BLUE PRINT
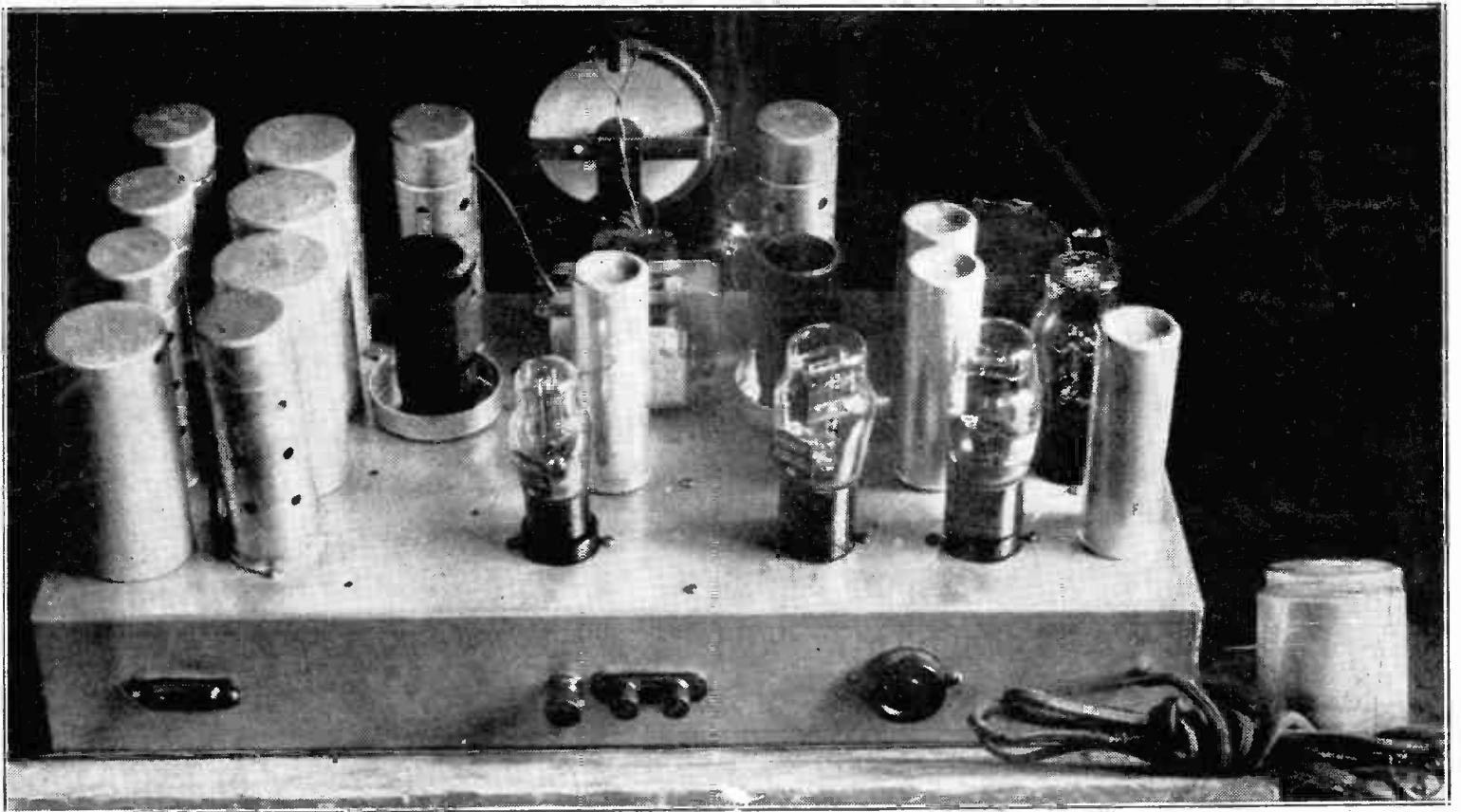### of a 2-Tube Short-Wave Battery Receiver

Antennas for All-Wave Propagation and Reception

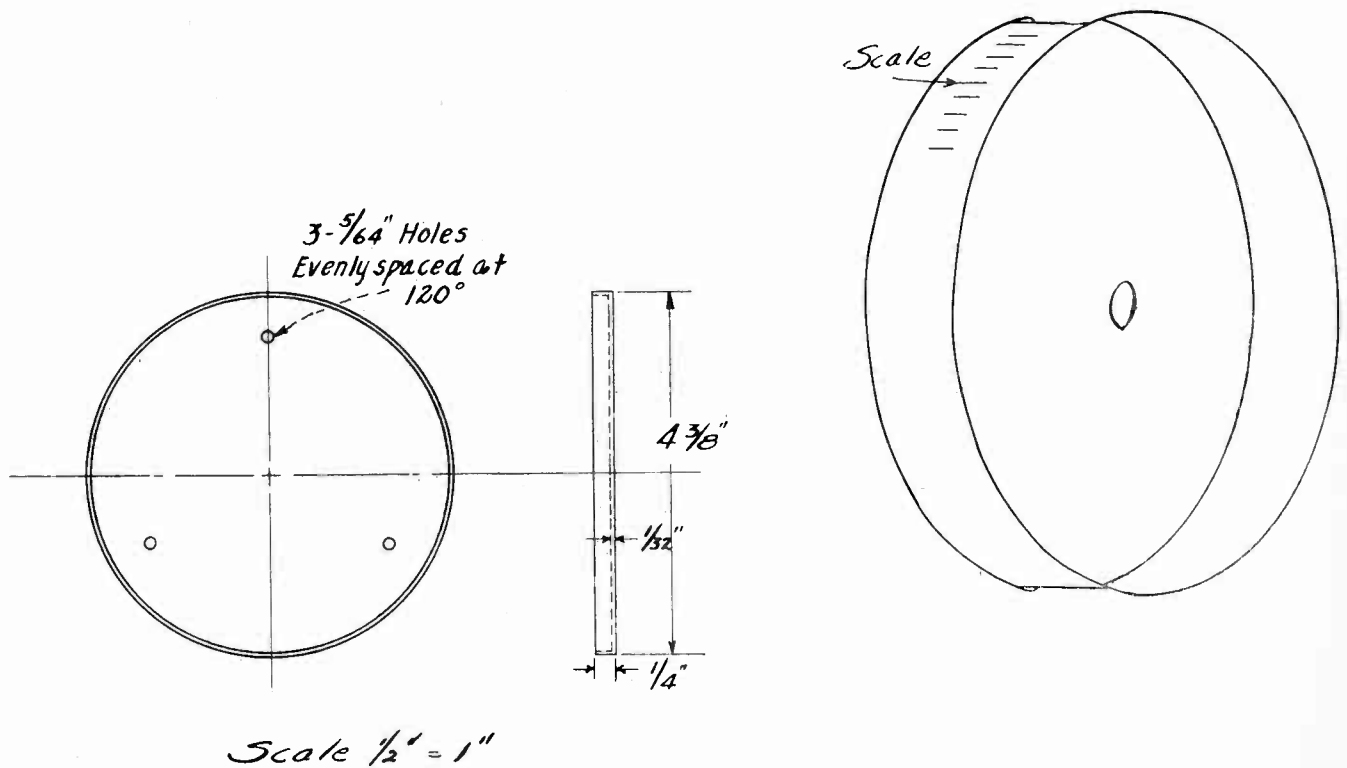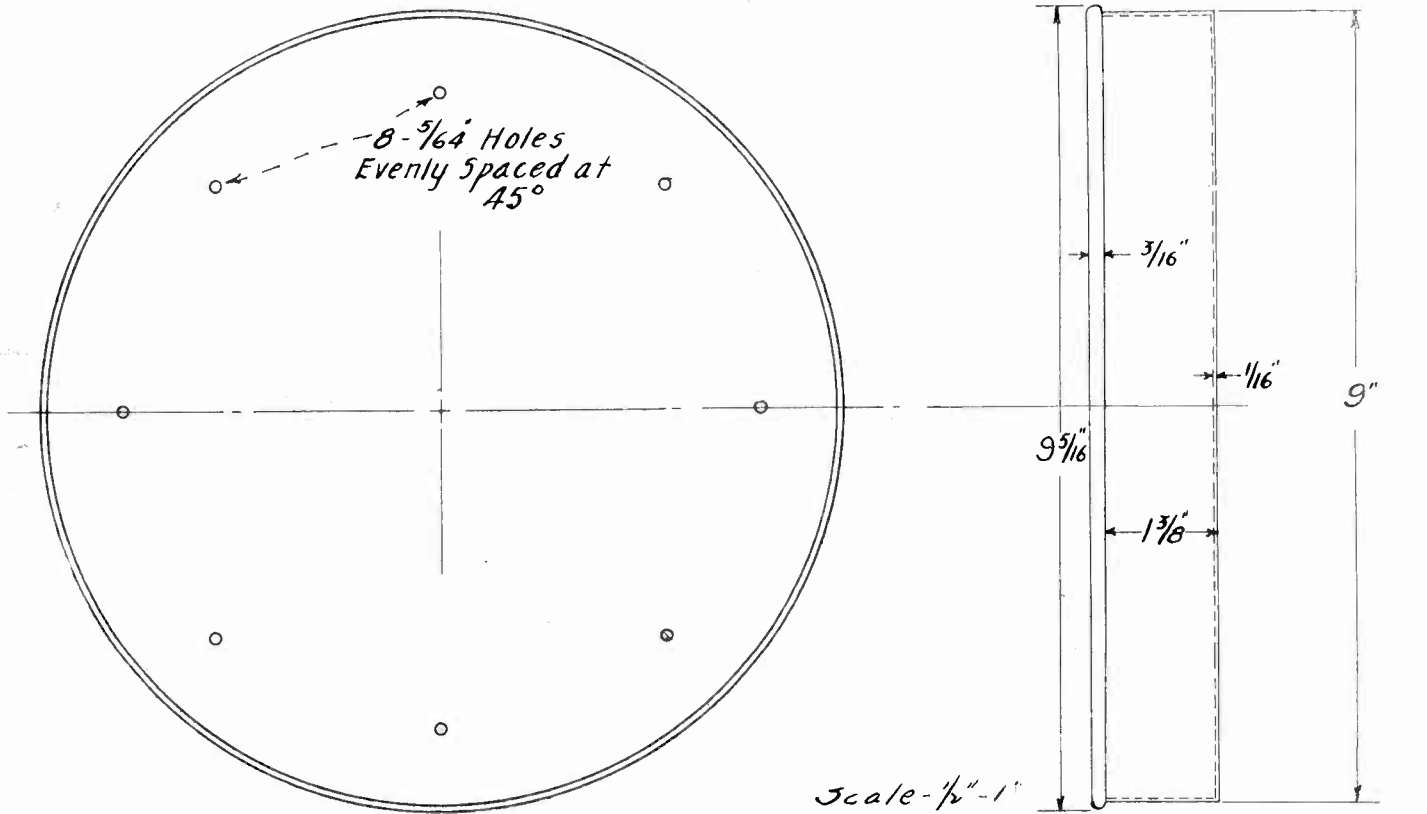# The New Pathfinder, 9 to 2,000 Meters

This All-Wave Super Has Numerous Latest Features.   See Pages 10, 11 and 12.

AN ALL-WAVE UNIVERSAL TEST OSCILLATOR

Latest Changes in Broadcasting Stations

A Large Drum for Short Waves
Makes Tuning-in Much Easier

8 - 5/64" Holes
Evenly Spaced at
45°

3/16"

1/16"

9 5/16"

9"

1 3/8"

Scale - 1/2" - 1"

Scale

3 - 5/64" Holes
Evenly spaced at
120°

4 3/8"

1/32"

1/4"

Scale 1/2" = 1"

By attaching a small drum plate to a 9-inch diameter aluminum cake pan, with perpendicular sides, and fast-
ening another such pan in the opposite direction, a large drum can be made. This gives high legibility and
slow-motion tuning, important for short waves.

