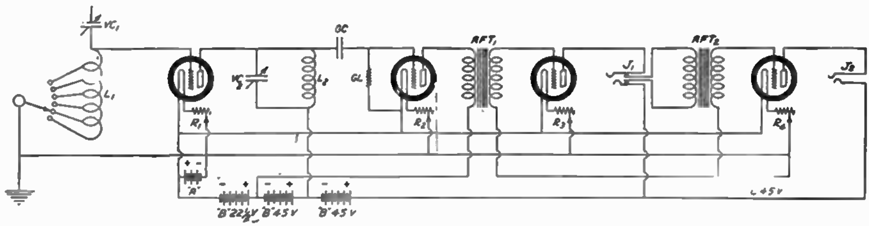
gently it is practically impossible to obtain good reproduction.

There are many modifications of the regenerative circuit first discovered by Armstrong. In some cases a capacity feed-back as shown in Fig. H is employed. Here there is a capacitative transformation of energy between the plate and grid circuits. As a matter of fact it is not always necessary to use a condenser for it usually happens that the capacity between the grid and plate is sufficient to bring this result about especially with American made tubes which have large plates and grids. English tubes, due to the ban on regenerative receivers in that country, are made with exceptionally small elements so that the capacity between them is small, hence these tubes are very good for radio-frequency amplification.

The only two really original adaptations of the regenerative circuit that have appeared since the advent of broadcasting are the Cockaday four-circuit tuner and the Reinhartz tuner. In each case the improvement has been brought about in the development of a selective tuning device. Cockaday achieves greater selectivity by employing the arrangement shown in Fig. I. Here four independent circuits can be traced in the tuning arrangement, the real feature being that, although involved, the circuit may be tuned with exceptional ease, and with a single knob. The four circuit tuner possesses features that closely approach the ideal tuning arrangement. Great selectivity with what practically amounts to unit control is something that engineers have been aiming at since 1922.

In Fig. J we see the second worthwhile adaptation of the regenerative principle which has been developed by Reinhartz, the American Amateur Ace who is recognized in his art on both continents.

In Fig. K we find another regenera-



REGENERATION WITH A TUNED GRID CIRCUIT

Figure L: Here we have a variable condenser used in the grid circuit of a regenerative set to bring about resonance.

tive circuit with a few improvements and refinements which help to bring about more agreeable results especially in the matter of control which is so important to the novice. This is a two variometer circuit, or more technically, a tuned plate and grid circuit which involves a variable grid condenser.

In Fig. L there is another version of the tuned plate circuit with the grid circuit controlled by a variable condenser of large capacity in place of the variometer described in connection with the previous receiver. While we are on the subject of reception by regenerative sets it might be advisable to broaden the discussion so as to include brief instructions in operation.

Before a regenerative set of the single circuit type can be operated successfully the novice must learn to control the regeneration; especially the audio-frequency regeneration. This audio-frequency note, which very often develops into an annoying squeal, is developed by the detector, and the amplifying system, of course, functions and makes it much louder than it would be with the detector alone.

There are really two ways of putting a regenerative detector into a responsive condition. One is to turn the filament rheostat until a point is reached just this side of squealing. In such a condition the loud speaker or telephones will emit a rushing sound of rather low intensity. Under such circumstances the detector will be in a most sensitive condition, and it should, by a little further adjustment of the filament rheostat, bring in very clear signals. There is still another way of adjusting single circuit receivers and this is to bring the filament rheostat to a point beyond that where noise is first heard into another zone of comparative silence. Here again a hissing sound will be registered which indicates a condition of high sensitivity.

Sometimes detector tubes in regenerative circuits are much too sensitive to oscillate because of too high voltage on the plate. It often happens that even 22½ volts, which is the regulation amount for detector tubes, is too high and must be brought down to 16½ volts before the tube will function normally. If a regenerative circuit gives trouble by breaking into oscillation, the reduction in B battery voltage is one of the first remedies that should be tried. It might be said in general that a regenerative set regardless of type is most sensitive to broadcasting and telegraphic signals when the detector is on the verge of breaking into audio-frequency oscillation. The filament rheostat should be brought up as far as possible and it will be found in general that the music will become slightly distorted just before the receiver breaks into a squeal.

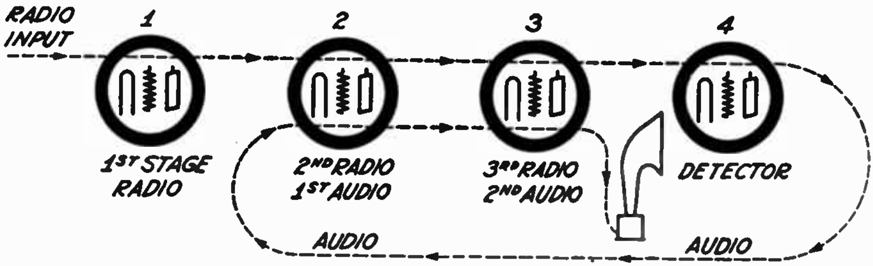
The three-circuit regenerative set similar to the one involving the two variometers and the loose coupler is, of course, a little more intricate for tuning but it should not completely baffle the novice if he follows the instructions given below. The initial operation is that of lighting the vacuum tubes and bringing the detector up to its position of maximum sensitivity. The amplifying tubes should never be worked beyond a point where clear reception is possible. Pushing the tubes may allow one to gain a little in volume but the quality of the reproduction is offensive to musically sensitive ears.

Having brought the set to a sensitive condition, it merely remains to tune in a broadcast wave. Of course, this operation is done with the aerial or primary circuit, for we could not hope to enmesh a wave unless it was first caught in the aerial system. The next operation is that of bringing the secondary circuit to a point where it will be resonant with the aerial circuit. This is done by moving the variometer or variable condenser and the position of the secondary coil on the vario-coupler. If this operation is done properly, the signal strength should now be built up to a point where further adjustment in connection with the variometer in the plate circuit should bring the ouptut current to maximum amplitude.

The principle of reflexing has been widely used in radio but so many variations have been made and so many different types of reflex sets have been placed upon the market and described in publications that it would take a fair sized volume to deal with the properties of all of them. The best that we can hope to do in this particular part of our manuscript is to outline in as practical a way as possible some of the principal receivers of this type. First, however, let us go into the general matter of reflexing. Let us assume that we have connected up in a simple reflex circuit a crystal detector and a vacuum tube. By employing the reflexing principle it is possible to make this one vacuum tube perform two functions. Current can be led to it from the aerial and amplified at radio frequency. It may then be passed on to the crystal detector where it is made audible. From this point it may be passed through the vacuum tube again and amplified at audio frequency. Thus it is seen that this single vacuum tube functions as a radio-frequency amplifier and audio-frequency amplifier simultaneously. In such a case we have a single tube receiver giving results often comparable and sometimes superior to those obtained with more conventional three-tube combinations.

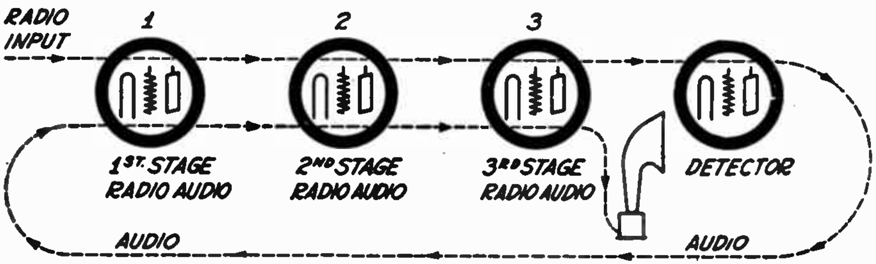
In Fig. M we have a four-tube reflex circuit in which the reflexing is done through two tubes only. The first three tubes function as radio-frequency amplifiers and the incoming signal passes through these tubes before it reaches the detector where it is brought down to an audible range. The output of a detector is then fed to tubes 2 and 3 where the current is amplified at audio frequency.

In Fig. N we have still another reflexing system where the first three tubes are used both as audio-frequency and radio-frequency amplifiers. However, the quality of this combination would not be as good as the qual-



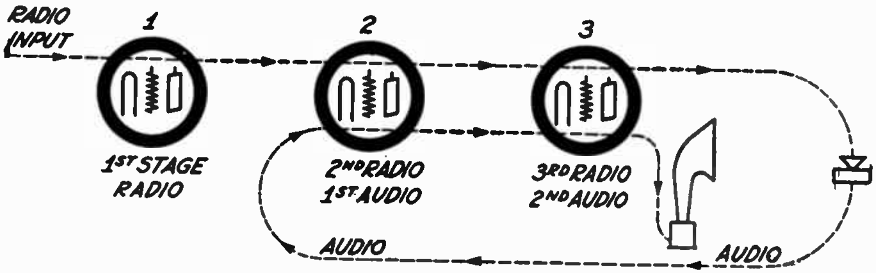
A FOUR-TUBE REFLEX

Figure M: In this set, two tubes of a four-tube set are caused to perform two separate functions, acting both as audio and radio-amplifiers simultaneously. The effect is that of six tubes.



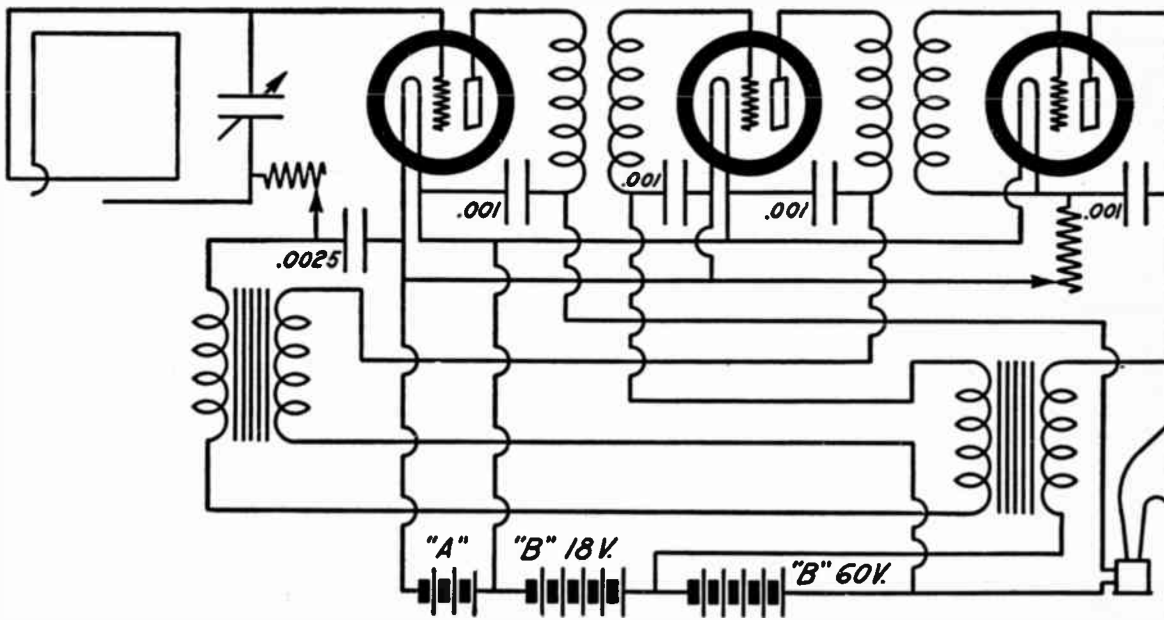
ANOTHER FOUR-TUBE REFLEX RECEIVER

Figure N: The first three tubes here are caused to do double duty and we have in a four-tube receiver the working equivalent of seven tubes. It will be noticed that the first three tubes are used as both audio and radio-amplifiers.



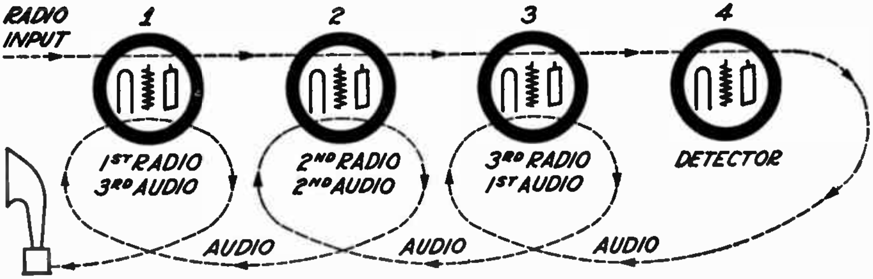
A THREE-TUBE REFLEX WITH CRYSTAL DETECTOR

Figure O: Here the reflex principle is used with a crystal detector, which, although not as sensitive as the vacuum tube detector, is found suitable when the current is amplified before it is detected.



A REFLEX PRINCIPLE IN PRACTICE

Figure P: Here is the hook-up of a Grimes inverse duplex receiver involving the reflex principle. Three tubes are made sensitive enough so that a loop aerial may be employed.



STILL ANOTHER PRINCIPLE OF REFLEX ACTION

Figure Q: Here is the Grimes principle illustrated in a simple way. It is this reflex principle that is employed in the receiver illustrated at Fig. P.

ity of the reflexer shown in Fig. M.

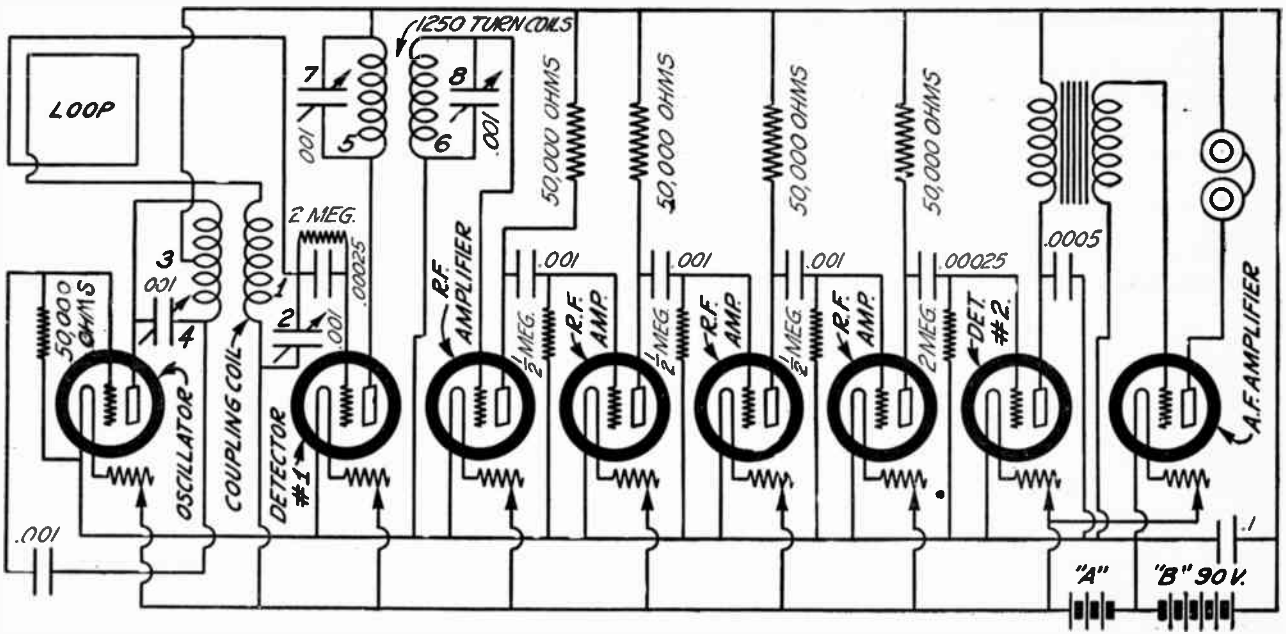
In Fig. O we have a reflex outfit very similar to the one shown in M save that three tubes are used, a crystal performing the function of a detector tube.

Grimes, a radio experimenter who has done a great deal of research work in reflexing, has constructed a receiver in which the current takes the path shown in Fig. Q. It will be seen that the current reverses on itself. It will also be noted that the output is taken from the first tube which is both a radio- and audio-frequency amplifier. The circuit used in carrying out this principle is illustrated in Fig. P. The receiver shown is a three-tube Grimes reflex and standard radio material is used throughout.

In the past a great deal of trouble has been experienced with radio-frequency amplifiers because of audio-frequency regeneration taking place between the various circuits involved. This regeneration, even though carefully guarded against, would take place because of the capacity coupling established by the elements of the tubes used. Professor Hazeltine of Stevens Institute, Hoboken, N. J., developed the neutrodyne principle to eliminate this disadvantage of radio-frequency amplifiers. In Fig. R we have a circuit which in a way describes the Hazeltine method. The phantom condenser connected between the grid and the plate of the vacuum tube represents the always present capacity between the tube elements. The capacity directly opposite this, at the bottom of the drawing is a neutralizing capacity, which tends to stabilize the system and to prevent audio frequency regeneration. This neutralizing condenser takes various forms, but in all cases it is adjustable so that the right capacity can be inserted to overcome the tendency previously mentioned. In the construction of every homemade neutrodyne the real trouble will come in the work of neutralizing the capacity in the tubes of the radio-frequency amplifiers.

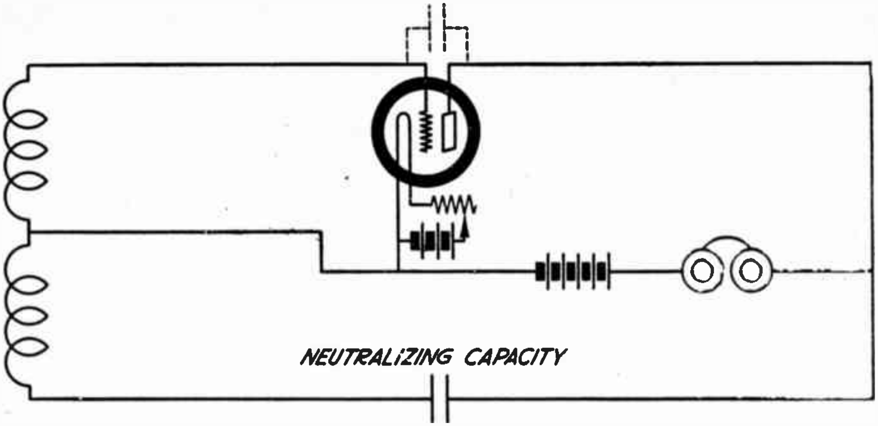
In Fig. S we have placed before us what is without doubt the most sensitive and practical combination of radio instruments that can be devised at the present time. This is Armstrong's superheterodyne, and although, large, clumsy and intricate it is an instrument of marvelous sensitivity and will, if properly constructed and intelligently manipulated, afford music of a pleasing character.

Let us see what happens when signals are picked up by the loop in the super-



THE COLOSSUS OF RADIO—THE SUPERHETERODYNE

Figure 8: Here is an exceptionally good hook-up of a super heterodyne circuit which affords marvelously sensitive reception with a great degree of quality providing the engineering is done correctly. This is an eight-tube receiver and should have a normal receiving range of 2,500 miles when used with the correct type of aerial.



THE HAZELTINE NEUTRODYNE

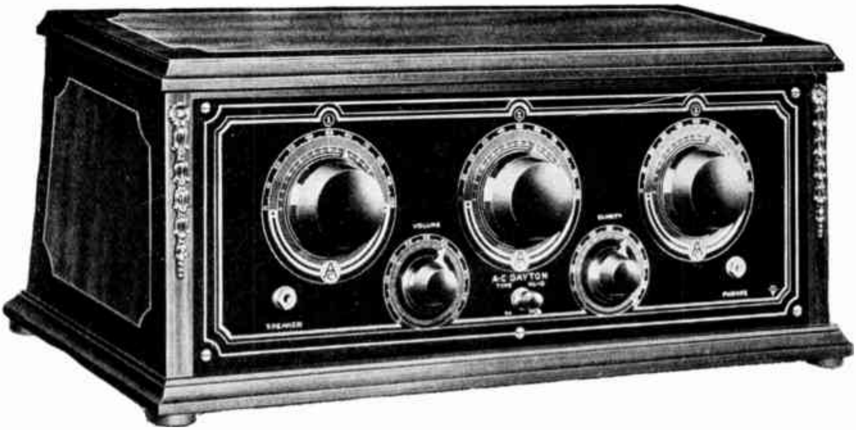
Figure R: This diagram shows how the capacity of a tube, which is indicated by the dotted lines, can be neutralized by placing a capacity in the position shown. This has the effect of preventing vacuum tubes from oscillating through capacity feed-backs which results from the capacity between the elements of the tube.

heterodyne. It will be noted that this loop is in series with a small coupling coil (1). Connected across the loop and the coupling coil is a 43 plate condenser (2). This particular circuit should cover a wavelength range from about 175 to 600 meters. The inductance (3) and the condenser (4) form a tuned circuit which determines the frequency of the local oscillations. This local oscillation is nothing more or less than a vacuum tube set up to oscillate as it might in an ordinary regenerative receiver. It is made to oscillate at a given frequency depending upon the wavelength of the station being received. It is always adjusted to a frequency 50,000 cycles less than the signal frequency. The output of the first detector will make available this frequency modulated with the desired signal of audio frequency. The 50,000 cycle output is tuned to by means of the two tuned circuits containing coils 5 and 6 and condensers 6 and 7. It is then amplified by the 4-stage resistance coupled amplifier. The signals are then detected by detector (2) and amplified at audio frequency. Briefly this is the principle of the super-heterodyne but as in the case of the reflex many variations are possible and each experimenter has his own particular idea as to what is best to use.

A-C DAYTON RECEIVER

Specifications

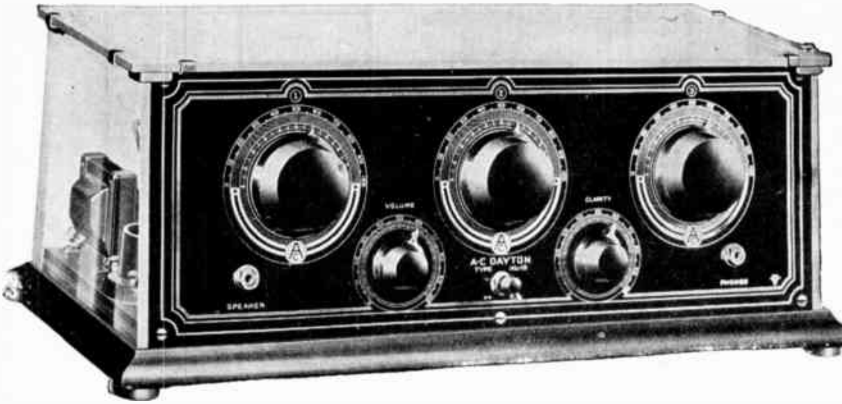
MANUFACTURER; A-C Dayton Electric Co.
Model; Phono-set
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $95.00
Antenna; single wire outside
Tubes; UV-201A or C-301
A battery; 6 volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Dimensions; 14 inches wide



A-C DAYTON RECEIVER

Specifications

MANUFACTURER; A-C Dayton Electric Co.
Model; XL10
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $115.00
Antenna; single outside wire
Tubes; UV-201A or 301A
A battery; 6 volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Finish; two-tone mahogany



A-C DAYTON RECEIVER

Specifications

MANUFACTURER; A-C Dayton Electric Co.
Model; XL10
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $125.00
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6 volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600
Number of tuning controls; 3
A battery current; 1.25 amps.
Finish; plate glass

A. H. GREBE RECEIVER

Specifications

MANUFACTURER; A. H. Grebe and Co., Inc.
Model; Synchrophase
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories;
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6 volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 150 to 550 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
B battery current; approx. 22 milli-amperes
Finish; mahogany

ADLER ROYAL RECEIVER

Specifications

MANUFACTURER; Adler Mfg. Co.
Model; 199
Number of tubes; 5
Type of tuning; neutrodyne, tuned radio frequency
Cost without accessories; $125.00
Antenna; single outside wire
Tubes; 199 type
A battery; dry cells
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; .3 amps.
Finish; walnut or mahogany

ADLER ROYAL RECEIVER

Specifications

MANUFACTURER; Adler Mfg. Co.
Model; 201A
Number of tubes; 5
Type of tuning; neutrodyne tuned radio frequency
Cost without accessories; $125.00
Antenna; single wire outside
Tubes; UV-201A or C-301A
A battery; 6 volt storage 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
B battery current approx. 16 milli-amperes
Finish, mahogany or walnut

ADAMS-MORGAN RECEIVER

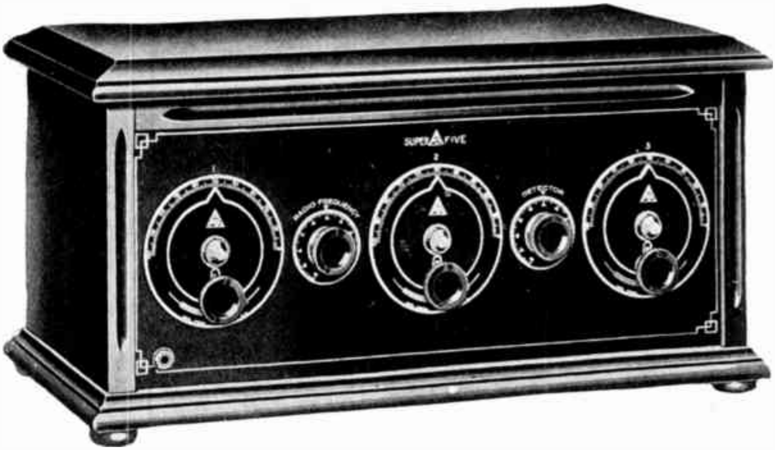
Specifications

MANUFACTURER; Adams-Morgan Co.
Model; 2
Number of tubes; 2
Type of tuning; capacity
Cost without accessories; $27.50
Antenna; single wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage 80 a.h.
Detector B battery; 20-45 volts
Wavelength range; 200-580 meters
Number of tuning controls; 1
A battery current; ½ amp.
B battery current 6 milliamperes
Finish; mahogany