Modulation of Waves

Frequency and Amplitude Methods, Also Microphone Uses, Described in Third Instalment of "The Short-Wave Authority"

By J. E. Anderson and Herman Bernard
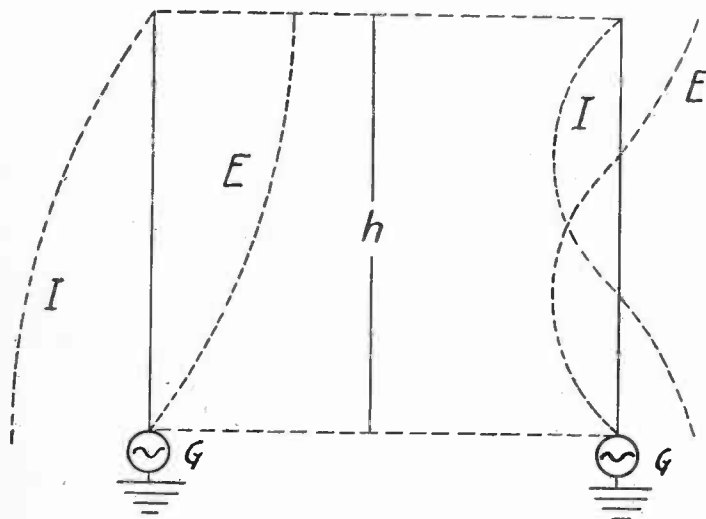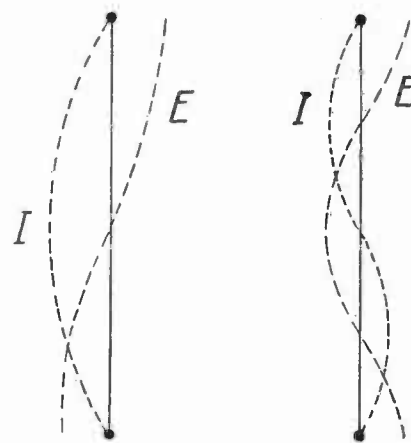
FIG. IV—1   FIG. IV—2

ONE of the most important parts of a radio communication system is the antenna. Two antennas are needed in every radio circuit, one at the transmitter for radiating radio-frequency energy and the other at the receiver for collecting a portion of the radiated energy. It is convenient to use the name aerial for the radiating structure and the name antenna for the collecting system. In principle the two are the same and any conclusions regarding one usually hold for the other.

The Marconi, or grounded vertical aerial, is illustrated in Fig. IV-1. The energy is fed to the aerial by a generator, G, located near the ground. This generator may be an actual machine or it may be simply the secondary of a transformer.

The effective height of the antenna is measured from ground to the top of the vertical wire, provided there is no flat-top portion, and this height is indicated by h. The figure on the left represents a quarter-wave aerial. The current is maximum near ground at the generator and minimum at the top. The voltage is minimum at the ground and maximum at the top. The voltage and current are represented, respectively, by E and I. The figure on the right represents a three-quarter-wave aerial.

As before, the current is maximum at ground and minimum at the top, but there is also one intermediate point at which the current is minimum and another point at which it is maximum. In this case, also, the voltage is minimum at ground and maximum at top, as for the current, there is one point between at which the voltage is maximum and another point at which it is minimum. The minimum value of either the voltage or the current in this case is zero. A current maximum occurs at a voltage minimum and a current minimum at a voltage maximum.

There is no difference between the two aerials shown at Fig. IV-1. The different voltage and current distributions in the two cases is due to the fact that the aerial on the left is excited by the fundamental frequency of resonance and in the other it is excited by the third harmonic of this frequency. If the height of the aerial on the right were three times greater and the frequency of excitation were the same as that used on the aerial on the left, the current and voltage distributions would be as shown on the right.

Grounded aerials can be excited in any number of odd multiples of quarter wavelengths. The two cases illustrated are the first two that are possible, that is, the first and the third harmonics.

When an aerial is not grounded it is called a Hertz aerial or antenna. It may be vertical or horizontal, or it may make any other angle with the surface of the earth. The ungrounded aerial is usually a half-wave radiator but may be excited in any number of half-wavelengths, or in any even number of quarter-wavelengths.
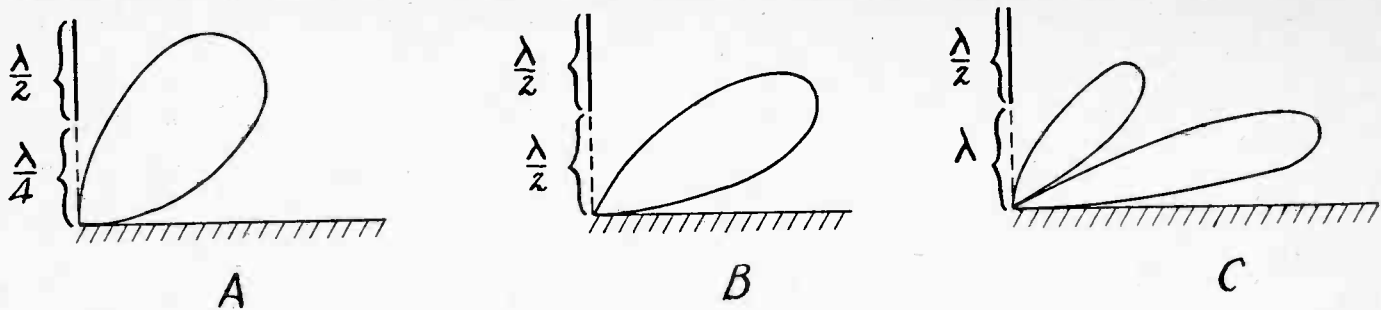
FIG. IV-3
Polar radiation diagrams when the ground is very poorly conducting and when the dipole is raised different distances above ground. Low angle radiation results when the radiator is raised.

(Continued from preceding page)
In other words, the ungrounded aerial can be excited by all those harmonics by which the grounded aerial cannot be excited.

In Fig. IV-2 are shown the current and voltage distributions of the ungrounded aerial when it is excited by the second harmonic, left, and by the fourth harmonic, right. No current can flow at either end. Hence, the current curve passes through both ends, and this is true regardless by what even harmonic the aerial is excited. The voltage is maximum at the ends, or at current minima, and the voltage is minimum, that is, zero, at the current maxima. A Hertz antenna excited as in Fig. IV-2, left, is called a dipole.

The radiation from an ungrounded vertical aerial depends largely on how far above ground it is. It also depends on how good the conductivity of the earth is. For waves, say, below 25 meters, it is better to assume that the ground has no conductivity than to assume that its conductivity is perfect, which is often done. On the assumption that the conductivity is very poor, the radiation in any direction can be computed for any elevation of the dipole. In Fig. IV-3 are three different cases, when the lowest end of the vertical wire is one quarter wavelength above ground, when it is one-half wavelength, and when it is one wavelength.

It will be noticed that when the elevation is one-fourth wavelength, maximum radiation occurs at an angular elevation of 45 degrees. When the elevation is half wavelength, the angular elevation of the maximum radiation is about 30 degrees. Again, when the aerial is lifted a whole wavelength above ground, there are two directions in which the radiation is maximum, one about 15 degrees and the other about 50 degrees. The important thing to notice here is that the maximum radiation is closer to ground the higher the dipole is raised. However, if it is raised more than one wavelength the radiation pattern becomes complicated. Fig. IV-3 shows how the direction of radiation varies with the elevation of the vertical dipole.

When the vertical wire is made high and it is excited in many half wavelengths, the radiation pattern exhibits several loops and most of the radiation is on a high angle. Very little radiation occurs at a low angle. It is best to have most of the radiation on a low angle, and for that reason the high aerial excited by harmonics is not suitable.

If the radiating aerial is mounted horizontally, the electrical field of the radiated wave is horizontal while the magnetic field is vertical. Therefore, a vertical antenna at the receiver should not pick up the signals. But the fact is that it does. Either a vertical or a horizontal antenna will pick up signals from either a vertical or horizontal aerial. Therefore, it is clear that the plane of polarization does not remain fixed, but turns so that there are components both in the horizontal and vertical directions. This is especially the case at great distances from the transmitting aerial.

THE effect of tall steel structures and of water courses on the propagation of radio is clearly shown by the map in Fig. II-2. This represents an aerial view of Manhattan Island New York, the solid lines representing shore lines and the dotted lines curves of equal radio field intensity about the radio transmitter located at T. The Hudson River is on the left and the East River on the right, with the upper bay and Governors Island in the foreground. The view will be printed next week.

The station, which is no longer existent, was located among tall steel skyscrapers and its antenna was on top of one of them. Notwithstanding the lofty position of the antenna, the shadows caused by other structures are clear. As an illustration, consider the 20 microvolt per meter line in the bay. It bends upward toward the station within a few blocks of the station itself. All the other lines do the same. The reason for this is that between the station and the lower tip of Manhattan is a large number of very tall steel buildings. The radio signal is absorbed within a few blocks of the transmitting antenna. Almost the entire bay is in the shadow of these buildings.

If we go in the opposite direction we note the same phenomenon. The lines of equal signal strength are close together, indicating that the intensity dies down rapidly, and the reason is that this entire area is covered with tall steel buildings. In the middle of the city, over Central Park to be exact, the lines of equal radio strength are closed lines, and the lowest field intensity given is only one microvolt per meter. This hollow in the field pattern is the shadow of the steel buildings. As we go farther north we come to stronger signals again. Radio energy flows into the region above the shadow from the two rivers on the sides and also from above.

That the two rivers aid the propagation of the waves is shown by the fact that the lines of equal field intensity are farther apart over the water than over the land, especially over the steel buildings. Another interesting phenomenon is shown on the field pattern map, and that is the effect of the bridges across the river. The dashed line marked B is one of the bridges across the East River, and it points almost directly toward the transmitter. A sharp bulge in the 75-microvolt line in the direction away from the station is obvious. This shows that the bridge, which is mostly steel, helps to transmit the waves. A continuous steel structure, like a railroad or a bridge, helps to conduct the waves longitudinally but obstructs their passage transversely. The same may be said of water courses.

THE wave generated by a tube oscillator and radiated into space is continuous and invariable in amplitude. Such a wave can carry no intelligence. If the wave is to carry a message it must be modulated in some manner. The modulation may be a variation in the intensity or amplitude of the wave or it may be a variation in the frequency. In either event the modulation must be done according to a scheme that is understood by the recipient. The simplest and most common form of modulation is a variation in the amplitude, of which there are two forms, namely, start and stop and continuous variation by means of a tone. Ordinarily, only the continuous type of variation is called modulation, the start-and-stop being referred to as keying.

The keying may either start and stop the wave or it may merely change the amplitude or frequency. In either event the wave is broken up into shorter or longer periods. If the key is held down a very short time, just enough to start oscillation, a dot is formed. If it is held down about twice as long as is required for a dot, a dash is formed. The time between two dots, or two dashes, or a dot and a dash, is called a space, the duration of which is about the same as that of a dot. The alphabet is made up of various combinations of dots and dashes while numerals and punctuation marks are made up of other combinations.

The intermittent oscillation involved when sending by means of starts and stops is illustrated in Fig. III-1. A represents a dot, B a space and A another dot. By lengthening the dots to contain twice as many waves, dashes would result. In the lower part of the figure is shown another method of forming the dots and dashes. In this case A still stands for a dot, while C stands for a space. The only difference between the upper and lower figures is that in the space B no wave is going out while in C a wave is transmitted but it has a different frequency from that of a dot or a dash. The variation in frequency is called frequency modulation.

The reception of either intermittent modulation requires another oscillator. This is adjusted until the frequency differs by a convenient amount, say 1,000 cycles per second, from the frequency of the incoming wave during a dot or dash. By detection the dots and dashes will be heard in the receiver as a tone of 1,000 cycles per second. In case of frequency modulation the adjustment of the local oscillator is the same, but when a dot or dash is not sounded, the frequency of the transmitter differs so much from that of the receiver heterodyne oscillator that the beat is above audibility. Frequency modulation is not used much because it requires sending out power when there is no necessity for sending out any.

Instead of starting and stopping the wave, or instead of changing the frequency suddenly by fixed amounts, the continuous wave could be modulated by varying the amplitude in accordance with an audible tone. Let A in Fig. III-2 be the unmodulated wave. Let B represent one cycle of an audio tone, say one of 1,000 cycles per second. By impressing the audio tone B on the radio wave A, a modulated wave C is obtained. It is a radio-frequency wave of the same frequency as A but its amplitude varies according to B.

A signal modulated as in Fig. III-2 can be received without the aid of a heterodyne oscillator, and it requires only an ordinary detector to make it audible. The tone used for modulation may have any value within the audible range and two or more tones may be used simultaneously. Since voice and music are
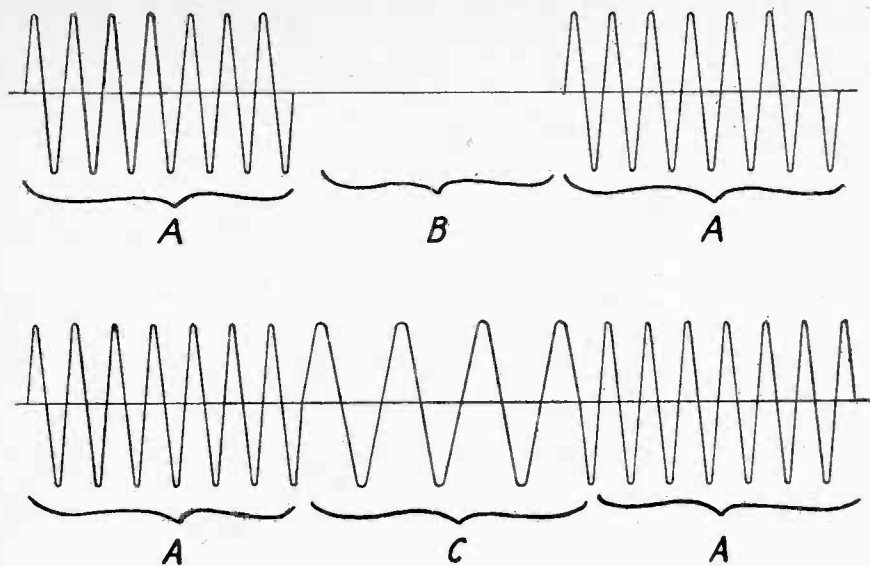
FIG. III-1
Radio telegraphic communication is carried on by means of dots and dashes, which are wave-trains of shorter and longer duration. Upper figure shows two dots (A) separated by a space (B). Lower figure shows two dots and a space in which the space is made by frequency variation.

made up of audio tones of different frequencies, the intelligence sent by the amplitude-modulated wave may be either of these.