ALL-AMERICAN RECEIVER

Specifications

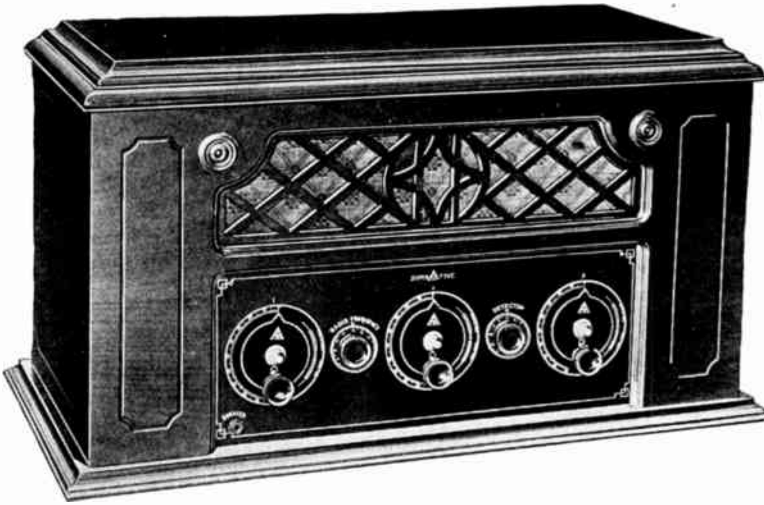
MANUFACTURER; All-American Radio Corporation
Model; R
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $90.00
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ to 45 volts
Wavelength range; 200-600 meters
Number of tuning controls; 2
A battery current; 1.25 amps.
Finish, two-tone walnut



APEX RECEIVER

Specifications

MANUFACTURER; Apex Elec. Mfg Co.
Model; Super-five
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $95.00
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-550 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Dimensions; 20½ x 11 x 10 ins.
Finish; walnut



APEX RECEIVER

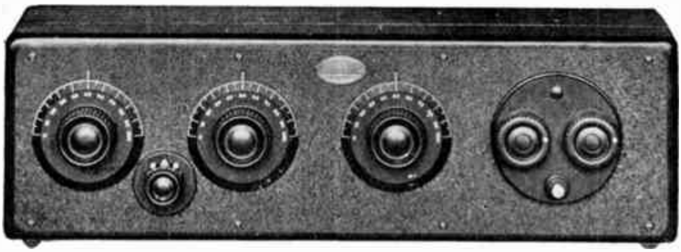
Specifications

MANUFACTURER; Apex Elec. Mfg. Co.
Model; De Luxe
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $135.00
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-550 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Dimensions; 29⅝ x 15¼ x 18 ins.
Finish; walnut

ARAGAIN RECEIVER

Specifications

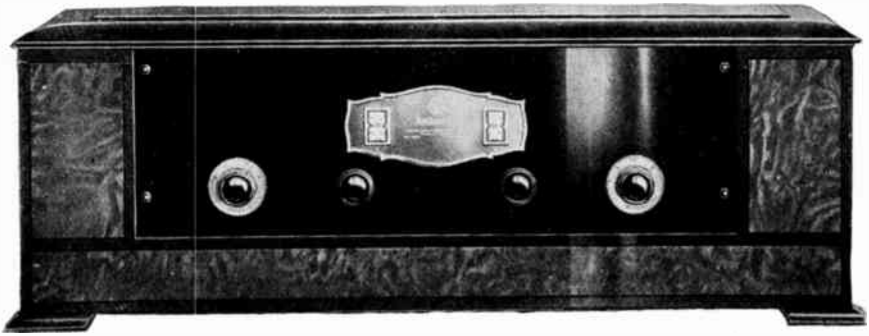
MANUFACTURER; Auto Metal Corporation
Model; B
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost (without accessories); $150.00
Antenna; single outside wire 80 to 100 feet.
A battery; 6-volt storage
Detector tubes; UV-201A
Amplifier tubes; UV-201A
Amplifier voltage; 67½ to 72
Detector voltage; 45
Wavelength range; 200 to 550 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
B battery current; 9 to 12 milliamperes



ATWATER-KENT RECEIVER

Specifications

MANUFACTURER; The Atwater-Kent Mfg. Co.
Model; No. 20 compact
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $80.00
Antenna; single outside wire
Amplifier tubes; UV-201A or C-301A
Detector tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 amp. hr.
A battery current; 1.25 amp.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
C battery; 4½ volts
Wavelength range; 200 to 600 meters
Number of tuning controls; 3
Size; 19¾ x 5¾ x 6½ ins.
Finish, walnut



BOSCH RECEIVER

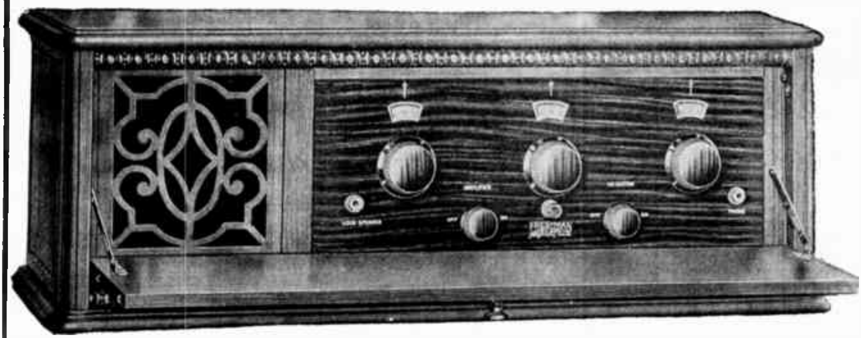
Specifications

MANUFACTURER; American Bosch Magneto Corp.
Model; Amborola
Number of tubes; 6
Type of tuning, tuned radio frequency
Number of tuning controls; 2
Cost (without accessories); $145.00
Antenna; single outdoor wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage
Amplifier voltage; 90 volts
Detector voltage; 45
Wavelength range; 200 to 550 meters
A battery current; 1½ amps.
Dimensions; 29¾ x 10⅛ x 10 3/16 ins.

CHARLES FRESHMAN RECEIVER

Specifications

MANUFACTURER; Charles Freshman Co.
Model; Concert
Number of tubes; 5
Type of tuning; tuned radio-frequency
Cost without accessories; $75.00
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; storage, 6-volt, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Finish; mahogany



CHARLES FRESHMAN RECEIVER

Specifications

MANUFACTURER; Charles Freshman Co.
Model; Franklin console
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $75.00
Antenna; single wire, outside
Tubes; UV-201A or C-301A
A battery; 6-volt, storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Finish; mahogany

CHARLES FRESHMAN RECEIVER

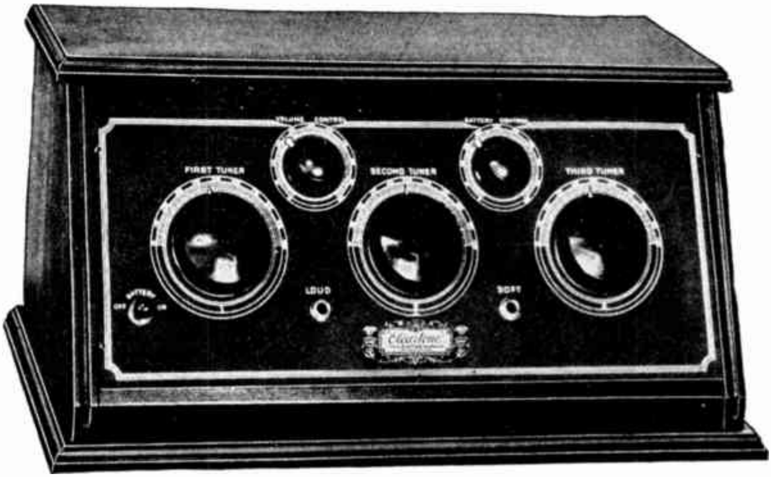
Specifications

MANUFACTURER; Charles Freshman Co.
Model; 5-F-5
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $60.00
Antenna; single wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Finish; mahogany

CHARLES FRESHMAN RECEIVER

Specifications

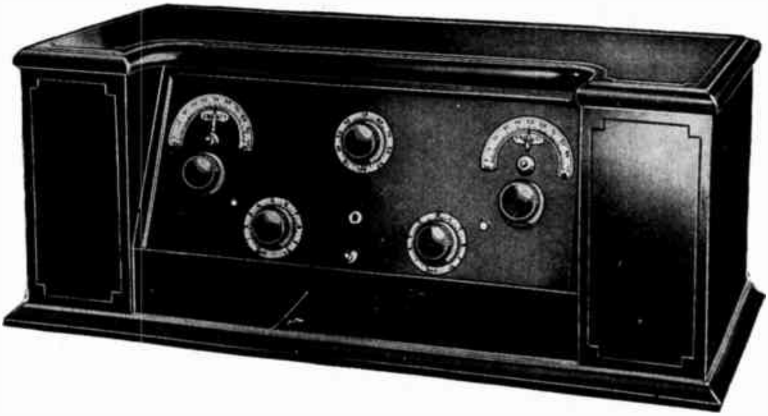
MANUFACTURER; Charles Freshman Co.
Model; 5-F-2
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $39.50
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Finish; mahogany



CLEARTONE RECEIVER

Specifications

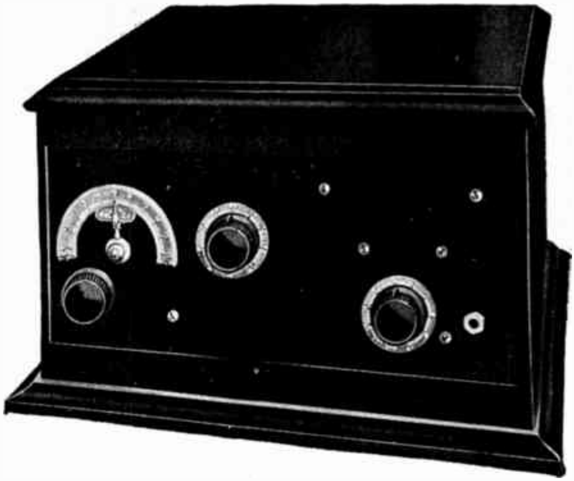
MANUFACTURER; Cleartone Radio Mfg. Co.
Model; 100
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $85.00
Antenna; single outside wire
Tubes; UV-201A or 199 types
A battery; dry cells or storage battery
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; depends upon tubes used.
Finish; walnut



CROSLEY RECEIVER

Specifications

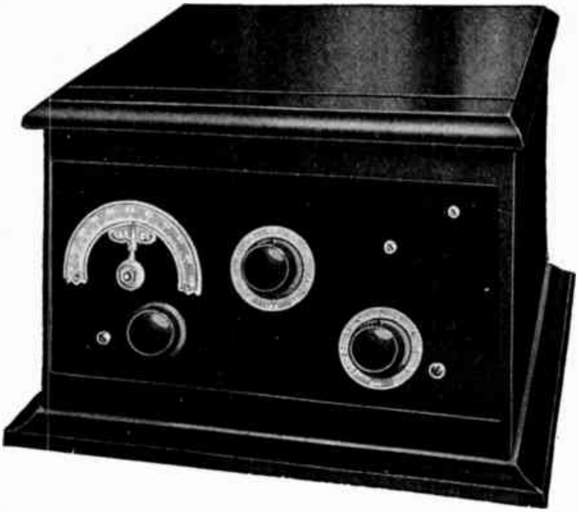
MANUFACTURER; Crosley Radio Corporation
Model; Super Trirdyn
Number of tubes; 3
Type of tuning; regenerative, reflex and R.F.
Antenna; single outside wire
Tubes; UV-201A or C-301A or dry cell tubes
A battery; 6-volt storage, 80 a.h. or dry cells
Amplifier B battery; depends upon tubes
Detector B battery; depends upon tubes
Wavelength range; 200-600 meters
Number of tuning controls; 2
A battery current; depends upon tubes
B battery current; depends upon tubes
Finish; mahogany



CROSLEY RECEIVER

Specifications

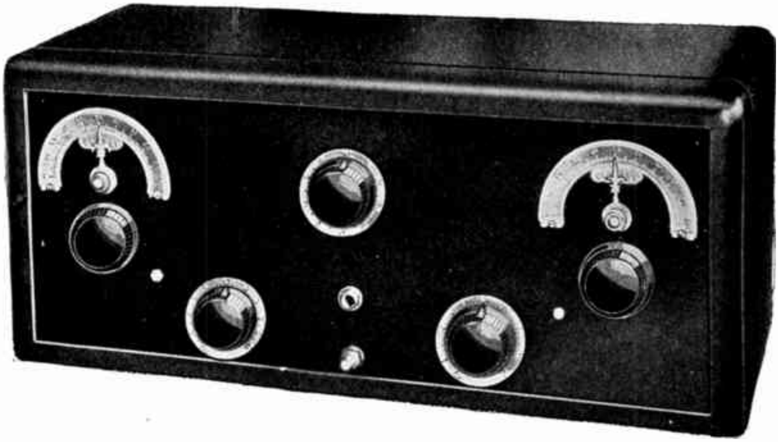
MANUFACTURER; Crosley Radio Corporation
Model; 52
Number of tubes; 3
Type of tuning; double circuit regenerative
Cost without accessories; $32.50
Antenna; single outside wire
Tubes; dry cell or storage battery types
A battery; dry cell or storage battery
Amplifier B battery; depends upon tubes
Detector B battery; depends upon tubes
Wavelength range; 200-600 meters
Number of tuning controls; 1
A battery current; depends upon tubes
Finish; mahogany



CROSLEY RECEIVER

Specifications

MANUFACTURER; Crosley Radio Corporation
Model; 51
Number of tubes; 2
Type of tuning; double-circuit regenerative
Cost without accessories; $23.50
Antenna; single outside wire
Tubes; dry cell or storage battery
A battery; dry cell or storage type
Amplifier B battery; depends upon tubes
Detector B battery; depends upon tubes
Wavelength range; 200-550 meters
Number of tuning controls; 1
A battery current; depends upon tubes
Finish; genuine mahogany



CROSLEY RECEIVER

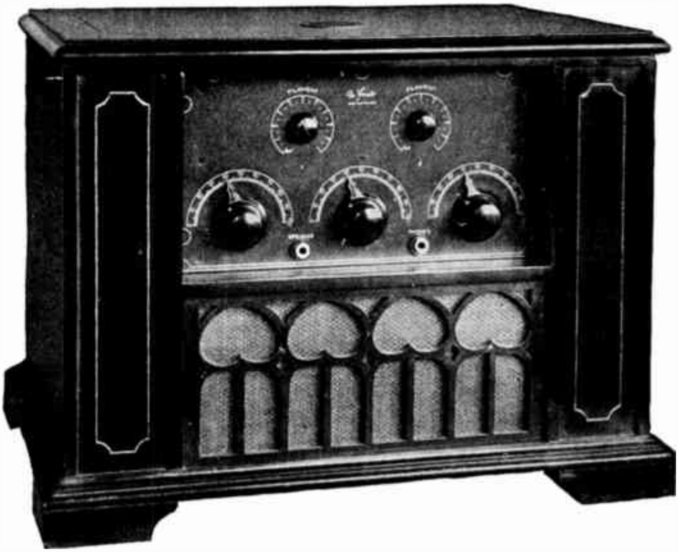
Specifications

MANUFACTURER; Crosley Radio Corporation
Model; Super-Trirdyne Regular
Number of tubes; 3
Type of tuning; regenerative, reflex and R.F.
Cost without accessories; $45.00
Antenna; single wire
Tubes; storage or dry cell
A battery; dry cell or storage
Amplifier B battery; depends upon tubes
Detector B battery; depends upon tubes
Wavelength range; 200-550 meters
Number of tuning controls; 2
A battery current; depends upon tubes
Finish; genuine mahogany

CROSLEY RECEIVER

Specifications

MANUFACTURER; Crosley Radio Corporation
Model; Pup
Number of tubes; 1
Type of tuning; regenerative
Cost without accessories; $9.75
Antenna; single wire
Tubes; Ux199
A battery; dry cells
Amplifier B battery; none
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 1
A battery current; .06 amps.
Finish; metal



DE FOREST RECEIVER

Specifications

MANUFACTURER; De Forest Radio Corporation
Model; W6
Number of tubes; 5
Type of tuning; tuned radio frequency
Antenna; single outside wire
Tubes; De Forest
A battery; storage
Amplifier B battery; 90 volts
Detector B battery; 45 volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
C battery; 9 to 18
Finish; mahogany

ELKAY RECEIVER

Specifications

MANUFACTURER; Langbein-Kaufmann Radio Co.
Model; 5S
Number of tubes; 5
Type of tuning; tuned radio frequency
Detector tube; UX-201A or UX-199
Radio frequency tube; UX-201A or UX-199
Audio tubes; UX-199, UX-201A, UX-112 or UX-120
A battery; 6-volt storage
B battery current; 13 milliamperes
Amplifier B battery; 135 volts
Detector B battery; 22 to 145 volts
Wavelength range; 200 to 600 meters
Tuning controls; 2

FADA RECEIVER

Specifications

MANUFACTURER; F.A.D. Andrea
Model; Neutrolette
Number of tubes; 5
Type of tuning; neutrodyne radio frequency
Cost without accessories; $85.00
Antenna; single outside wire
Tubes; dry cell or storage battery
A battery; storage or dry cells
Amplifier B battery; 90 volts
Detector B battery; 22.5 volts
C battery; 1½ to 4½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
Dimensions; 22½ x 9 7/16 x 13¼ ins.
Finish; walnut

FADA RECEIVER

Specifications

MANUFACTURER; F. A. D. Andrea
Model; 185-A
Number of tubes; 5
Type of tuning; neutrodyne tuned radio frequency
Cost without accessories; $175.00
Antenna; single wire
Tubes; dry cell or storage battery
A battery; dry cell or storage battery
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps. for UV-201A tubes
Dimensions; 27 x 21 x 17 ins.
Finish; dark mahogany

FADA RECEIVER

Specifications

MANUFACTURER: F. A. D. Andrea
Model; 196A
Number of tubes; 5
Type of tuning; tuned radio frequency (neutrodyne)
Cost without accessories; $100.00
Antenna; single wire
Tubes; dry sell or storage battery
A battery; dry cell or storage battery
Amplifier B battery; 90 volts
Detector B battery; 22 ½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps. for UV-201A's
Dimensions; 15 3/16 x 16 x 6 ins.
For phonograph cabinets

FERGUSON RECEIVER

Specifications

MANUFACTURER; J. B. Ferguson
Model; 8
Number of tubes; 6
Type of tuning; tuned radio frequency
Cost without accessories; $226.00
Antenna; single wire
Tubes; 6 UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 135 volts
Wavelength range; 200-600 meters
Number of tuning controls; 1
A battery current; 1.5 amps.
Finish; mahogany

FREED-EISEMANN RECEIVER

Specifications

MANUFACTURER; Freed-Eisemann Corporation
Model; NR-7
Number of tubes; 6
Type of tuning; tuned radio frequency, neutrodyne
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 180 a.h.
Amplifier B battery; 135 volts
Detector B battery; 45 volts
Wavelength range; 220-575 meters
Number of tuning controls; 3
A battery current; 1.5 amps.
Finish; mahogany

FREED-EISEMANN RECEIVER

Specifications

MANUFACTURER; Freed-Eisemann Radio Corporation
Model; NR-20
Number of tubes; 5
Type of tuning; neutrodyne, tuned radio frequency
Cost without accessories; $175.00
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 220-575 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
C battery; 4½ volts
Dimensions, 35 x 17 x 17 ins.
Finish; mahogany

FREED-EISEMANN RECEIVER

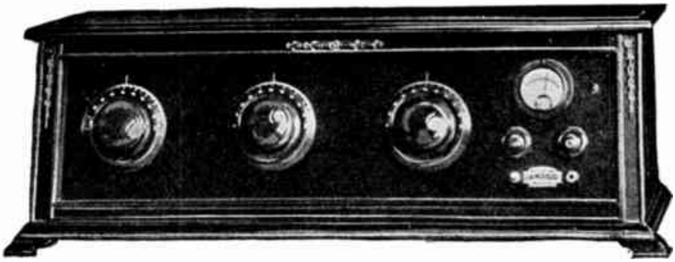
Specifications

MANUFACTURER; Freed-Eisemann Radio Corporation
Model; FE-18
Number of tubes; 5
Type of tuning; neutrodyne
Cost without accessories; $90.00
Antenna; single wire
Tubes; 199 type
A battery; dry cells (6)
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 220-575 meters
Number of tuning controls; 3
A battery current; .3 amps.
C battery; 4½ volts
Finish; mahogany

FREED-EISEMANN RECEIVER

Specifications

MANUFACTURER; Freed-Eisemann Radio Corporation
Model; FE-15
Number of tubes; 5
Type of tuning; neutrodyne
Cost without accessories; $75.00
Antenna; single wire antenna
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-550 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Dimensions; 23½ x 13¾ x 13¼ ins.
Finish; mahogany



GAROD RECEIVER

Specifications

MANUFACTURER; Garod Corporation
Model; F
Number of tubes; 5
Type of tuning; neutrodyne, tuned radio frequency
Cost without accessories; $195.00
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 45 volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.5 amps.
Finish; walnut

GAROD RECEIVER

Specifications

MANUFACTURER; Garod Corporation
Model; "M"
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost (without accessories); $125.00
Antenna; single outside wire
Amplifier tubes; UX-201A or CX-301A
Detector tube; UX-200 or CX-300
Detector voltage; 45
C battery voltage; 4½
Storage battery; 6-volt, 120 amp. hours
Wavelength range; 200 to 600 meters
Number of tuning controls; 2
Dimensions; 22½ x 10 x 10 ins.
Cabinet; mahogany

GILFILLAN RECEIVER

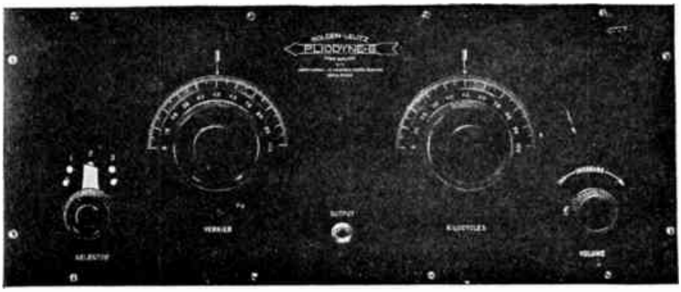
Specifications

MANUFACTURER; Gilfillan Bros.
Model; GN-5
Number of tubes; 5
Type of tuning; neutrodyne, tuned radio frequency
Cost without accessories; $110.00
Antenna; single wire outside
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Finish; mahogany

GILFILLAN RECEIVER

Specifications

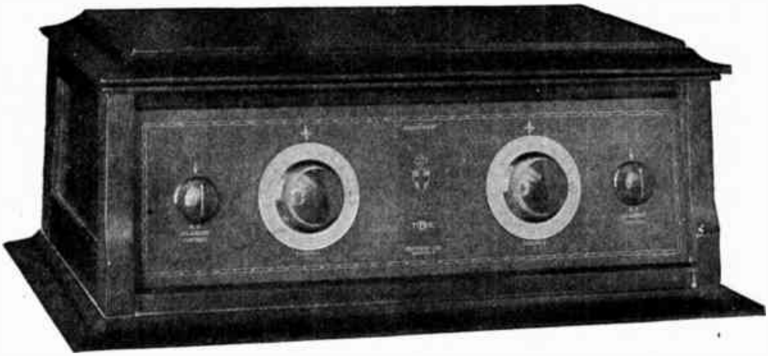
MANUFACTURER; Gilfillan Bros.
Model; GN-4
Number of tubes; 4
Type of tuning; tuned radio frequency, neutrodyne
Cost without accessories; $70.00
Antenna; single outside wire
Tubes; 199 type
A battery; dry cells
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-350 meters
Number of tuning controls; 2
A battery currents; .24 amp.
Finish; mahogany



GOLDEN LEUTZ RECEIVER

Specifications

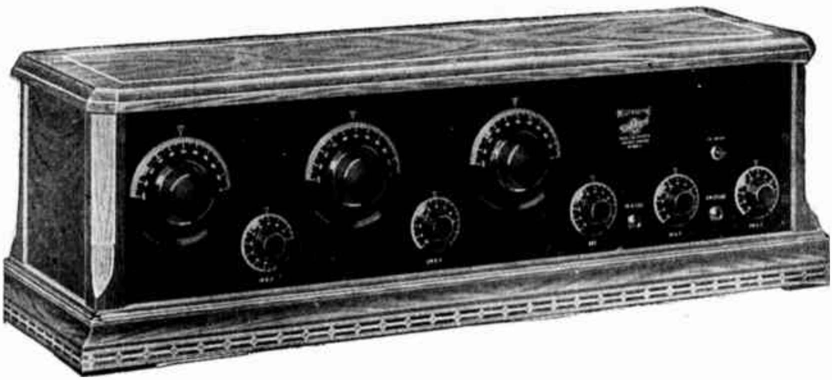
MANUFACTURER; Golden-Leutz, Inc.
Model; 6
Number of tubes; 6
Type of tuning; tuned radio frequency
Cost complete; $150.00
Antenna; single wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-546 meters
Number of tuning controls; 2
A battery current; 1½ to 2½ amps.
B battery current; 30 milli-amperes