There are many different ways of keying when sending messages by code. Sometimes the key is placed in series with the plate supply, sometimes in the grid circuit in series with the leak, and sometimes across the bias. When the key is placed in series with the plate supply, oscillation stops when the key is released, for then no plate voltage is applied to the oscillating tube. When the key is in series with the grid leak oscillation cannot occur when the key is open because the tube is then blocked. When it is placed across the bias, depressing the key changes the bias to a value at which oscillation can occur and releasing it returns the bias to a value at which oscillation cannot be maintained.

In Fig. III-3 is an oscillator circuit in which the key, K, has been placed in series with the grid leak, which in this case consists of a resistance R and a radio-frequency choke Ch. The key could also have been placed at any one of the three points marked (X). The best place to put the key, in this circuit at least, is where it is, that is, in series with the grid leak, for in this place at does not have to break much current.

Fig. III-4 illustrates the method of changing the bias on the grid by means of the key. When the key is open the bias on the grid is so high that oscillations cannot start, but when the key is pressed down the bias is zero except for the drop in the resistance R1 due to the grid current. Oscillations start quickly. If the battery B is replaced by a condenser, the oscillations can be started and stopped with the key, for when the key is open the grid is blocked and the circuit cannot oscillate and when the key is closed there is a path for the grid current.

In Fig. III-5 is shown a circuit by which a tone-modulated wave can be generated and transmitted. There are two Hartley oscillators, one working at an audio frequency and the other at a radio frequency. The high-frequency oscillator is functioning all the time but the audio-frequency oscillator is operating only while dots and dashes are being set. The key is placed in the lead between the centertap on the filament and the negative of the plate supply. Thus when the key is opened the plate circuit of the tube is opened and oscillation stops. As soon as the key is closed, however, audio oscillation occurs.

While the audio tube is oscillating the plate voltage applied to the radio-frequency tube varies according to the audio oscillation. That is, the plate voltage on the radio tube is alternately higher and lower than the mean voltage. The amplitude of the generated radio-frequency wave is proportional to the plate voltage on the tube, and therefore the amplitude varies. The manner in which this occurs is illustrated in Fig. III-2. At A is shown the unmodulated wave as generated by the second tube in Fig. III-5 when the key is open. At B is shown the audio wave generated by the first tube when the key is pressed down. B also represents the plate voltage on the second tube, if the horizontal line is the mean voltage and the curve is the instantaneous voltage. C represents the modulated wave resulting from the simultaneous oscillation of the two tubes.

The circuit in Fig. III-5 is not used for radio telegraphy because the start-and-stop method of modulation of the carrier is much more efficient. It is, however, used for testing receivers designed for broadcast purposes. To adapt the circuit to broad-
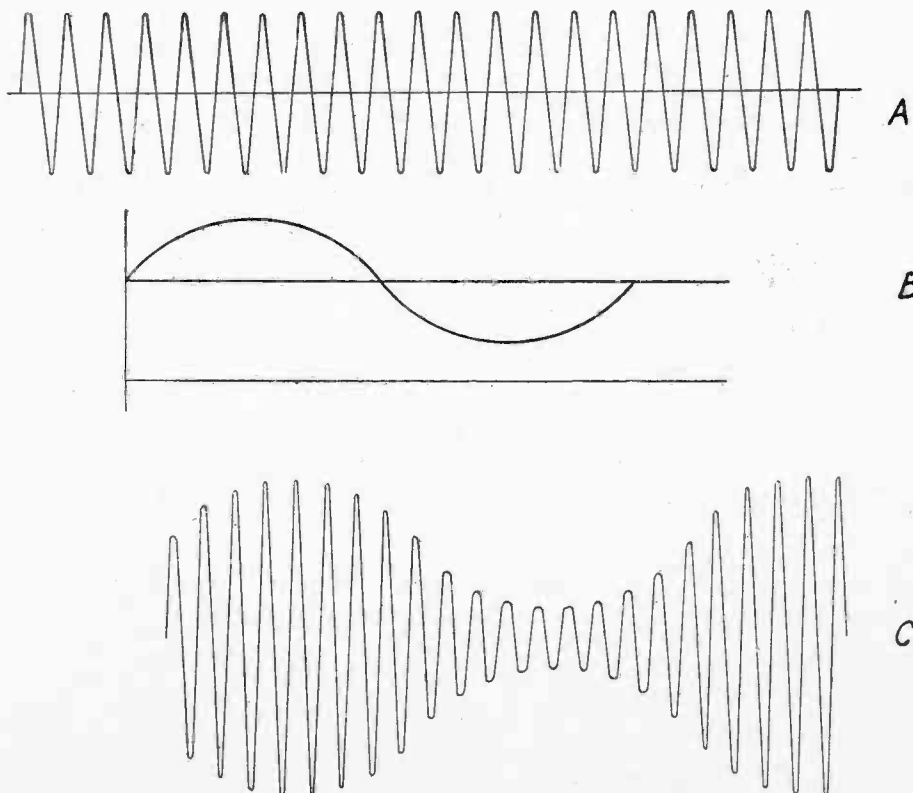
FIG. III-2
(A) shows an unmodulated wave, which is ordinarily called the carrier when voice and music are transmitted by radio waves. (B) shows one wave of some audio tone. (C) shows the resulting modulated wave when (B) is impressed on (A).
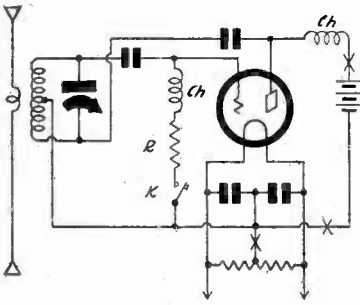
FIG. III-3
A simple oscillating circuit in which the key is placed in series with the grid leak. When the key is depressed an unmodulated wave as (A), Fig. 2 results. The key is used for making dots and dashes in the upper part of Fig. III-1.
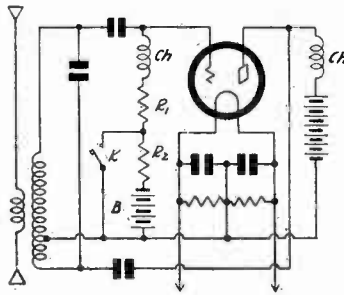
FIG. III-4
Another oscillator circuit in which the keying is done by varying the grid bias on the oscillating tube. The bias is too high for oscillation to exist when the key is open.
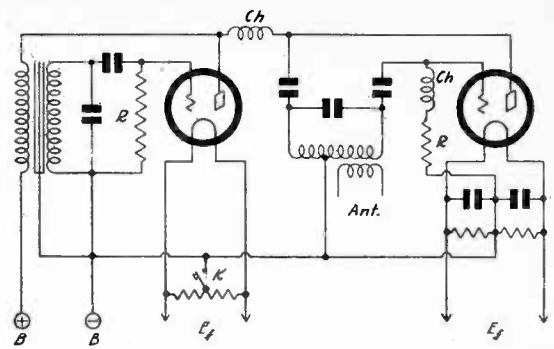
FIG. III-5
Two oscillators, one operating at radio frequency and the other at audio frequency, coupled together by the Heising scheme of modulation. This produces a modulated wave like that in Fig. 2 (C) when the key, K, is depressed.

(Continued from preceding page)

cast transmission it might be arranged as in Fig. III-6. In this case the source of the audio signal is a sound picked up by a microphone, M. When sound impinges on the microphone an electrical current will flow in the primary of the transformer and this will vary according to the intensity and frequency of the incident sound. The signal is transferred to the grid of the first tube, which is called a modulator, by the transformer. This voltage will vary the plate voltage on the tube and also on the second tube. Since the output of the radio-frequency oscillator depends on the plate voltage on that tube, the sound that falls on the microphone will cause a variation in the amplitude of the radio-frequency output of the second tube. This variation, which is an exact duplicate of the sound, is modulation.

The method of modulation used in Figs. III-5 and III-6 is called the Heising, or constant-current, modulation method. It is considered one of the best. Another way of modulating is to impress the audio signal on the grid of the high-frequency oscillator tube, which is called grid modulation. Fig. III-7 shows how the grid method of modulation can be applied to the same radio-frequency oscillator as that used in Figs. III-5 and III-6.

In Fig. III-7 the audio tube, which is on the right, is used as an audio-frequency amplifier. It delivers its output to an audio coupling transformer, T2, the secondary of which is connected in the grid circuit of the radio-frequency oscillator. The radio-frequency chokes, Ch, are employed to prevent the radio frequency currents from shorting and the grid condenser, C2, is used to prevent the audio currents from shorting.

Microphones

When sounds are to be transmitted by radio a means is necessary for picking up the air waves constituting sound and converting them into equivalent electrical waves. A device which does this is called a microphone. There are many different forms of microphone and several different principles on which they work. Of the more common types are the carbon granule type, the condenser or electrostatic type, the dynamic or electrodynamic type, the ribbon or velocity type, and the piezo-electric type. The ribbon or velocity type is really a limiting form of the dynamic microphone.

The Carbon Microphone

The carbon granule microphones are of two kinds, the single-button and double-button. In Fig. III-8 is illustrated the single button type. C1 and C2 are two carbon blocks. Between them is a mass of fine carbon granules G. A diaphragm D, usually held at the periphery by a rubber ring, is connected mechanically to one of the carbon blocks, C1. A battery B, in series with the primary of a transformer T, is connected between the two carbon blocks. Thus a circuit is formed which comprises C1, G, C2, the transformer primary, and B. The e. m. f. of the battery will send a current around this circuit and the intensity of the current will depend on the resistance of the circuit.

As sound impinges on the diaphragm D this will vibrate, the vibration will be communicated to the carbon granules in the form of a varying pressure. As the pressure on the carbon granules varies the resistance between C1 and C2 varies. Therefore, since the e. m. f. in the circuit is constant, the current will vary. In this manner the air pressure variations constituting sound waves will be converted into a varying current. If the motion of the diaphragm is very minute, say 0.0001 inch, the current variations will follow closely the sound variations, and the conversion is effected without distortion.

The double button microphone differs from the single button only that it has a carbon granule chamber on each side of diaphragm, the two sides being equal. This type of microphone is illustrated in Fig. III.-9. The battery B now is connected between the diaphragm and the center of the transformer. It is recognized immediately that this is a push-pull arrangement and therefore that harmonics of even order, that is, second, fourth, sixth, and so on, are eliminated. Therefore a double button microphone will stand more sound input than a single button type before appreciable distortion occurs. This is the main advantage of the double button microphone.

The resistance of a carbon granule microphone varies from about 50 ohms to 200 ohms. The allowable current is around 25 milliamperes. If a higher current is allowed to flow the carbon granules heat up excessively and small arcs may form between adjacent grains. Heating and arcing would render the microphone useless. The double button microphone will carry twice the current of a single button.