GUTHRIE RECEIVER

Specifications

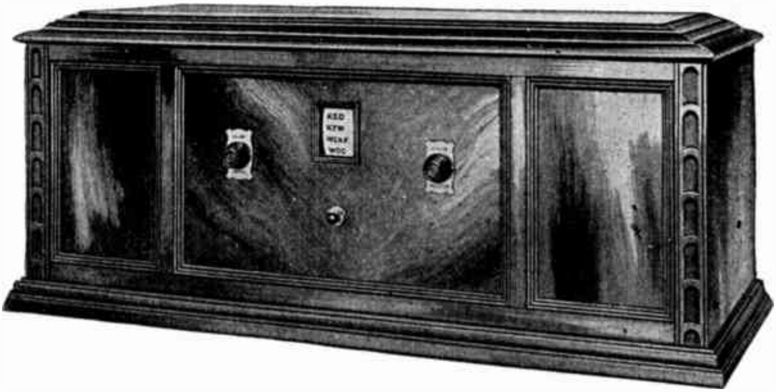
MANUFACTURER; Guthrie Co.
Model; Goldfinch
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $75.00
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Wavelength range; 200-700 meters
Number of tuning controls; 2
A battery current; 1.25 amps.
B battery current; 13 milli-amperes
Finish; mahogany



HOWARD RECEIVER

Specifications

MANUFACTURER; Howard Mfg. Co.
Model; A. B. C.
Number of tubes; 5
Type of tuning; neutrodyne tuned radio frequency
Cost complete; $200.00
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 45 volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
B battery current; 12 milli-amperes
Finish; walnut



KELLOGG RECEIVER

Specifications

MANUFACTURER; Kellogg Switchboard and Supply Co.
Model; RFL
Number of tubes; 7
Type of tuning; tuned radio frequency
Antenna; single outside wire
Tubes; UX-201A or CX-301A
A battery; 6-volt storage, 180 a.h.
Amplifier B battery; 135 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 2
A battery current; 1.75 amps.
Finish; walnut

KODEL RECEIVER

Specifications

ANUFACTURER; Kodel Radio Products Co.
Model; Unitrol
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $87.50
Antenna; single wire
Tubes; UV-201A or 301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Dimensions; made to fit phonograph cases.

KODEL RECEIVER

Specifications

MANUFACTURER; Kodel Radio Products Co.
Model; Logodyne Big Five
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $90.00
Antenna; single wire
Tubes; dry cell or storage battery type
A battery; dry cell or storage battery
Amplifier B battery; depends upon tubes
Detector B battery; depends upon tubes
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; depends upon tubes
B battery current; depends upon tubes
Finish; dark Adam brown

LE MOR RECEIVER

Specifications

MANUFACTURER; Le Mor Radio Inc.
Model; Unicontrol-Pretuned
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $145.00
Antenna; single wire
Tubes; UX-201A or CX-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-550 meters
Number of tuning controls; 1
A battery current; 1.25 amps.
Finish; five-ply walnut veneer

LIBERTY RECEIVER

Specifications

MANUFACTURER; Liberty Transformer Co.
Model; 6262
Number of tunes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $120.00
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Finish; walnut

LIBERTY RECEIVER

Specifications

MANUFACTURER; Liberty Transformer Co.
Model; 6161
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $100.00
Antenna; single wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Finish; two-tone mahogany

LIBERTY RECEIVER

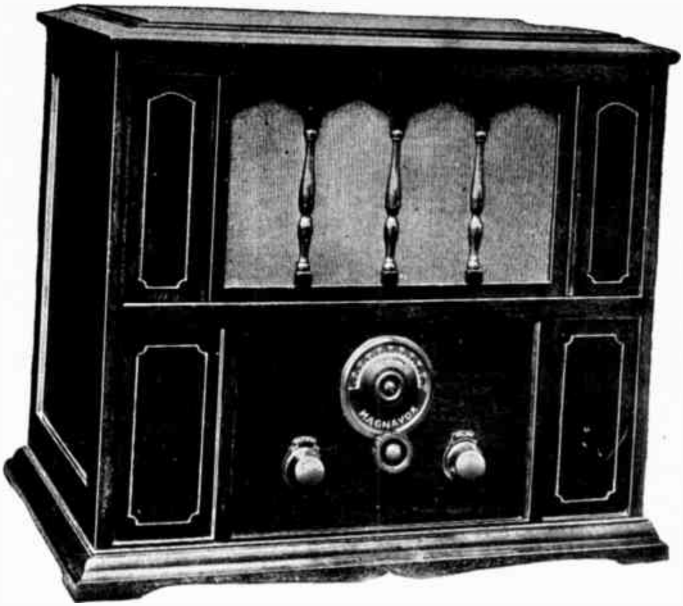
Specifications

MANUFACTURER; Liberty Transformer Co.
Model; Sealed-Five Console De Luxe, 6452
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $325.00
Antenna; single wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage. 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Finish; mahogany

MAGNAVOX RECEIVER

Specifications

MANUFACTURER; Magnavox Co.
Model; 10
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $110.00
Antenna; single outside wire
Tubes; UV-201A or 301A
A battery; 6-volt, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ to 45 volts
Wavelength range; 200-550 meters
Number of tuning controls; 1
A battery current; 1.25 amps.
Dimensions; 11 x 15½ x 24 ins.
Finish; mahogany



MAGNAVOX RECEIVER

Specifications

MANUFACTURER: Magnavox Co.
Model; 25
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $150.00
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ to 45 volts
Wavelength range; 200-600 meters
Number of tuning controls; 1
A battery current; 1.25 amps.
Dimensions; 20 x 16½ x 23 ins.
Built-in loud speaker

MAGNAVOX RECEIVER

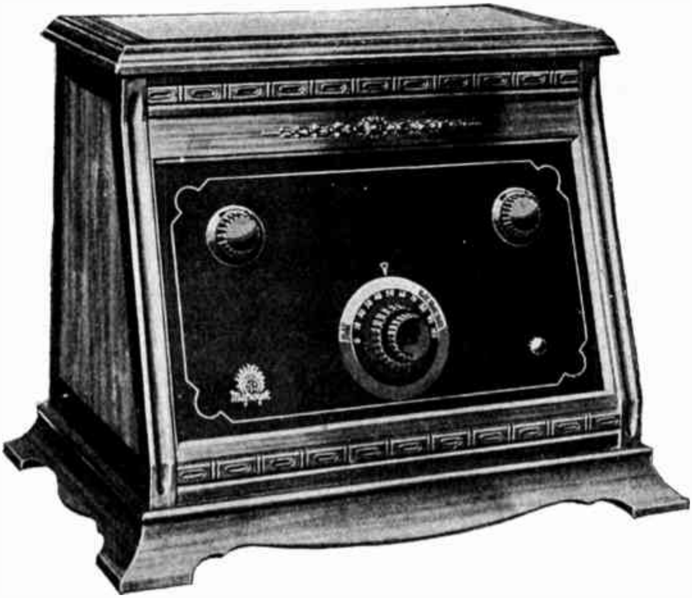
Specifications

MANUFACTURER; Magnavox Co.
Model; Junior
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $85.00
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-550 meters
Number of tuning controls; 1
A battery current; 1.25 amps.
Dimensions; 15½ x 15½ x 10½ ins.
Finish; mahogany

MIDWEST RECEIVER

Specifications

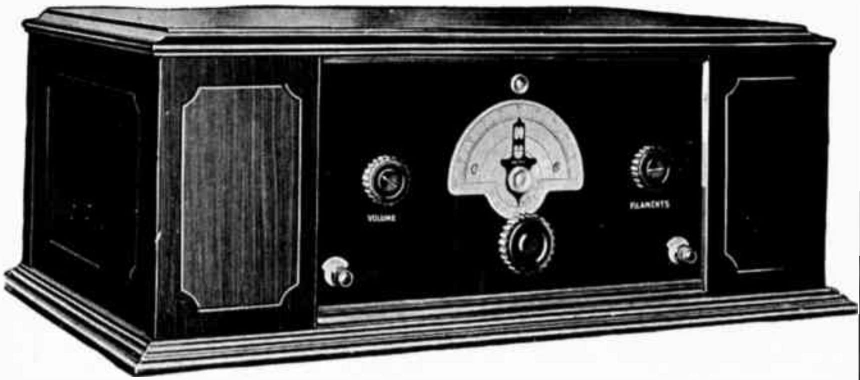
MANUFACTURER; Midwest Radio Corp.
Model; Miraco
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $59.50
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Dimensions; 27 ins. long
Finish; mahogany



MOHAWK RECEIVER

Specifications

MANUFACTURER; Mohawk Corporation of Illinois
Model; 100
Number of tubes; 5
Type of tuning; tuned radio frequency (2 radio and 2 audio)
Cost without accessories; $100.00
Antenna; single outdoor wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage
A battery current; 1.25 amps.
Wavelength range; 200 to 600 meters
Tuning controls; 1
Cabinet; 5 ply walnut, two tone finish
Panel; black bakelite
Dimensions; 16 x 21½ x 14½ ins.



MU-RAD RECEIVER

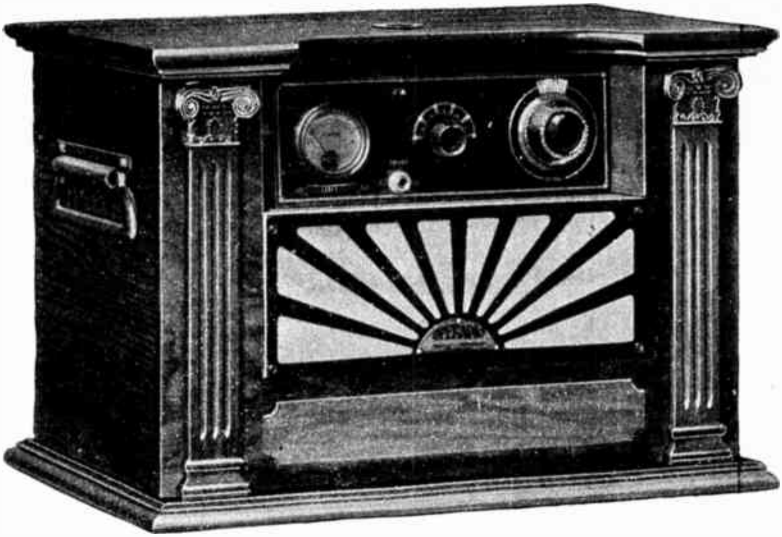
Specifications

MANUFACTURER; Mu-Rad Corporation
Model; B
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $125.00
Antenna; single outside wire
Tubes; UV-201A or 199 type
A battery; 6-volt storage or dry cells
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 1
A battery current; depends on tubes
Dimensions; 23 x 13 x 8½ ins.
Finish; two-tone mahogany

MU-RAD RECEIVER

Specifications

MANUFACTURER; Mu-Rad Corporation
Model; A
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $155.00
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 1
A battery current; 1.25 amps.
Dimensions; 3½ x 14 x 12 ins.
Finish; two-tone mahogany



OPERADIO RECEIVER

Specifications

MANUFACTURER; Operadio Corporation
Model; Consolette
Number of tubes; 6
Type of tuning; tuned radio frequency
Cost without accessories but inc. loudspeaker; $180.00
Antenna; inside cabinet
Tubes; 199 type
A battery; dry cells
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 1
Finish; walnut or mahogany

PHENIX RECEIVER

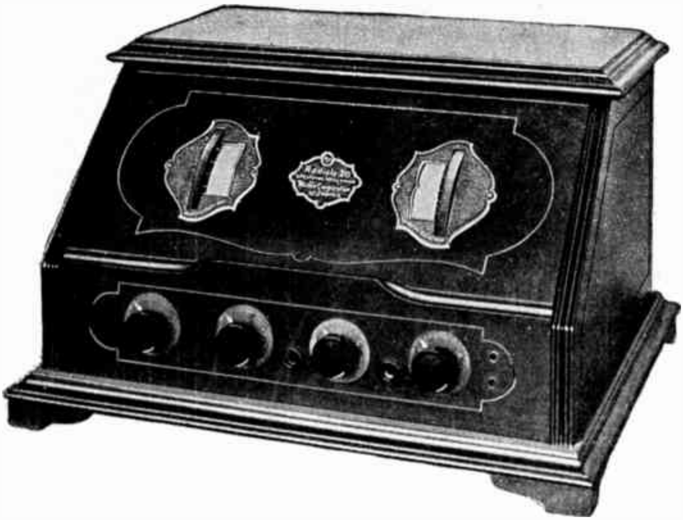
Specifications

MANUFACTURER; Phenix Radio Corporation
Model; Ultradyne
Number of tubes; 6
Type of tuning; tuned radio frequency
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage; 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 180 to 560 meters
Number of tuning controls; 2
A battery current; 1.5 amps.
B battery current; 20 milli-amperes
Finish; mahogany