The Electrostatic Microphone

The condenser or electrostatic microphone works on the principle of charging and discharging a small condenser. Referring to Fig. III-10, DD is a stretched metallic diaphragm and A is a heavy
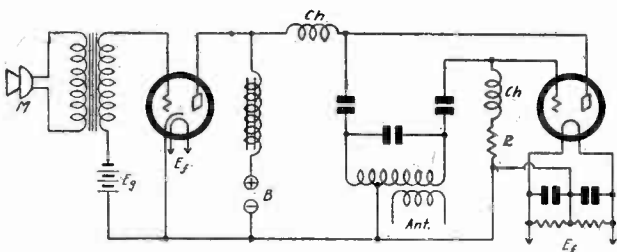
FIG. III-6
The second tube generates the carrier and this is modulated by the output of the first tube when sound falls on the microphone, M. The circuit illustrates the Heising method of modulation and the Hartley radio-frequency oscillator.
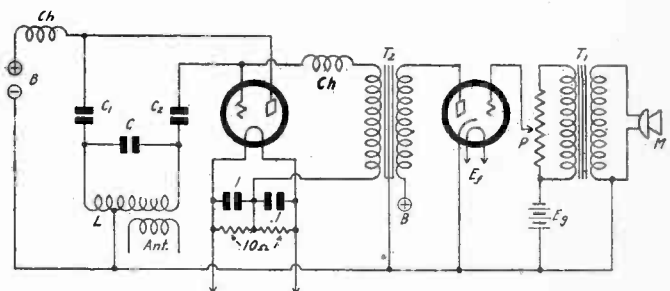
FIG. III-7
This circuit is similar to that in Fig. 6 but the grid method of modulation is used. That is, the output of the audio-frequency amplifier is impressed on the grid of the radio-frequency oscilator. The potentiometer P provides a means for varying the degree of modulation.
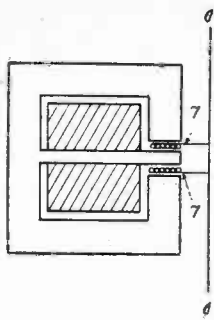
FIG. III-8

This shows the essential elements of a single-button carbon granule microphone. D, diaphragm; C1, C2, carbon blocks; G, a chamber filled with a large number of small carbon granules; B, a battery for driving a current around the circuit; T, a microphone transformer.
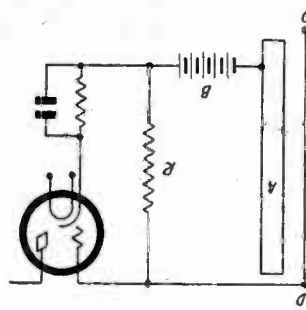
FIG. III-9

This outlines the elements of a double-button carbon granule microphone. There are two equal carbon granule units, one on each side of the diaphragm. The primary of the microphone transformer is now center-tapped and the battery is connected between the tap and the diaphragm.
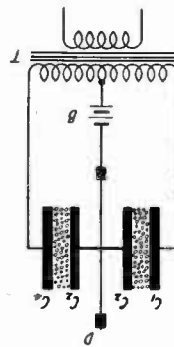
FIG. III-10

The condenser or electrostatic type of microphone illustrated here is based on the principle of charge and discharge of a small condenser. The diaphragm DD and the plate A are the two electrodes of the condenser. Sound waves vary the capacity, forcing current in and out of the condenser. An alternating current flows through R and sets up a voltage.
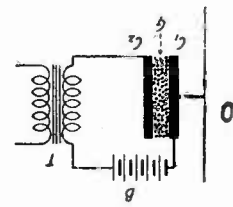
FIG. III-11

The dynamic microphone is the same in principle as the dynamic speaker, except that it works in reverse. Sound causes the diaphragm to vibrate, which in turn makes the coil move back and forth across the magnetic field. A voltage is induced in the coil which is stepped up with a transformer before amplified.

metal plate. The separation between the two is about 0.001 of an inch. By means of a battery B a voltage difference of several hundred volts is maintained between the two electrodes, DD and A, of the microphone, but the voltage is applied through a resistance, R, of several megohms. The condenser formed by the two electrodes has a capacity of a few micro-microfarads.

When a sound wave strikes the diaphragm DD, this will vibrate, making the distance between DD and A greater and less, alternately, than the mean distance. When the diaphragm moves toward A, the capacity decreases and current rushes into the condenser through R. When the diaphragm moves away from A the capacity decreases, a current is forced out of the condenser. Thus as the diaphragm moves back and forth in conformity with the sound wave, current flows through R first in one direction and then in the other. An alternating voltage drop results across R, and this is the output of the condenser microphone, which is applied to the grid of the amplifier tube.

The condenser microphone is regarded as the most nearly perfect device for changing sound into equivalent electrical values. It has a very uniform frequency characteristics from the lowest to the highest audio frequencies. Yet it has some disadvantages. First, it requires a high polarizing potential, and second, it is not very sensitive. In order to increase the sensitivity it is necessary to make the resistance R as high as possible, say 10 megohms or more. But it is not easy to get such high resistances, for leakage across and through insulators accounts for considerable conductivity. To reduce leakage as much as possible and hence to get a high sensitivity, the first amplifier tube is placed very close to the condenser microphone. Even then the sensitivity is only about 1/10 as great as that of the carbon button type. The advantages of the condenser microphone outweigh the disadvantages, and for that reason it is used in most broadcast studios.

Since it is essential that the resistance load on the microphone be as high as possible, it is clear that the amplifier tube must have a negative bias sufficient to insure that no grid current flows. In Fig. 10 a cathode resistor is indicated as a suitable means of getting the bias. In case the tube is of the filament type, which is the more practical for this service, the bias can be supplied by a small battery.

The Dynamic Microphone

The principle of the dynamic microphone is exactly the same as that of the dynamic speaker, except that the operation is in the reverse direction. That is, instead of converting electrical energy into sound energy it converts sound energy into electrical energy. Fig. 11 shows a cross section of a dynamic microphone. DD is the diaphragm that is set into motion by the air waves. To this diaphragm is fastened a very light coil with terminals LL. This coil is mounted in the airgap of a powerful magnet structure, which may be either of the permanent type or of the electro-dynamic type.

As the diaphragm vibrates the turns of the moving coil cut the lines of magnetic force in the airgap, and consequently an electromotive force is induced in the coil LL. Ordinarily this electromotive force is weak but as the resistance in the coil is low a relatively large current flows when the coil is closed through the primary of a step-up transformer. The voltage available in the secondary of this transformer is considerable and can be applied to the grid of an amplifier tube. The dynamic microphone is not as sensitive as the carbon button type but it is superior to it in respect to quality.

The latest microphone is the ribbon or velocity type, which is

a limiting case of the dynamic microphone. The main feature of the construction of this instrument is shown in Fig. III-12. An extremely light, corrugated, metal ribbon, DD, is suspended between the poles, NS, of a strong permanent magnet, and the leads, LL, of the ribbon are connected in series with the primary of a step-up transformer. There is only one turn on the primary of this transformer and the ribbon is a part of that turn.

Sound waves strike the corrugated ribbon and set it into vibration at right angles to the magnetic field. Since a voltage is always induced in a conductor moving across a magnetic field, a voltage is induced in the ribbon. This is stepped up by the transformer, which is usually mounted directly on the microphone, and then it is amplified.

The velocity microphone has many advantages. In the first place, the voltage generated is practically independent of the frequency, and for that reason the quality of signals picked up by this microphone is good. In the second place, it is directional. This makes it possible to exclude any sound which is not supposed to be transmitted. Greatest output occurs when the source of the sound is directly in front or directly back of the microphone, that is, when the sound waves travel at right angles to the plane of the ribbon. There is no output when the sound comes from either side. The ribbon type microphone is said to have nearly equal response for all frequencies from 30 cycles per second up to 14,000 cycles per second, that is, the entire audible range.

Piezo-Electric Microphone

When crystals of quartz, tourmaline, Rochelle salt, and a few others are subjected to pressure or other mechanical stress electric charges appear. This relationship between electricity and mechanical stress in crystals is called the piezo-electric effect. Of all the piezo-active crystals, Rochelle salt shows the greatest effect by far. If a crystal is twisted, for example, it will show a difference of potential across two of its faces of several hundred volts.

It is clear that if a crystal could be subjected to stress as a result of sound, a microphone could be made on this piezo principle. Indeed, there are such microphones and they are relatively sensitive. The diaphragm on which the sound waves fall is coupled mechanically to the Rochelle salt crystal in such a manner that when it vibrates, the crystal is twisted. Voltages then appear and they are impressed on the grid of a vacuum tube amplifier. As in the case of the condenser microphone, a very high resistance grid leak is required if this microphone is to be sensitive.

Special Tube Course
at RCA Institutes

RCA Institutes, Inc., 75 Varick Street, New York City, announce that a new class convened May 21. This course is devoted entirely to recent developments in receiving vacuum tubes and associated apparatus, their operation and testing. It can readily be understood that due to unusual facilities afforded through close connections in teh industry that most complete information on the recent developments and advances permit an authoritative analysis of the anticipated trend such as could not be duplicated in any other course. Class hours are from 7:15 to 9:15 on alternate evenings to August 24. Prospective students may register by mail or at R. C. A. Institutes, at the above address, from 9 A. M. to 9 P. M., Mondays to Fridays, inclusive.

THE ALL-WAVE 9-

Range is 9 to 2,000 Meters, with a T-R-F Sta

By Robert G. Herzog

Chief Engineer,
Thor Radio Co.
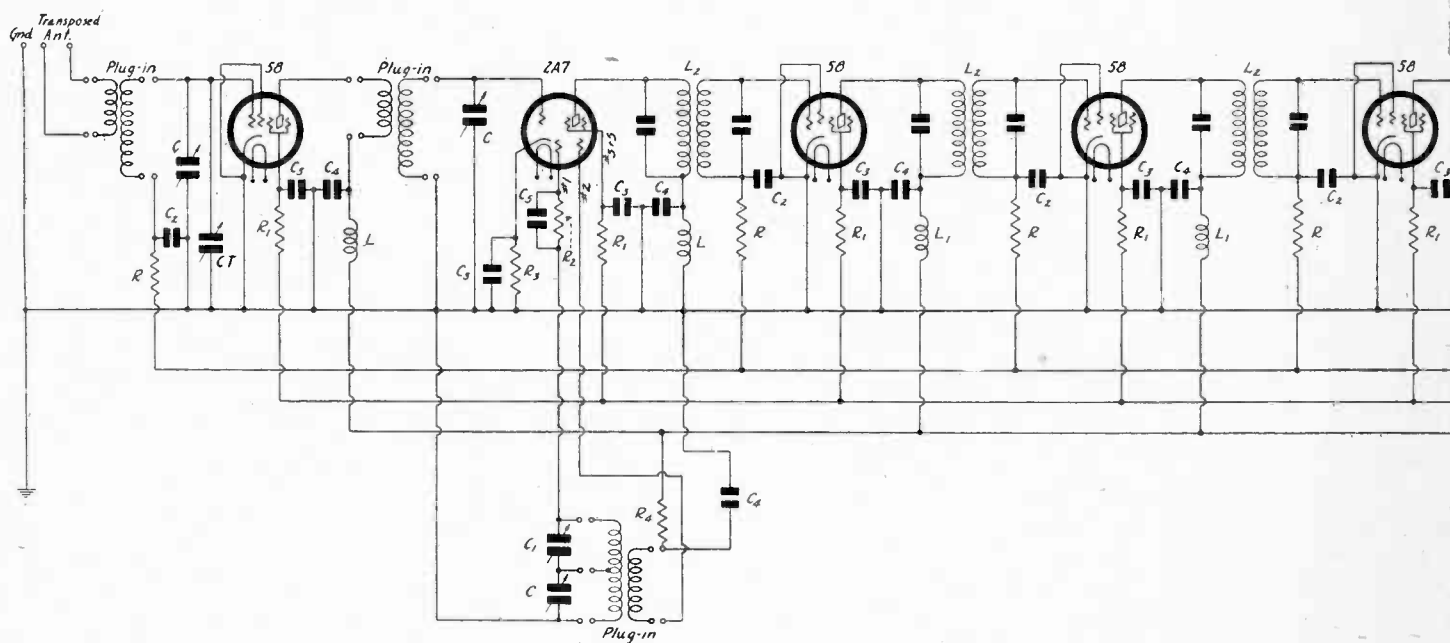
The newest Pathfinder, 9 to 2,000 meters, the result of months of experimenting. Plug-in coils

AFTER many months of experimenting in one of the best-equipped laboratories, the Pathfinder all-wave circuit finally was developed. The size of every resistor and condenser used was accurately calculated and carefully checked. The position of each part, even each wire, was actually decided with the one aim to produce an exceptional receiver on all bands.

In spite of the special complications of the many circuits, an experienced experimenter should have no great difficulty in building the receiver, provided he follows the layout and circuit exactly and carefully.

To much emphasis cannot be made on this point. The circuit as printed is the result of much effort. Any changes might make it ordinary or even worthless.

If the builder is anxious to have a really exceptional receiver it is our advice to follow the circuit and layout strictly. Any slight changes contemplated should be discussed with the authors before putting them into practice.

What the Circuit Has

With the exception of the special features the circuit is typical of the average good superheterodyne. It has a tuned r-f stage, a mixer stage; three i-f stages, a diode second detector stage, combined with a first audio stage which is transformer coupled to the push-pull output stage.

Bias on the r-f and i-f stages is controlled by the potentiometer R$_s$. which can vary it between minus 3 and minus 18 volts. This control can be used as a sensitivity or noise suppression control when the a-v-c switch is at the "on" position. When the control is in its extreme clockwise position the r-f and i-f stages will tend to oscillate. This action can be used to bring in unmodulated code signals.

Unique Method of Automatic Volume Control
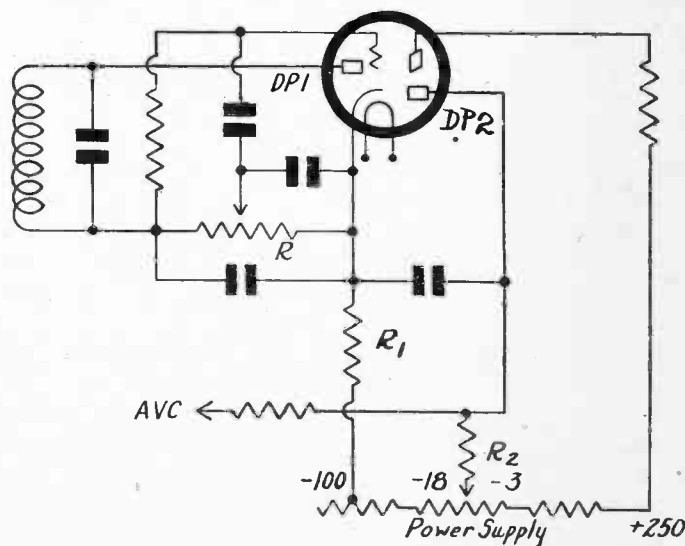
Detail of the second detector and a-v-c circuits.

TUBE PATHFINDER

ge in all Bands—Ingenious Control of Volume

and Joseph De France

Electrical Engineering Laboratory Instructor, College of the City of New York
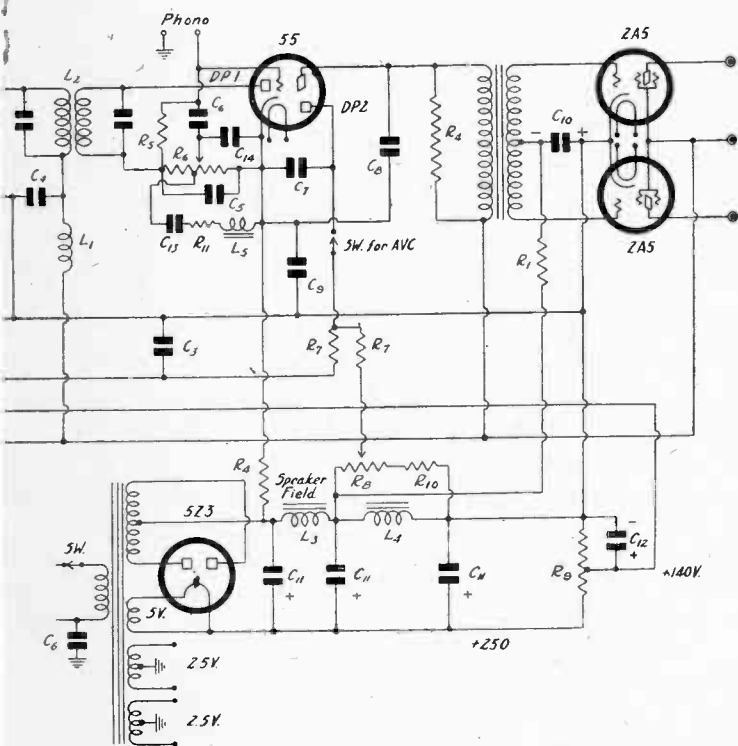
are used.   Automatic tone control is included.

Each r-f and i-f stage is adequately isolated by suitable chokes and resistors individually by-passed. The resistors used are of the highest quality, with small tolerances. Those of 25,000 ohms and under are wire-wound, further to reduce the temperature and voltage co-efficients.

Some Extra Parts in Can

The grid return isolation resistors and their condensers were mounted inside their respective i-f cans, together with the plate return by-pass condenser. This not only made shorter leads but gave more room on the underchassis for choke and transformer mounting.

Automatic tone control is accomplished by a tap on the volume control, connected to the tone filter R11, C13, L5. At maximum volume control position (weak signals) there is a minimum of tone compensation, at the half way position (strong signals) there is a maximum of tone compensation.

This arrangement not only does away with an added control on the front panel but gives the listener the full benefit of all the signal when he needs it most.

As was mentioned before, the bias on the r-f and i-f stages was obtained through the grid returns with the cathodes grounded. This bias can be set at some minimum between minus 3 and minus 18 volts and with the a-v-c switch in the "on" position this bias is automatically controlled by the signal strength.

The A. V. C. Action

The diode-biased 55 with no signal on DP, (no current in resist-

LIST OF PARTS

Coils

L—Two Bud 10-millihenry r-f chokes
L1—Three 30-millihenry Bud r-f chokes.
L2—Four doubly-tuned, litz-wound, 465 k.c. i-f transformers.
L3—One 650-ohm speaker field (part of speaker).
L4—One 160-ohm, 120 milliampere choke, United Transformer Co.
L5—One 250-millihenry r-f choke.

Condensers

C—One gang of three Bud 0.00035 mfd. tuning condensers.
Ct—One 0.000025 mfd. Hammarlund midget condenser.
C1—One 500 mmfd. padding condenser.
C2—Four 0.05 mfd., 400-volt, condensers.
C3—Six 0.1 mfd., 200-volt, by-pass condensers.
C4—Six 0.1 mfd., 400-volt, by-pass condensers.
C5—Two 0.00025 mfd., 600-volt, by-pass condensers.
6C—Two 0.01 mfd., 600-volt, by-pass condensers.
C7—One 0.006 mfd., 600-volt, by-pass condenser.
C8—One 0.0005 mfd., 600-volt, condenser.
C9—One 0.5 mfd., 200-volt, condenser.
C10—One 5 mfd., 35-volt, electrolytic condenser.
C11—Three 8 mfd., 500-volt, electrolytic condensers.
C12—One 4 mfd., 300-volt, condenser.
C13—One 0.02 mfd., 600-volt, condenser.
C14—One 0.0001 mfd. mica condenser.
Above condensers, Concourse Electric Co.
One 1000 mmfd. condenser.
One 0.005 mfd. mica condenser.
Nine Hammerlund 35 mfd. trimmer condensers for coils.

Resistors

R—Four 100,000-ohm, ½-watt resistor.
R1—Six 20,000-ohm, 1-watt wire-wound resistors.
R2—One 50,000-ohm, ½-watt resistor.
R3—One 300-ohm, 1-watt wire-wound resistor.
R4—Three 25,000-ohm, 1-watt wire-wound resistor.
5R—One 250,000-ohm, ½-watt resistor.
R6—One special tapped volume control; Centralab 201-901.
R7—Two 0.5 meg., ½-watt resistors.
R8—One 250,000-ohm Centralab potentiometer with attached switch.
R9—One 25,000-ohm, 55-watt voltage divider.
R10—One 50,000-ohm, ½-watt resistor. (This should be very accurate.)
R11—One 15,000-ohm, 1-watt, wire-wound resistor.
Resistors not otherwise specified are Ohmite.

Other Requirements

Eight Bud four-prong coil forms.
Four Bud five-prong coil forms.
Wire for coils.
Thorn Pathfinder nine-tube chassis, 10½ x 20 x 3 inches with bottom plate.
Two four-prong sockets.
Five five-prong sockets.
Seven six-prong sockets.
One seven-prong (small) socket.
One four-prong socket.
One five-prong socket.
Six tube shields.
Three coil shields.
One triple outpost.
One phono post.
One toggle switch.
One Crowe No. 120 airplane dial.
Six screen grid clips.
One 12-inch speaker for pp. 2A5.
One I. C. A. No. 659 antenna kit.
No. 18 hook-up wire, bus bar, solder, and super flux.
One United transformer U32B, pp. input.
One United transformer UM6, power transformer.
Four 58 tubes; one 2A7 tube; one 55 tube; two 2A5 tubes; one 5Z3 tube. All Arcturus.
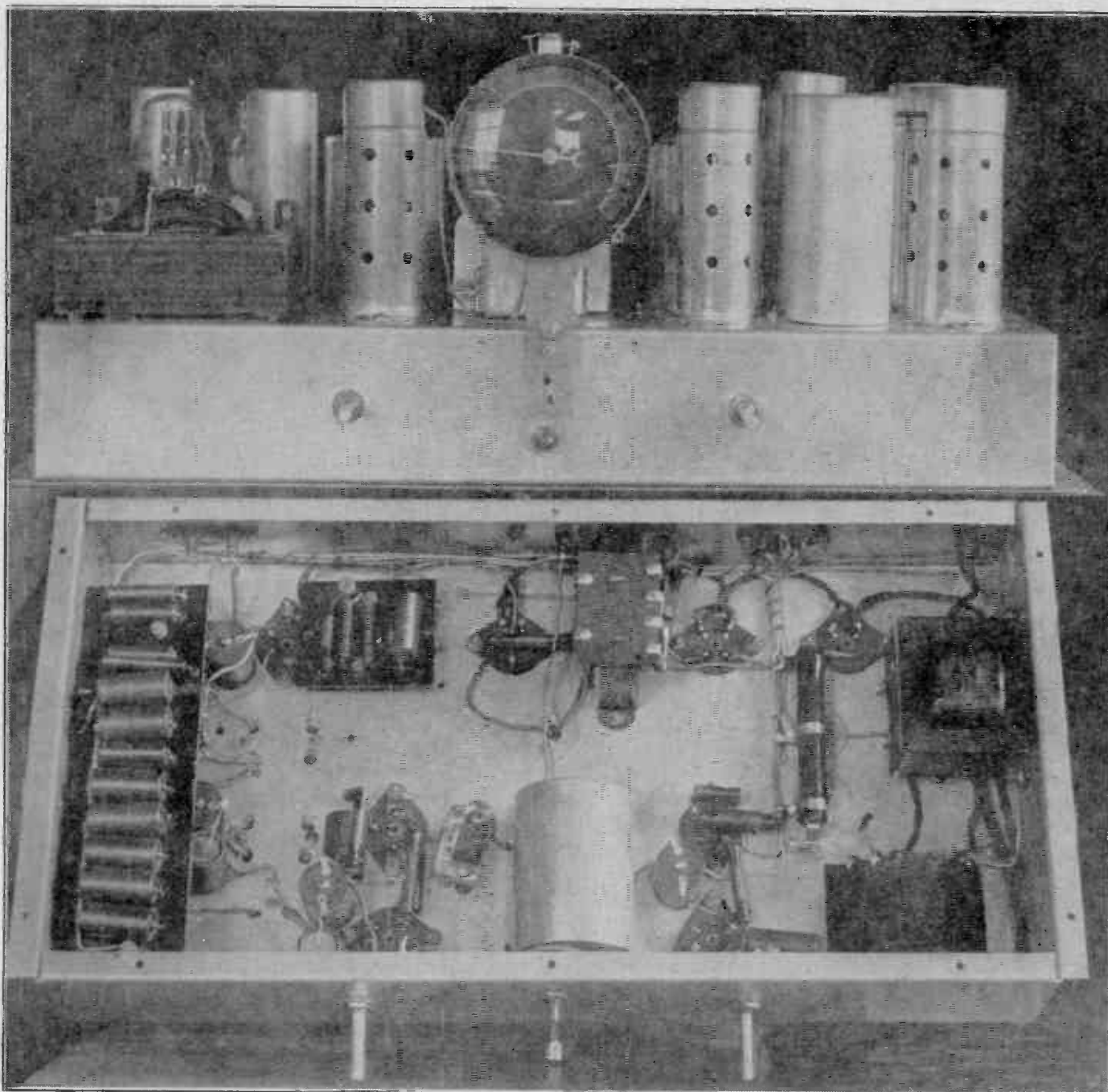
Top view of the completed receiver and a view of the neatly-arranged wiring as seen from the bottom.

(Continued from preceding page)

ance R) will have a high current between K and P and consequently a large voltage rise in the resistor R, which was so selected that K will then be at some positive voltage above DP₂.

There will be no current between DP₂ and K. As the signal increases on DP, current begins to flow in the resistor R, putting some negative voltage (with respect to K) on G. This in turn reduces the current flowing between K and P and consequently the rise in the resistor R_1. Depending on the strength of the signal, this change may be enough to make the voltage on K become negative with respect to DP₂. When this occurs current flows in the circuit R_2, DP₂, K, R_1. This current flow causes a voltage drop in the resistor R_3, which is passed on to the grid returns of the RF and IF circuits.

The advantages of this system are too numerous and involved to be here explained. These four are marked. The a-v-c action is amplified along with the signal and the action can be delayed by suitable adjustment of the sensitivity control.

Use of Transposed Leadin

Because of the extreme sensitivity of the receiver a transposed antenna is almost a necessity. Full directions for installing the transposed antenna is contained in the kits with the material for its erection. Should an ordinary antenna be used the lower end of the antenna coil primary may be grounded and a small trimmer inserted in the antenna lead-in.