RADIO CORPORATION RECEIVER

Specifications

MANUFACTURER; Radio Corporation of America
Model; 20
Number of tubes; 5
Type of tuning; tuned radio frequency with regeneration
Cost without accessories; $102.50
Antenna; single outside wire
Tubes; 4 UX-199's and 1 UX-120
A battery; dry cells
Amplifier B battery; 135 volts
C battery; 4½ volts
Wavelength range; 200-600 meters
No. tuning controls; 2
Finish; mahogany



RADIO CORPORATION RECEIVER

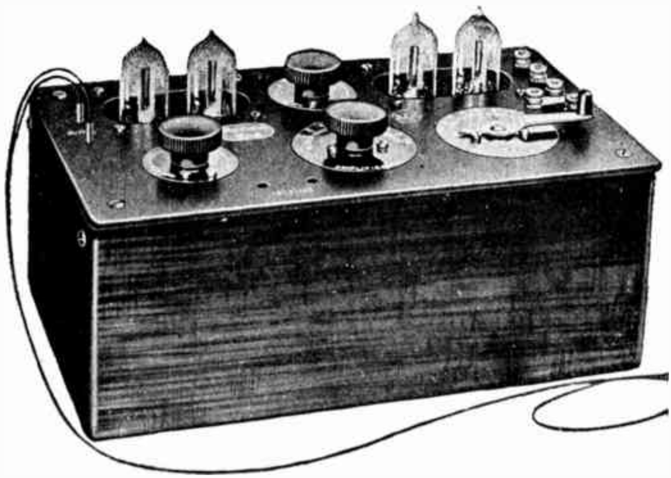
Specifications

MANUFACTURER; Radio Corporation of America
Model; 111-A with cabinet and loudspeaker
Number of tubes; 4
Type of tuning; regenerative
Cost without accessories; $67.50
Antenna; single outside wire
Tubes; UX-120 and UX-199
A battery; dry cells
Amplifier B battery; 135 volts
Wavelength range; 200-600 meters
Number of tuning controls; 1
Finish; walnut

RADIO CORPORATION RECEIVER

Specifications

MANUFACTURER; Radio Corporation of America
Model; 26
Number of tubes; 6
Type of tuning; superheterodyne
Cost with tubes and battery box; $225.00
Antenna; loop attached
Tubes; 199 type
A battery; dry cells
Amplifier B battery; 90 volts
Wavelength range; 200 to 600 meters
Number of tuning controls; 2
A battery current; .36 amps.
Finish; walnut



RADIO CORPORATION RECEIVER

Specifications

MANUFACTURER; Radio Corporation of America
Model; 111-A
Number of tubes; 4
Type of tuning; regenerative
Cost with tubes; $45.00
Antenna; single outside wire
Tubes; three UX-120's and one UX-199
A battery; dry cells
Amplifier B battery; 135 volts
Detector B battery; 20-45 volts
Wavelength range; 195 to 640 meters
Number of tuning controls; 1
A battery current; 1 amp.
B battery current; 7 milliamperes
Finish; mahogany

RADIO CORPORATION RECEIVER

Specifications

MANUFACTURER; Radio Corporation of America
Model: 111
Number of tubes: 2
Type of tuning: regenerative
Cost complete: $15.00
Antenna: single outside wire
Tubes; WD11
A battery; dry cells
Amplifier B battery; 45 volts
Wavelength range; 200 to 600 meters
Number of tuning controls; 1
A battery current; .12 amps.
Finish; mahogany

RADIO CORPORATION RECEIVER

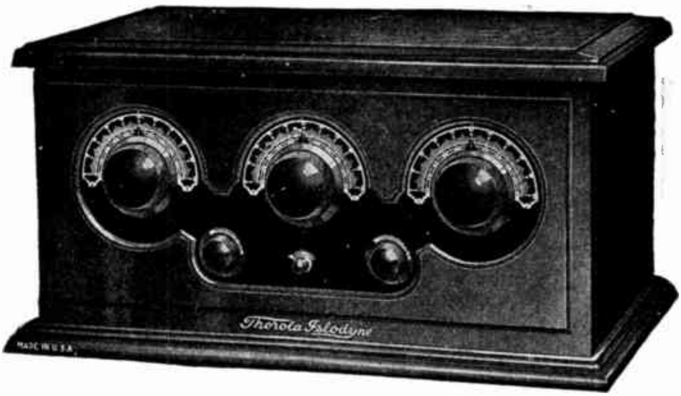
Specifications

MANUFACTURER; Radio Corporation of America
Model; Second Harmonic
Number of tubes; 6
Type of tuning; superheterodyne
Antenna; loop or single wire aerial
Tubes; 199 type
A battery; dry cells
Amplifier B battery; 90 volts
Wavelength range; 200-600 meters
Number of tuning controls; 2
A battery current; .36 amps.
Dimensions; 34 x 11 x 10
Finish; mahogany or walnut

REICHMANN RECEIVER

Specifications

MANUFACTURER; Reichmann Company
Model; 51
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $85.00
Antenna; single wire
Tubes; UV-210A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 175 to 575 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Dimensions; 21 x 10¼ x 13 ins.
Finish; mahogany



REICHMANN RECEIVER

Specifications

MANUFACTURER; Reichmann Co.
Model; Isolodyne
Number of tubes; 5
Type of tuning; tuned radio frequency
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 175 to 575 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Dimensions; 21½ x 11 x 13 ins.
Finish; walnut

REICHMANN RECEIVER

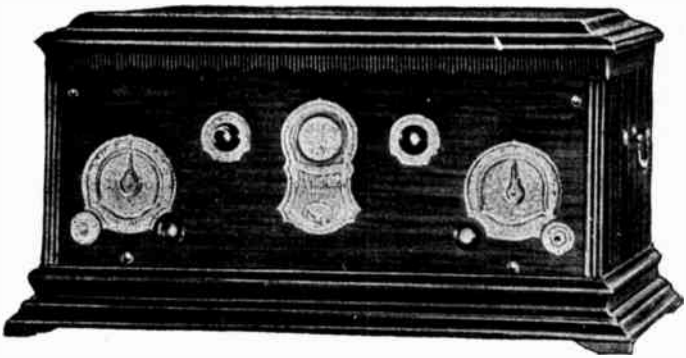
Specifications

MANUFACTURER; Reichmann Co.
Model; Isolodyne
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $85.00
Antenna; single wire
Tubes; UV-201A or C-301A
A battery; 6-volt, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 175 to 550 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Dimensions; 21¼ x 10¼ ins.
Finish; special

SIMPLEX RECEIVER

Specifications

MANUFACTURER; Simplex Radio Company
Model; SR8
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $65.00
Antenna; single outside wire
Tubes; 201A
A battery; 6-volt storage
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-500 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Dimensions; 7 x 18 x 7 ins.
Finish; mahogany, Adam Brown



STROMBERG-CARLSON RECEIVER

Specifications

MANUFACTURER; Stromberg-Carlson Telephone Mfg. Co.
Model; 602
Number of tubes; 6
Type of tuning; 2 main controls. Tuned radio frequency. Neutrodyne type
Cost without accessories; $210.00
Detector; UX-201A
Amplifiers; UX-210A and UX-112
Antenna; single outdoor wire
A-battery; standard 6-volt unit
Detector voltage; 45
Amplifier voltage; 130
Wavelength range; 200 to 550 meters or 1500 to 545 kilocycles

THERMIODYNE RECEIVER

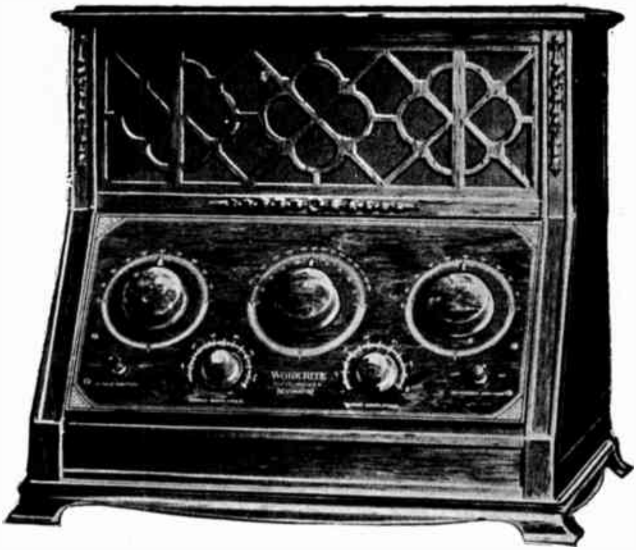
Specifications

MANUFACTURER; Thermiodyne Corp.
Model; TF-5
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $100.00
Antenna; single outside wire
Tubes; 5
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Wavelength range; 200-600 meters
Number of tuning controls; 1
A battery current; 1.25 amps.
Dimensions; 12 x 23 x 17 ins.
Finish; walnut

THERMIODYNE RECEIVER

Specifications

MANUFACTURER; Thermiodyne Corporation
Model; TF-6
Number of tubes; 6
Type of tuning; tuned radio frequency
Cost without accessories; $150.00
Antenna; single wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 135 volts
Wavelength range; 200-600 meters
Number of tuning controls; 1
A battery current; 1.5 amps.
Dimensions; 12 x 29 x 12½ ins.
Finish; mahogany

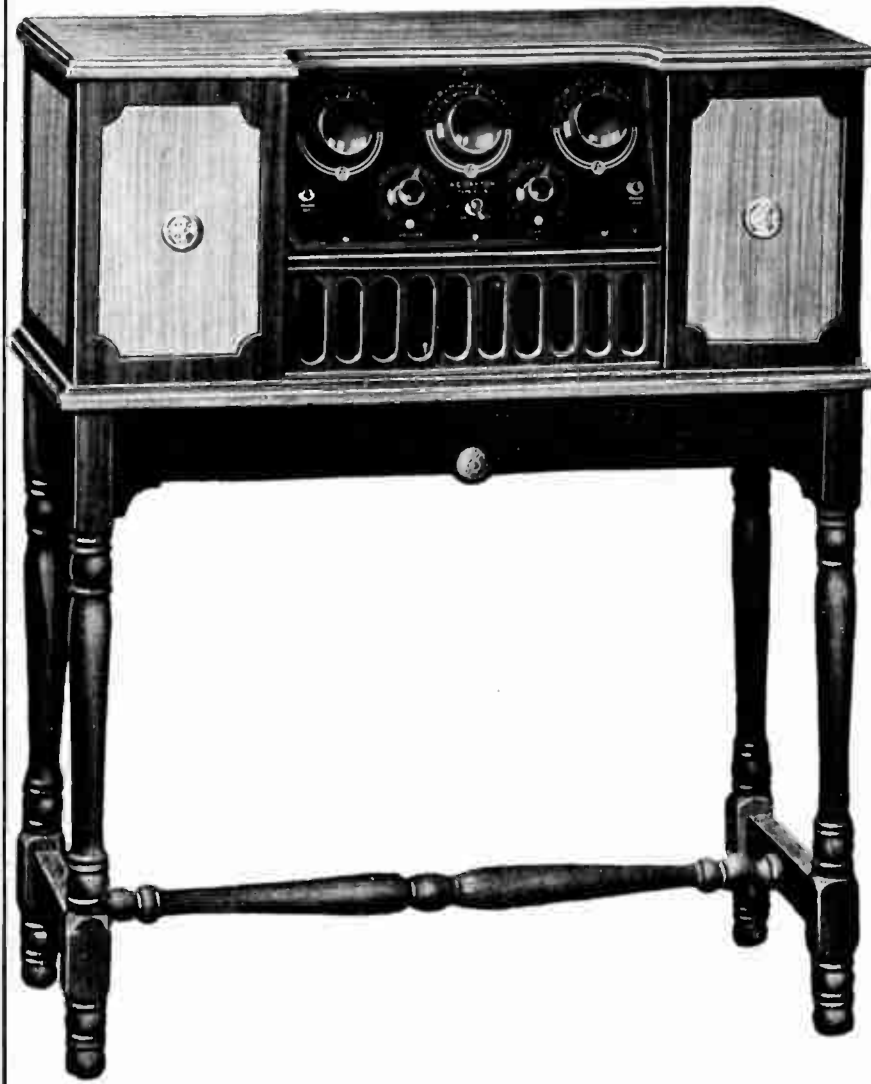


WORKRITE RECEIVER

Specifications

MANUFACTURER; Workrite Manufacturing Co.
Model; Radio King 6
No. of tubes; 6
Type of tuning: tuned radio frequency
Cost without accessories; $170.00 including loud speaker
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage
Amplifier voltage; 90
Detector voltage; 22½ to 45
Wavelength range; 200 to 550 meters
Number of tuning controls; 3
A battery current; 1½ amps.
Dimensions; 22 x 14 x 20 ins.
Cabinet; mahogany