The performance of the set cannot be exaggerated. Every available signal was received with never a lack of volume. Melbourne, Australia, on the loud speaker louder than the average set brings in locals, and not too much noise. On one occasion 1 2 R O, Rome, was tuned in with continued receiption for six hours uninterrupted with only occasional increase in background noise.

The experimenter whose desire it is to have a good all-wave receiver can find his dream realized in the All-Wave Pathfinder Nine, if he gives it adequate study and careful workmanship.

NEON OUTPUT INDICATOR

A small neon lamp may be put from plate to B plus of an output tube, and when a signal is introduced the a-c voltage will cause the lamp to light. The brilliancy will depend on the amplitude of the a-c signal, and therefore the lamp is an output indicator. It may be used without series limiting resistor.

A THOUGHT FOR THE WEEK

MADAME ERNESTINE SCHUMANN-HEINK is loved by those who admire her beautiful voice and fine artistry and by milions of others who think of her as a mother doubly bereaved by the Great War, for she lost a son in the German army and another son in the army of the United States, her adopted country. Therefore, the Gerber Products Company, in sponsoring "the world's best-loved mother" program, has made a choice of talent that is bound to attract and hold the attention of every member of the family. It is customary to cut out references to sponsors when talking about air programs, but we're not afraid to announce to all and sundry that we're glad to say that the Gerber Products Company is doing a fine thing for radio and for motherhood in presenting the beloved Mme. Schumann-Heink so that all may hear and become more human.

STATION SPARKS

BY ALICE REMSEN

Lanny Ross said farewell to Showboat audiences after May 17th, at least, for a while. Lanny has left for Hollywood to make another picture and will continue with Showboat upon his return to New York. . . . Madame Alda, who is heard over NBC networks each Tuesday evening at 6:00 p.m., is writing her autobiography. It should be very interesting, as Frances Alda was the intimate of many great and near-great people during her operatic career. . . . Have you ever listened to "Two Seats in the Balcony" over WEAF on Wednesdays at 2:00 p.m.? It's worth a twist of your dial, with such artists as Ivy Scott, Fred Hufsmith, Carol Deis, Donald Beltz and Alma Kitchell, Harold Sanford's Orchestra and Henry M. Neeley, the "Old Stager." They give you a delightful review of old musical shows. . . . Grace and Eddie Alberts have a new radio act which they call "The Honeymooners." They may be heard each Monday and Wednesday over an NBC-WJZ network at 11:00 p.m. EDST. . . . Irene Rich, famous screen and radio star, has started a new time schedule. She will now be heard each Wednesday evening at 7:30 p.m.; sponsored, as usual, by the Welch's Grape Juice Company.

Another old musical comedy favorite, Vivienne Segal, has come to the air. She replaced Muriel Wilson on the Waltz Time series sponsored by Starling Products, over NBC-WEAF network each Friday at 9:00 p.m. . . . Gogo de Lys, is a new contralto on the NBC staff at San Francisco. She has joined the crew of Captain Dobbsie's Del Monte Ship of Joy, which provides a shipload of entertainment each Monday evening at 9:30 p.m. EDST, over an NBC-WEAF network. . . . The Four Pickens Girls are sighing because they have no time for parties. They work the clock around, except for a few hours sleep and a few minutes for eats! Keep working girls! Save your money and then you'll find time for parties after you have retired with a nice big bankroll.

Georgie Jessel will head a new one-hour program series to start on June 3rd, and each Sunday evening thereafter at 8:00 p.m. The program will be known as the Voice of Columbia. It will have an unique feature; a forty-five piece orchestra which will be conducted by five different leaders on the one program, thus providing a diversity of styles in music. . . . Edith Davis and Helen Gennert, well-known two-piano team, and Hector De Lara, concert baritone, will inaugurate a new series of weekly recitals over the WABC-Columbia network. They will be heard each Wednesday at 4:00 p.m. EDST. . . . Elizabeth Lennox, contralto, and Irving Kaufman, vaudeville impersonator, have been added to the "Broadway Vanities" show starring Everett Marshal, over the WABC-Columbia networks each Wednesday at 8:30 p.m. . . . A few weeks ago in this column I said that Jimmy Kemper probably learned the art of song dramatization while trouping in Australia, through the English production called "song scenes." In the Columbia "quotes of the week," Jimmy is listed as saying: "I first began dramatizing songs while trouping in Australia in 1929. The English call such dramatizations 'song scenes' and use them to vivify the meaning of a composition." So you see, I made a pretty good guess, didn't I, Jimmy? . . . The Studebaker Champions have returned to the air via CBS, this time with Richard Himber and his Ritz Carlton Orchestra, each Saturday at 9:30 p.m. EDST.

A broadcast from England which should not be missed is that of Queen Mary, launching the "super-Cunarder" on Wednesday, September 26th; further details will be announced later. . . . Veronica Wiggins, WOR contralto, has been ordered to take a six-months' rest from broadcasting. . . . Block and Sully, have joined WOR's Pebeco on Parade program, which also features Vera Van and Will Osborne's Orchestra, each Friday night at 9:00 p.m. EDST.

BROADCAST STATION CHANGES

Alterations and corrections to the edition dated January 1, 1934, of the Radio Commission's "Radio Broadcast Stations in the United States" and Supplement No. 1.

Call Studio Location	Alterations and Corrections
KFGO—Boone, Iowa.	Frequency 1370 kc.
KGCR—Watertown, S. D.	Call letters changed to KWTN.
KGHF—Pueblo, Colo.	C.P. power 500 w, quota units 0.6.
KNX —Los Angeles, Calif.	Power 50 kw.
KOTN—Pine Bluff, Ark	C.P. covered by license.
KPCB—Seattle, Wash.	C.P. power 250 w, quota units 0.27.
KSO —Des Moines, Iowa.	Frequency 1320 kc, power 250 w, quota units 0.4.
KTRH—Houston, Texas.	S.A. Exp. 250 w, 1 kw-LS, 630 kc, quota units 0.57.
KWCR—Cedar Rapids, Iowa.	Strike out 500 w-LS on C.P., quota units 0.4.
WBAL—Baltimore, Md.	Licensee, The WBAL Broadcasting Co.
WCAP—Asbury Park, N. J.	Quota units 0.26.
WCHS—Charleston, W. Va.	Power 500 w. Strike out S.A.
WDBJ—Roanoke, Va.	Power 500 w, quota units 0.6.
WDBO—Orlando, Fla.	S.A. Exp. 1 kw-LS, quota units 0.7.
WDRC—Hartford, Conn.	C.P., power 2½ kw-LS, quota units 1.25.
WGN —Chicago, Ill.	Power 50 kw.
WHBD—Mt. Orab, Ohio.	Licensee, Veebee Corporation.
WHEF—Kosciusko, Miss.	Licensee, Attala Broadcasting Corporation. U, quota units 0.2.
WIBM—Jackson, Mich.	Frequency 1500 kc, U, quota units 0.2.
WJBK—Detroit, Mich.	Licensee, Sunbury Broadcasting Corp.
WKOK—Sunbury, Pa.	Power 100w-LS.
WLBC—Muncie, Indiana.	S.A. Exp. power 500 kw.
WLW —Cincinnati, Ohio.	Frequency 1200 kc.
WMPC—Lapeer, Mich.	C.P., power 500 w, quota units 0.3.
WNBX—Springfield, Vt.	Licensee, Muscle Shoals Broadcasting Corporation.
WNRA—Muscle Shoals City, Ala.	Call letters changed to WALA. C.P. T-Mobile.
WODX—Mobile, Ala.	Licensee, Durham Radio Corporation, call letter changed to WDNC.
WRAM—Wilmington, N. C.	Call letters WODX changed to WALA.
WSFA—Montgomery, Ala.	Power 500 w. Strike out S.A.
WTAG—Worcester, Mass.	Quota units 0.21.
WTNJ—Trenton, N. J.	C.P., power 1 kw-LS, quota units 0.8.
WTOC—Savannah, Ga.	

LITERATURE WANTED

Benjamin Cefino, Apt. 15, 1774 Lexington Ave., New York City.
Charles J. Sandberg, 1757 N. Whipple St., Chicago, Ill.
Harry J. Ochs, Allentown, Penna.
C. F. Hubley, 923 Churchill Ave., Utica, N. Y.
L. H. Veach, c/o Sou. R.R., Union Station, Columbia, S. C.
J. H. Whitcomb, Essex Junction. South St., Vermont.
E. L. Douglass, 205 Stahlman Bldg., Nashville, Tenn.
Lorenzo O. Graham, c/o Graham Radio Service, 1703 Decatur St., Richmond, Va.
Jos. Reamis, 596 Avenue A, Bayonne, N. J.
A. Corrales, 35 W. 25th St., Tucson, Ariz.
Albert Driver, 199 Collette St., New Bedford, Mass.
J. S. Power, 14128 E. Jefferson, Detroit, Mich.
A. S. Mackay, 17 W. 98th St., New York City.
M. Wiener, 3958 Washington Ave., St. Louis, Mo.
Wilbur F. Pearson, Libertyville, Iowa.
Fred Mitchell, Millbridge, Maine.
J. D. Fingeroth, 308 Melrose No., Seattle, Wash.
Al. Baldwin, 672 Seina Way, San Bernardino, Calif.
G. W. Taggart, Apt. 5D, 610 W. 135th St., New York City.
M. C. Hughes, Head, Elec. Engineering Dept., Agricultural and Mechanical College of Texas, College Station, Tex.
Harry Tam, P. O. Box 1880, Honolulu, Hawaii.
Fred Trake, 319 Fairlawn Ave., Waterbury, Conn.
James Karuza, Supt. of Mails Office, Ferry Annex Post Office, San Francisco, Calif.
R. G. Willoh, 19 Custom House, Norfolk, Va.
J. A. Macfarlane, c/o Vancouver Motors Limited, Seymour at Smythe Street, Vancouver, B. C., Canada.
G. D. Gratton, c/o A.E.D. Co., Island Falls, Ont., Canada.
J. A. P. Lafleur, Kenogami, Con Chicoutimi. Pro. Quebec, Canada.
Russell B. Deschler, 1720 Center Street, Racine, Wisc.

Definitions Created for "All-Wave" and "Standard" Receivers

Chicago.

To inform the radio buying public as well as the trade, means to establish identification of "all-wave' and other receiving sets have been adopted by the RMA. The object is to definitely classify the new and improved receivers, to avoid misrepresentation and to facilitate merchandising of sets.

Nomenclature and frequency ranges for a standard broadcast receiving set, the "all-wave" receiver and the "standard and short-wave," or "dual-wave" receiver, were adopted by the RMA Board of Directors, following recommendations from the Association's Engineering Division.

The "standard broadcast" receiver is defined to include sets having the regular frequency range from 540 to 1,500 k.c.

The "standard" and "short-wave" or "dual-wave" receiver as defined by the RMA will apply to sets having frequencies between 4,000 and 20,000 k.c. with a short-wave range covering a ratio of maximum to minimum frequencies of at least two and one-half to one.

The definitions outlined above were adopted by the Board as the simplest possible correctly to advise the buying public and the trade. Detailed standards defining the nomenclature and frequency ranges of the three types of receivers will be issued.

"High Fidelity" Sets Sold Too Soon for RMA Morale

The RMA has deceived to develop, trade-mark and protect for the industry a new name for the so-called "high-fidelity" receiver which is being gradually developed in the laboratories. Commercial presentation of the "high-fidelity" receiver is not possible for many months, possibly not before next year, according to opinion.

Because of application now of the term "high-fidelity" to many current receiving sets, although the receiver actually is only in laboratory developments, the RMA directors decided to develop a new and definite name for the receiver and have it trade-marked by the RMA for industry purposes. Inability to trade-mark the name "high-fidelity" because of its general scope, and the application of the term to current set models far in advance of commercial introduction, prompted the RMA adequately to safeguard future commercial presentation if and when it may be developed.

FORDS HAVE NATIONAL UNION TUBES

The Ford Motor Company, Dearborn, Mich., announced that National Union Radio tubes have been chosen as exclusive standard equipment for all Ford automobile radio sets. The selection was made after many weeks of severe testing which proved National Union tubes particularly suitable for the heavy duty requirements of vacuum tube equipment used in automotive installations.

All-Wave Oscillator

Universal Type Uses Plug-in Coils, 100 to 20,000 kc

By Jack Tully

The line is blocked in the all-wave signal generator. Also there is an attenuator. Commercial coils (Alden's) cover 100 to 20,000 kc with 0.00014 mfd., using this diagram.
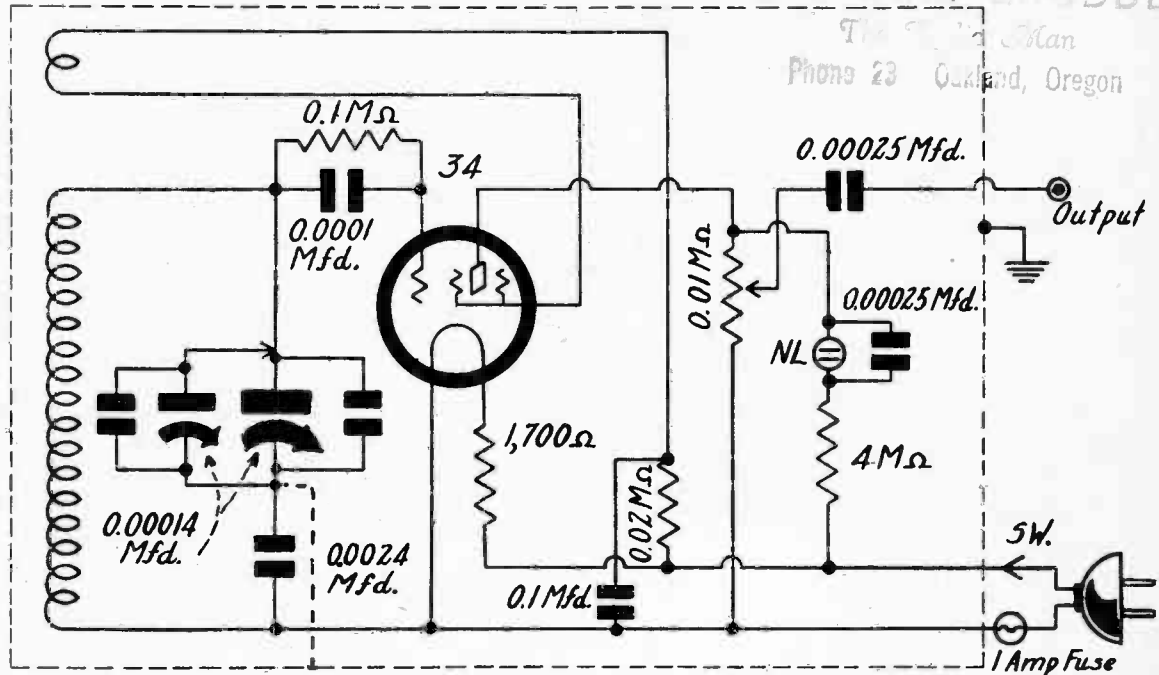
ASIDE from the fact that the calibration has to be done, which is quite a job, the signal generator illustrated on the opposite page is quite a simple device for rendering a wide range of service. The usual plug-in coils for a tuning condenser of 0.00014 mfd. may be used, and since the B voltage is around 100, or even more, the conventional tickler windings will be sufficient to insure oscillation on all coils and at all settings of the condenser.

The circuit is that of a universal type oscillator, meaning that it may be used on alternating-current line, direct-current line, or on B batteries. The current for the filament is automatically taken from the single voltage source. For a-c use the hum frequency of the line produces modulation. For d-c use the neon tube audio oscillator serves this purpose.

How Short Is Avoided

A new wrinkle consists of the method of protecting the shield box from causing a short of the voltage-source line. Suppose one side of the line, whether a.c. or d.c. is used, is grounded, as is commonly true. Then if the tuning condenser frame or rotor, and the shield box, were connected in common, and an external ground were attached to the oscillator box, if the ground polarities happened to be opposite at the line outlet and in the oscillator, there would be a short. But by putting a fixed condenser in series with the tuning condenser, between negative filament of the 34 tube and the frame of the condenser, and leaving the frame alone common with the box, this particular short is avoided.

There is one possibility, however, if applying an unintentional voltage, although harmless. The grid of the 34 tube is the connection at top of the tube. This is indirectly connected to the line, too, albeit through a resistance of 50,000 ohms, plus the tube resistance, some 10,000 ohms more. Thus if the cap of the tube is touched to the metal shield box when the circuit is "on," about 2 milliamperes will flow, and the grid gets a positive excitation. As stated, this is harmless, but it is better to take the precaution to slide the chassis in and out for coil changing only when the oscillator is turned "off."

The parts and the connections are shown in the circuit diagram, all being familiar except perhaps NL, a neon lamp not widely obtainable, but made by General Electric Company without any internal series resistance. Thus it is practical to put a small condenser across the lamp alone, and not have the effect marred by a series resistance. The desired external series resistance, about 4 meg., may be selected so that a suitable frequency of audio oscillation will result.

Calibration Is Quite a Job

As stated, the real work consists of the calibration, as the parts, even the chassis and box, can be obtained commercially. To calibrate the coil-condenser systems it is preferable to build a small broadcast-band oscillator, and beat it with stations tuned in on a tuned-radio-frequency receiver for ascertaining particular frequencies, or determining unknown frequencies.

The problem is therefore two-fold. First, the easiest work is to pick up stations distributed as well as possible over the dial. Find points on, say, the coil for just above the broadcast band of frequencies. For this part it is safe to accept the coil manufacturer's designation of the approximate frequency span, noting that it is an approximation, particularly so because the series condenser has increased the frequency at the lower portion of tuning.

Somewhere around 1,550 kc will be the low-frequency limit.

Built in a shield cabinet, the signal generator has a National precision dial. Calibrations are communicated to graph paper. The oscillator tube is a 34.
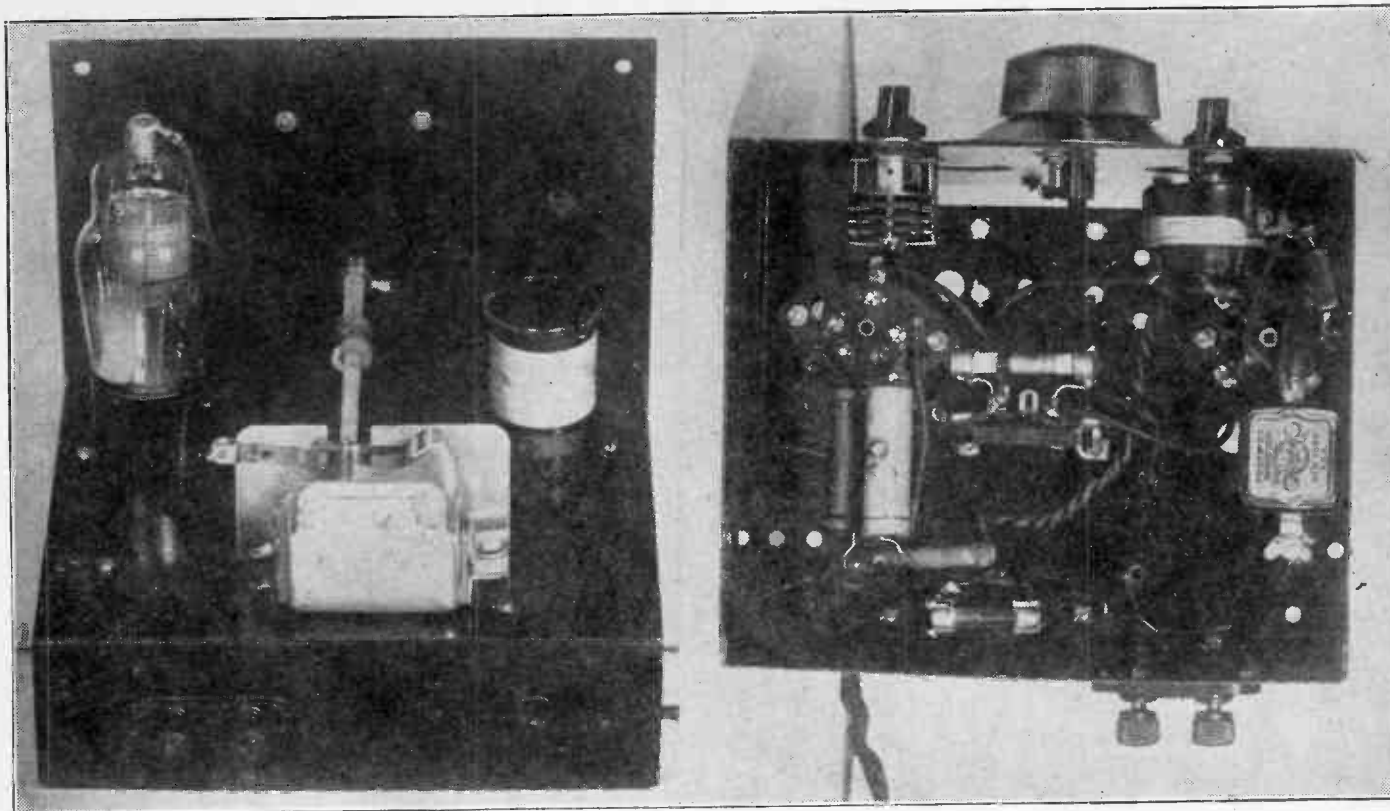
Rear and underneath views of the all-wave signal generator.

Suppose you divide that in half, making 775 kc. There is no station handy on that frequency, but use the broadcast-band extra oscillator to beat with a station at some frequency not much higher, say, 780, 790 or 800 kc. The second harmonic will be 1,560, 1,580 or 1,600 kc, and thus one point near the low-frequency end established. Usually it will not be possible to reach the third harmonic, that is, use this same station twice for the one coil.

Zero Beats Most Accurate

Taking other stations, and adopting the same principle, points may be registered, with a great accuracy of reading, preferably using zero beats with the aid of the t-r-f set. That is, tune the set to the station, beat the broadcast-band oscillator to zero, turn off the set, and zero beat the oscillator that is now being calibrated, with the broadcast-band oscillator. The National laboratory dial can be read to one part in 1,000, so there is no cause to complain about readings being too course. And zero-beating gives you the most accurate source for determination.

Thus the coil is calibrated in conjunction with the condenser.

The next coil, the approximate band of which is known, is calibrated the same way, except that higher frequencies of the broadcast band are used at first, to spot points that give you a sense of location. Then it is practical to switch to lower broadcast-station frequencies, because though the harmonics coming through will be more numerous, the previous exploration prevents any confusion. Thus, if one used 600 kc for the second coil, the harmonics he might expect to hear reproduced would be the fifth, sixth, seventh, eighth, ninth and tenth. Sometimes there is a gap, that is, one of the expected harmonics is not heard, but the prior exploration has prevented any one from being fooled on this point.

Nearly a Straight Line

When a curve is drawn on plotting paper, or, as some say, graph paper, it will be regular. With the Bud condenser used in this oscillator the line was practically straight in respect to frequency, so that if two frequencies, at or near the extremes, are used, if one draws a straight line between these points he gets a first approximation of what the frequencies will be. At the higher frequencies of tuning in any one band the curve is as straight as could be expected, but above for frequencies below the middle there is a slight upward bulge. At the extreme high-frequency end, represented by 0 to 5 on the dial, or 95 to 100, if the dial reads in that direction, the curve flattens out, that is, departs completely from the straight line.

When the third coil is to be calibrated the trouble begins, as harmonics of broadcasting stations may become confusing, if fundamentals are low enough, and if fundamentals are as high as desired, the resultant points may be few. The best plan is to convert the broadcast-band oscillator to one that starts at 1,500 kc at the low end, by putting in a different coil, and the new calibration of that oscillator may be copied by beating with the principal signal generator you are building. The new temporary oscillator will serve nicely for the fourth coil, also.

For Low Frequencies

For low frequencies, since the approximate range is known again, instead of multiplying the fundamental of the broadcast stations, divide into the fundamental, as test oscillator harmonics will be beating with station fundamentals. No harmonics of the broadcasting stations are used.

As an aid, a commercial test oscillator that is calibrated in low frequencies may be used, but not relied on completely, as the accuracy is much higher by using broadcasting stations. Beat the commercial oscillator harmonic with a station fundamental, divide that fundamental by the whole number that yields approximately what the commercial oscillator reads, and you will have an harmonic order, fourth, fifth, etc. Which one will be yielding response in the main oscillator you are building you may tell from the known shape of the tuning curve and the approximate frequency limits as revealed by the manufacturer.

The subject of calibration is too wide for full treatment in the space available. A complete treatise on the subject, for all-wave service, is expected in an early issue, possibly next week.

Electron-Coupled Antenna Input
Tried, But Pickup is Too Small

In connection with the circuit shown on page 18, since there is an extra element put to no valuable purpose, namely the conventional plate, the author considered connection of antenna to this circuit. He actually tried resistors and coils, but the pickup was insufficient. There was regeneration without the antenna series condenser, as the series capacity was contributed by the extra element.

Considered theoretically, the idea seemed to be all right. Indeed, it was all right. Here was an opportunity to introduce for the first time an electron-coupled antenna system, hence a coupling that was practically independent of frequency. This offered temptations, especially in line with attempts to maintain calibrations.