A-C DAYTON MODEL XL15 RECEIVER



A-C DAYTON RECEIVER

Specifications

MANUFACTURER; A-C Dayton Elec. Co.
Model; XL-15
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $185.00
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Dimensions; 38 x 31 x 13½ ins.
Finish; two-tone mahogany

ADLER-ROYAL MODEL F RECEIVER

ADLER-ROYAL MODEL F RECEIVER

Specifications

MANUFACTURER; Adler Mfg. Co.
Model; F
Number of tubes; 5
Type of tuning; neutrodyne, tune radio frequency
Cost without accessories; $340.00
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volts, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200 to 600 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Dimensions; 50½ x 35 x 21¾ ins.
Finish; walnut

ADLER-ROYAL MODEL E RECEIVER

ADLER-ROYAL MODEL E RECEIVER

Specifications

MANUFACTURER; Adler Mfg. Co.
Model; E
Number of tubes; 5
Type of tuning; tuned radio frequency (neutrodyne)
Cost without accessories; $240.00
Antenna; outside wire
Tubes; UV-201A or C-301A
A battery; 6-volts, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Dimensions; 53 x 35 x 19 ins.
Finish; walnut

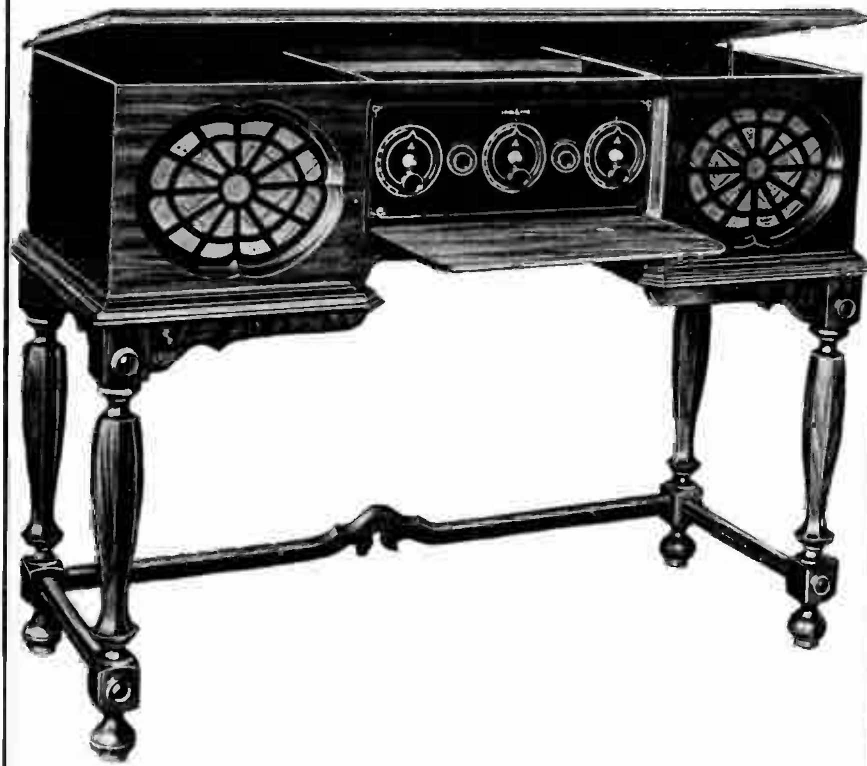
ADLER-ROYAL MODEL 201-A RECEIVER

ADLER-ROYAL 201-A RECEIVER

Specifications

MANUFACTURER; Adler Mfg. Co.
Model; 201-A
Number of tubes; 5
Type of tuning; neutrodyne, tuned radio frequency
Cost without accessories; $125.00
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Finish; walnut or mahogany

APEX BABY GRAND CONSOLE RECEIVER



APEX RECEIVER

Specifications

MANUFACTURER; Apex Manufacturing Co.
Model; Baby Grand Console
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $225.00
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage; 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-550 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Dimensions; 48 x 18 x 36½ ins.
Finish; solid walnut
With loud speaker

CHARLES FRESHMAN CONSOLE RECEIVER

CHARLES FRESHMAN CONSOLE RECEIVER

Specifications

MANUFACTURER; Charles Freshman Co., Inc.
Model; Console
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories
Antenna; single outside wire
Tubes; 5
A battery; 6-volt, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Finish; mahogany

CHARLES FRESHMAN MODEL 5-F6 RECEIVER

CHARLES FRESHMAN 5-F6 RECEIVER

Specifications

MANUFACTURER; Charles Freshman Co., Inc.
Model; 5-F6
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $82.50
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Finish; mahogany

CHARLES FRESHMAN FRANKLIN RECEIVER

CHARLES FRESHMAN FRANKLIN RECEIVER

Specifications

MANUFACTURER; Charles Freshman Co., Inc.
Model; Franklin Console
Tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $115.00
Antenna; single outside wire
Kind of tubes; UV-201A or C-301A
Detector B battery; 90 volts
Amplifier B battery; 22½ volts
Wavelength range; 195 to 550 meters
Number of tuning controls; 3
A battery; 6-volt 120 amp. hr.
A battery current; 1.25 amp.
Cabinet; mahogany finish

CHARLES FRESHMAN MODEL 5-F7 RECEIVER

CHARLES FRESHMAN 5-F7 RECEIVER

Specifications

MANUFACTURER; Charles Freshman Co., Inc.
Model; 5-F7
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $97.50
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Finish; mahogany

CROSLEY TRIRIDYNE RECEIVER

CROSLEY TRIRIDYNE RECEIVER

Specifications

MANUFACTURER; Crosley Radio Corp.
Model; Super-Triridyn
Number of tubes; 3
Type of tuning; regenerative-reflex and R.F.
Cost without accessories; $60.00 (loudspeaker and table $52.50 extra)
Antenna; single wire
Tubes; dry cell or storage type
A battery; depends on tubes used
Amplifier B battery; depends on type of tubes
Detector B battery; depends on type of tubes
Wavelength range; 200-550 meters
Number of tuning controls; 2
A battery current; storage or dry cells depending upon tubes
Finish; solid mahogany, two-tone

DE FOREST RECEIVER

DE FOREST RECEIVER

Specifications

MANUFACTURER; De Forest Radio Corporation
Model; Renaissance
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $450.00
Antenna; single wire
Tubes; De Forest
A battery; 6-volt storage
Amplifier B battery; 90 volts
Detector B battery; 45 volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
C battery; 9 and 18
Finish; antique

F. A. D. ANDREA MODEL SF-20 RECEIVER

F. A. D. ANDREA SF-20 RECEIVER

Specifications

MANUFACTURER; F. A. D. Andrea Co.
Model; SF-20
Number of tubes; 5
Type of tuning; tuned radio frequency, neutrodyne
Cost without accessories; $225.00
Antenna; single outside wire
Tubes; dry cell or storage battery
A battery; dry cell or storage battery
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps. for storage battery tubes
Dimensions; 50 x 46 x 16 ins.
Finish; walnut, Adam brown

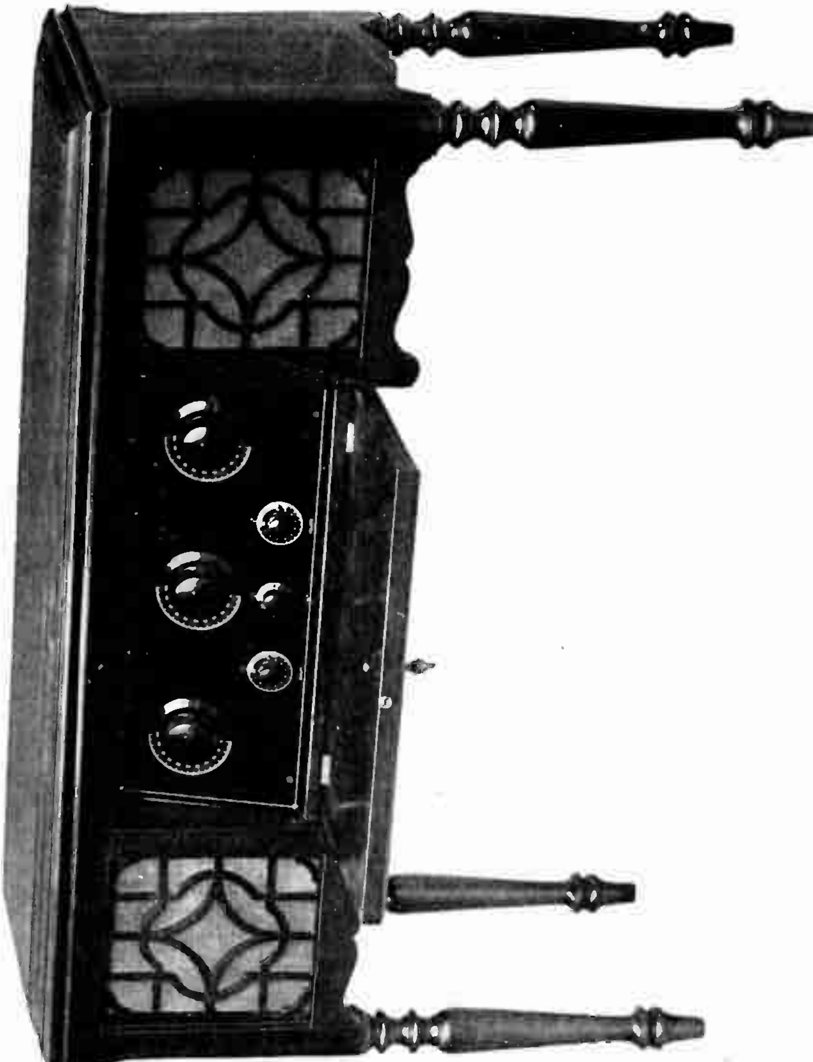
F. A. D. ANDREA MODEL SF-30/70 RECEIVER

F. A. D. ANDREA SF-30/70 RECEIVER

Specifications

MANUFACTURER; F. A. D. Andrea
Model; SF-30/70
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $300.00
Antenna; single outside wire
Tubes; dry cell or storage battery types
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
Dimensions; 38 x 44 x 23 ins.
Finish; Adam brown walnut

F. A. D. ANDREA MODEL SF-10/70 RECEIVER



F. A. D. ANDREA SF-10/70 RECEIVER

Specifications

MANUFACTURER; F. A. D. Andrea
Model; S. F. 10/70
Number of tubes; 5
Type of tuning; neutrodyne, tuned radio frequency
Cost without accessories; $225.00
Antenna; single wire
Tubes; dry cell or storage battery tubes
A battery; dry cell or storage battery
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps. for UV-201A tubes
Dimensions; 49 x 33 x 14 ins.
Finish; walnut, Adam brown

F. A. D. ANDREA MODEL SF-40/70 RECEIVER

F. A. D. ANDREA SF-40/70 RECEIVER

Specifications

MANUFACTURER: F. A. D. Andrea, Inc.
Model; SF-40/70
Number of tubes; 5
Type of tuning; neutrodyne, tuned radio frequency
Cost without accessories; $275.00
Antenna; single wire
Tubes; dry cell or storage battery
A battery; dry cell or storage battery
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps. for UV-201A tubes
Dimensions; 37 x 42 x 19 ins.
Finish; walnut, Adam brown

F. A. D. ANDREA NEUTRORECEIVER GRAND

F. A. D. ANDREA NEUTRORECEIVER GRAND

Specifications

MANUFACTURER; F. A. D. Andrea
Model; Neutroreceiver Grand
Number of tubes; 5
Type of tuning; neutrodyne radio frequency
Cost without accessories; $175.00
Antenna; single outside wire
Tubes; storage battery or dry cell types
C battery; 1½ to 4½ volts
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
Dimensions; 27 x 44 x 18 ins.
Finish; mahogany

KODEL BIG FIVE RECEIVER

KODEL BIG FIVE RECEIVER

Specifications

MANUFACTURER; Kodel Radio Products Co.
Model; Big Five Console
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $275.00
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-550 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Finish; dark brown mahogany

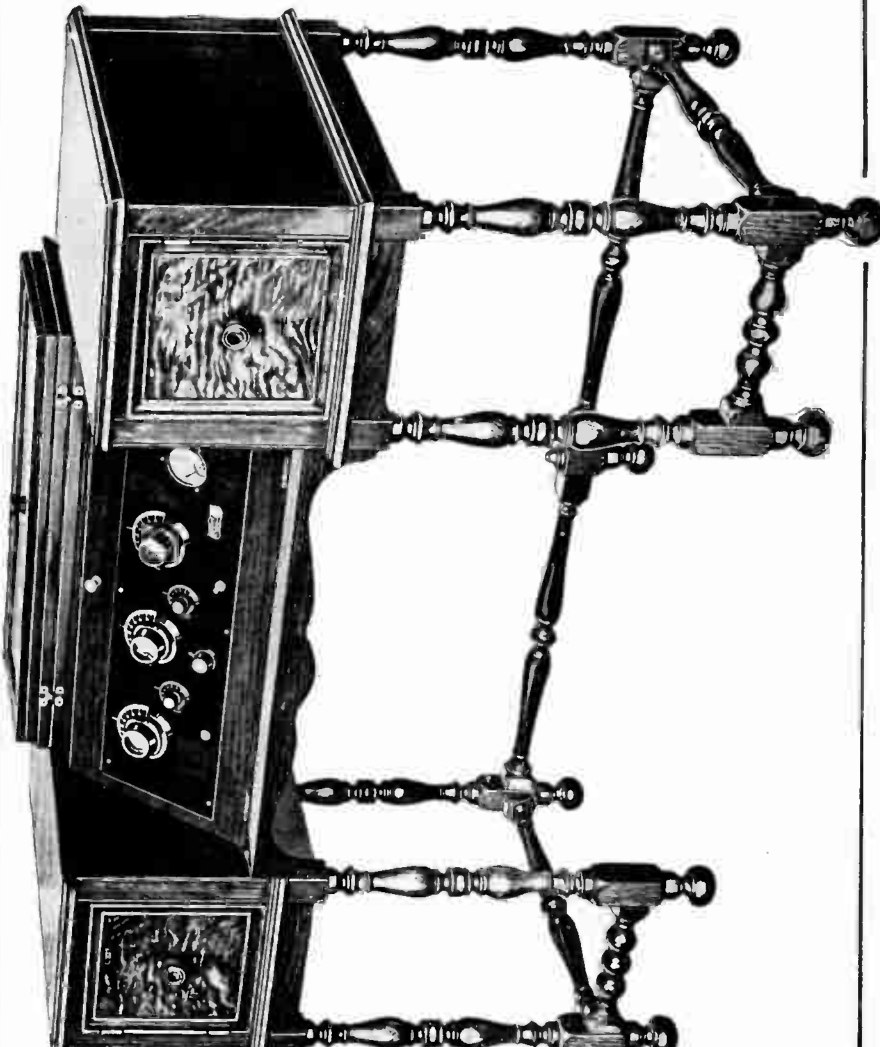
EAGLE MODEL F-C1 RECEIVER

EAGLE MODEL F-C1 RECEIVER

Specifications

MANUFACTURER; Eagle Radio Co.
Model; F-C1
Number of tubes; 5
Type of tuning; tuned radio frequency, neutrodyne
Cost without accessories; $235.00
Antenna; single outside
Tubes; UV-201A or C-301A
A battery; 6-volt storage 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls: 3
A battery current; 1.25 amps.
Finish; mahogany or walnut

LIBERTY CONSOLE RECEIVER



LIBERTY CONSOLE RECEIVER

Specifications

MANUFACTURER; Liberty Transformer Co.
Model; console de luxe
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $325.00
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt, 120 a.h. storage
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-550 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Finish; mahogany

LIBERTY MODEL 6363 RECEIVER

LIBERTY RECEIVER

Specifications

MANUFACTURER; Liberty Transformer Co.
Model; 6363
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $165.00
Antenna; single wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Finish; mahogany

MAGNAVOX MODEL 75 RECEIVER

MAGNAVOX MODEL 75 RECEIVER

Specifications

MANUFACTURER; Magnavox Co.
Model; 75
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $200.00
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage battery, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-500 meters
Number of tuning controls; 1
A battery current; 1.25 amps.
Dimensions; 46 x 18 x 22 ins.

MU-RAD MODEL A RECEIVER

MU-RAD MODEL A RECEIVER

Specifications

MANUFACTURER; Mu-Rad Corporation
Model; A
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $185.00
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-550 meters
Number of tuning controls; 1
A battery current; 1.25 amps.
Finish; mahogany

MOHAWK MODEL 115 RECEIVER

MOHAWK MODEL 115 RECEIVER

Specifications

MANUFACTURER; Mohawk Corporation of Illinois
Model; 115
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $225.00
Antenna; single wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 200-600 meters
Number of tuning controls; 1
A battery current; 1.25 amps.
Dimensions; 50 x 21 x 16 ins.
Finish; Adam brown walnut

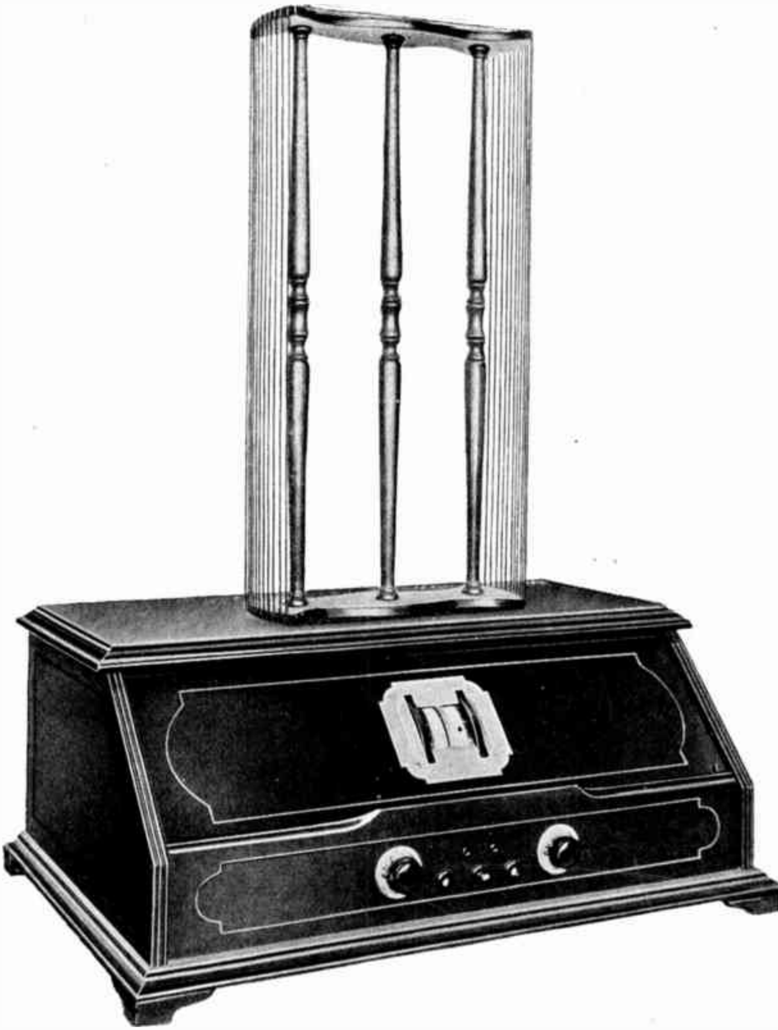
OPERADIO PORTABLE RECEIVER

OPERADIO PORTABLE RECEIVER

Specifications

MANUFACTURER; The Operadio Corp.
Model; Portable
Type of tuning; tuned radio frequency
Cost with loud speaker; $160 (no tubes or batteries)
Antenna; folding loop
Kind of tubes; UX-199
A battery; dry cells
Amplifier battery; 90 volts
Detector battery; 22½ volts
Wavelength range; 200 to 600 meters
Number of tuning controls; 1
Cabinet; imitation leather covering

RADIO CORPORATION MODEL 25 RECEIVER



RADIO CORPORATION 25 RECEIVER

Specifications

MANUFACTURER; Radio Corporation of America
Model; 25
Number of tubes; 6
Type of tuning; superheterodyne
Cost with tubes; $165.00
Antenna; loop attached
Tubes; 5 UX-199 and UX-120
A battery; dry cells
Amplifier B battery; 135 volts
Wavelength range; 200-600 meters
Number of tuning controls; 1
A battery current; .36 amps.
Finish; mahogany

RADIO CORPORATION MODEL 28 RECEIVER

RADIO CORPORATION MODEL 28 RECEIVER

Specifications

MANUFACTURER; Radio Corporation of America
Model; 28
Number of tubes; 8
Type of tuning; superheterodyne
Cost with tubes; $260.00
Antenna; loop attached
Tubes; 7-199 and 1-UX120
A battery; dry cells
Amplifier B battery; 135 volts
Wavelength range; 200-600 meters
Number of tuning controls; 1
Finish; mahogany

RADIO CORPORATION MODEL 8 RECEIVER

RADIO CORPORATION MODEL 8 RECEIVER

Specifications

MANUFACTURER; Radio Corporation of America
Model; Super- VIII
Number of tubes; 6
Type of tuning; superheterodyne
Cost complete; $340.00 including doublet speaker
Antenna; loop
Tubes; 199 type and UX-120 power tube
A battery; dry cells
Amplifier B battery; 135 volts
Wavelength range; 220 to 550 meters
Number of tuning controls; 2
A battery current; .36 amps.
B battery current; 12 milliamperes
Finish; mahogany

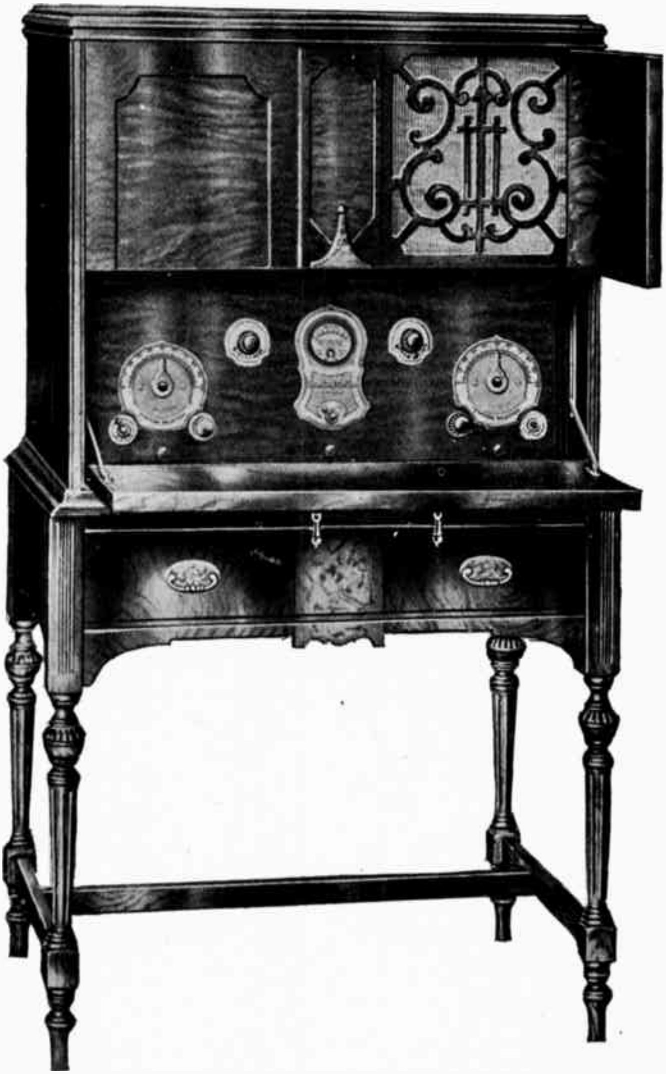
REICHMANN MODEL 52 RECEIVER

REICHMANN MODEL 52 RECEIVER

Specifications

MANUFACTURER; Reichmann Co.
Model; 52
Number of tubes; 5
Type of tuning; tuned radio frequency
Cost without accessories; $225.00
Antenna; single outside wire
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 90 volts
Detector B battery; 22½ volts
Wavelength range; 175 to 575 meters
Number of tuning controls; 3
A battery current; 1.25 amps.
Dimensions; 40 x 36 x 15½ ins.
Finish; burled walnut

STROMBERG-CARLSON MODEL 602-A RECEIVER



STROMBERG-CARLSON MODEL 602-A RECEIVER

Specifications

MANUFACTURER; Stromberg-Carlson Telephone Co.
Model; 602-A
Number of tubes; 6
Type of tuning; neutrodyne, tuned radio frequency
Antenna; single outside wire
Tubes; UX-201A and UX-112
A battery; 6-volt storage, 120 a.h.
Amplifier B battery; 135 volts
Detector B battery; 22½ volts
C battery; 9 volts
Wavelength range; 200-550
Number of tuning controls; 2
A battery current; 1.75 amps.
B battery current; 23 milliamperes
Finish; walnut

THERMIODYNE RECEIVER

THERMIODYNE RECEIVER

Specifications

MANUFACTURER; Thermiodyne Corporation
Model; CTF-6
Number of tubes; 6
Type of tuning; tuned radio frequency
Antenna; single wire outside
Tubes; UV-201A or C-301A
A battery; 6-volt storage, 180 a.h.
Amplifier B battery; 135 volts
Wavelength range; 200-600 meters
Number of tuning controls; 1
A battery current; 1.5 amps.
Dimensions; 53 x 33 x 15½ ins.
Finish; walnut