However, when one considers that the capacity between normal plate and cathode of the 34 is of the order of 12 mmfd., no matter if a resistor is used as load, or a radio-frequency choke coil, there arise occasions, particularly at the higher frequencies, when more energy flows from this element to ground than into the intended circuit of grid to ground, hence in practice the method did not work out. The coupling was so feeble that stations easily heard when the diagramed method was used were wiped out.

This does not say that the idea is impractical totally or will not work in a more sensitive system. It is hoped that soon it will be given a trial in a super-sensitive superheterodyne, where only tiny pickup is required. If it works out well, it will be recommended to readers of these columns. Otherwise you won't hear any more

Radio University

Answers to Questions of General Interest to Readers. Only Selected Questions are Answered and Only by Publication in These Columns. No Correspondence Can be Undertaken.

Voltage and Current Feeds

WHAT is the difference between voltage and current feeds? What does either mean? It is my understanding that in order to feed energy to an antenna or a coil both current and voltage are involved.—W. H. L.

When energy is fed to an antenna at high voltage and low current, the antenna is said to be voltage-fed. On the other hand, when the energy is fed to the antenna at low voltage and high current, it is said to be current-fed. Perhaps it would be better to high-impedance feed for voltage feed and low-impedance feed for current feed. But the terms voltage and current feed are well established and it does not matter if they are not quite accurate if they are understood correctly.

* * *

Resistivity and Resistance

IS there any difference between resistivity and resistance, or do the two terms mean the same thing? If they are different please explain—T. J.

If R is the resistance of a conductor of uniform shape, such as a wire, a the cross section area, and l the length, then $R = rl/a$, where r is the resistivity. Thus the two are not the same. The resistivity is a coefficient which gives the resistance per unit volume of the material of which the conductor is made. Obviously, if the length is unity and the cross section is unity, the volume is also unity. Then the resistance is numerically equal to r, the resistivity. It is customary to give the resistivities of various conductive materials in ohms per centimeter cube or in ohms per mil foot, depending on which system of units is employed. In physics where the c.g.s. system of units is employed, the resistivity is given in ohms per cubic centimeter.

* * *

Cost of Storage Battery Power

HOW much more does it cost to operate a radio receiver with a storage battery than with a filament transformer that steps the voltage down to the right value? Please show how to calculate. —E. L. J.

It will be necessary to take a particular battery. Suppose that the storage battery has a capacity of 100 ampere-hours and that it costs 75 cents to have it fully charged. Let us further suppose that mean voltage during discharge is 6 volts. The energy that we can take out of the battery is then 0.6 kilowatt-hour, and this cost us 75 cents. Therefore the cost per kilowatt-hour is $1.25. Perhaps the average cost per kilowatt-hour of electrical energy in the United States is 6 cents. The ratio is about 20 to 1 in favor of the step-down transformer. Of course, the 75-cent charge was not all for energy, for most of the cost was for service. By charging at home the cost would be reduced greatly. Suppose, for example, that the charging and discharging process is 80 per cent. efficient and that the charger, aside from the battery, is only 75 per cent. efficient. The overall efficiency would then be 60 per cent. This would raise the cost of each kilowatt-hour from 6 to 10 cents. Even with this low efficiency it would not cost a great deal more to operate the set with a battery than directly from the power line by means of a transformer. We must add the depreciation of the battery and the charger.

* * *

Voltage Doubling

WITHOUT the use of a high-voltage transformer is it possible in a rectifier circuit to get a d-c voltage greater than the a-c voltage applied? If so, will you kindly explain how it can be done?—T. P.

If the supply voltage is alternating it is possible to get a d-c voltage about double that of the effective value of the alternating by the use of a voltage doubler type of rectifier circuit.

* * *

Wound By-Pass Condensers

WHAT is the difference between the inductive and the non-inductive by-pass condensers? Both are wound, are they not. If so, why will one kind have inductance and another kind none? —W. E. J.

Two condensers may be wound the same way, yet one will be inductive and the other non-inductive depending on the connection of the terminals. If the terminals are connected at the same end of the foils forming the two electrodes of the condenser the condenser will have a high inductance. If, on the other hand, the terminals are connected to the sides of the foils the condenser will be practically non-inductive, because in this case the length of the circuit will only be the width of the foils whereas in the other construction the length of the circuit will be the same as the length of the foil, and that may be very great when the capacity of the condenser is high.

* * *

Construction of Heaters

HOW is it that the heater wire in a heater tube does not come in contact with the cathode? It would seem that there would be a direct short, or that the insulation would necessarily be poor between the heater and the cathode.—T. K.

There is a comparatively high insulation between the heater wire and the cathode. A small conduit of magnesia is used as insulator. Two tiny longitudinal holes are made in the magnesia and the heater wires are threaded through these. Outside the conduit is the cathode in the form of a closely fitting sleeve. Magnesia is one of the best known refractory materials and for that reason the tungsten wires can be operated at very high temperature without any danger of fusing the insulator.

* * *

Range of Hearing

WHAT is the average tonal range of hearing for an adult individual? Does the range of hearing in any way depend on the intensity of the sound? If so, what is that dependence?—R. H. J.

The hearing limits depend on age of the individual, on the frequency, on the intensity, and possibly on the health of the person. In regards to intensity there is a threshold of feeling and a threshold of audibility. If the sound is louder than the threshold of feeling no sound is heard but the air disturbance is perceived as a feeling of pain. If the sound is weaker than the threshold of audibility, it is not heard. Neither is it perceived in any other way. The thresholds of feeling and audibility meet at about 16 cycles per second. Therefore no sound can be heard at a lower frequency than 20 cycles per second. Again they meet at about 20,000 cycles per second. Hence no sound can be heard above 20,000 cycles. The human ear is most sensitive to sounds of about 1,500 cycles per second. That applies to the average ear. Particular ears may deviate greatly from the average ear in all respects.

* * *

Television Progress

SO FAR, what is the best system in television? That is, which method of scanning has been most successful?—E. L.

There are two methods which have been successful. One is the cathode ray tube scanner and the other is the Peck mirror scheme. The cathode ray method received a great boost when Dr. Zworykin invented the Kinoscope, and a still greater boost when he invented the Iconoscope. The Iconoscope is the device for sending pictures by means of the cathode ray tube and the Kinoscope the device for receiving with the same tube.

* * *

Single Side Band Transmission

HOW is it possible to send a signal on a single side band? The ordinary signal, as I understand it, is composed of the carrier, the upper and the lower side band. If two of the components are eliminated how can signals be sent on the rest?—W. B.

How single side band transmission works may be seen from the superheterodyne. The local oscillator generates the carrier. The signal at radio frequency modulates this carrier. There are three products of the modulation, the carrier, the upper side band, and the lower side band. The lower side band is tuned in by the intermediate frequency selector. This, however, is not exactly the same as regular single side band transmission. Suppose we have a carrier modulated by a single tone and that we start and stop this tone. When the tone is sounding the modulation results in the three components. By means of filters we can supress the carrier and either of the side frequencies. Let us transmit the side frequency not suppressed. Whenever the tone is sounding this side frequency goes out. It can be received by any sensitive receiver tuned to it. It is a radio frequency and therefore we cannot hear it in the loudspeaker. We could detect it, though, with the aid of a rectifier and a milliammeter. But we shall say that to receive it we must restore the original tone without any appreciable frequency deviation. Suppose, now that we start a local oscillator having a frequency slightly different from the original carrier. This will beat with the side frequency received and the result will be a tone that can be heard in the loudspeaker. If we make the frquency of the local oscillator exactly the same as that of the original carrier generator, the audible note will be exactly the same as the tone with which the original carrier was modulated. If the tone is variable, such as it would be if the carrier were voice modulated, the same reasoning applies, and it would be necessary only to supply at the receiver the frequency equal to the original carrier to recreate any tone impressed on that carrie.

* * *

Work on 400 Megacycles

IS ANY experimental work being done in the 400-megacycle band and is there any indication that this band will be useful as a means for communication? Can you sugest any circuits by which frequencies of this order can be generated?—T. H. I.

Very little work has been done in this range of frequencies. As a rule, the Barkhausen-Kurz oscillator is used for generating these frequencies, but even with this oscillator it is not the easiest thing to generate the waves. Moreover, tubes do not last long

in the B-K oscillator. The thing to do in any case when extremely high frequencies are to be generated is to reduce the interelectrode capacities. This is true even for the B-K oscillator.

* * *

Break-In

WHAT is the meaning of break-in in radio telegraphy?—L. W. C.

By break-in is mean that a radio operator who is receiving a message from some other station, stops the sender by breaking into the message. The object of breaking in is to get the sender from repeating a letter or word that has been missed or to stop sending entirely in case interference is so severe that continued reception is unpractical.

* * *

Field Intensity

WILL you kindly give a brief and simple explanation of the meaning of field intensity? How do you measure it?—E. L. W.

Suppose you mount a metal plate in the ceiling and another one on the floor. Assume that the distance between the two plates is 15 feet. Connect a battery of 45 volts between the two plates. There is a difference of potential of 45 volts between the plates and the distance is 15 feet. Therefore the field intensity, by definition, is 3 volts per foot, assuming that the field is uniform, which it will be in this case. The field intensity is the voltage difference between two points a unit distance apart. A field intensity of 3 volts per foot is the same as a field intensity of 10 volts per meter, very nearly. If a radio wave is passing over a point, there actually is a voltage difference between two points, one above the other, and if a wire connects the two points an e. m. f. will be induced in the wire which is equal to the potential difference between the points. If an antenna is erected at a place where there is a field, the total e. m. f. induced in the antenna is equal to the height of the antenna multiplied by the intensity. If the intensity varies along the antenna the average value must be taken. Suppose, for example, that the effective height of the antenna is 5 meters and the intensity of the field at every point along the antenna is 1.000 microvolts per meter, the total e. m. f. induced in the antenna wire is then 5,000 microvolts, or 5 millivolts. The field intensity is measured by measuring the actual e. m. f. induced in an antenna of known effective height. In most instances a loop is used for the measurement because for such a collector the effective height can easily be computed.

* * *

The Proximity Effect

I HAVE seen references to the proximity effect in connection with resistance of coils. Will you kindly explain what this effect is, and how it can be minimized, that is, if it adds appreciably to the resistance of tuning coils?—R. H. J.

If a conductor is located in a varying magnetic field eddy currents will be induced in the wire, and as a consequence the losses will be increased. The current in the wire itself will cause eddy current losses, and there are the greatest. Some of the varying magnetic field may be due to currents flowing in conductors near by. The losses produced by these are called the proximity effect.

* * *

Pentagrid Tubes

IS THE coupling loose or tight in the pentagrid converter tubes? Are not these tubes principally intended for broadcast use, and does not the coupling increase with frequency, so that it would be greater at the higher frequencies in an all-wave receiver? Can the 1A6, for instance, be used to good advantage as the mixer tube in a battery-operated short wave set? How about the harmonics, are they strong in the pentagrid converter tubes?—J. S. X.

The pentagrid converter tube, useful as mixer in a superheterodyne, was brought out primarily for broadcast receivers, and the coupling may be regarded as fairly tight. It can not be considered loose coupling by any means. Of course the coupling is adjustable in the sense that the oscillation intensity may be held down in the oscillator section, so that not much will be put into the modulator, although this is in reality control or limitation of the e.m.f., rather than coupling adjustment in its stricter sense. Since electron coupling is used this is practically independent of frequency. However, the tube elements have the usual capacity relationship between one another, and as frequency is increased, the coupling does increase, due to this capacity effect. At broadcast frequencies the capacity coupling amounts to little, at 10 mgc it amounts to much, and higher than 10 mgc to still more. The 1A6 tube is not particularly good, for its mutual conductance is rather low, and it is expected a new tube will be brought out to replace it, that will have much greater emission, for the filament current will be about twice that of the 1A6. This is to meet short-wave requirements.

Effects of Incorrect Bias

IF the grid bias on audio tubes and on the detector are wrong, what are the effects first noticed? Is it possible to tell by the tone whether or not the bias it not right?—L. M. N.

Several effects are possible. The bias may not be sufficient. In that case the plate current in the tube where the bias is not enough will be excessive. It might well be that the first effect is that the plate of the tube gets red hot. Distortion, of course, occurs. The bias may be excessive. In that case there will be a distortion and it will first be noticed on the low tones. They will break. Sometimes it is said that the tones are feathery. This might occur when the bias is excessive on any audio tube or on the detector. The effect is not likely to be serious unless the volume level in the tube is very high. But whether or not it is high in this respect depends on the amplification factor of the tube.

* * *

A Delay Relay

WILL you kindly suggest a relay that can be constructed easily that will cause a delay of several seconds between the application of an impulse and the operation of the relay?—R. L.

A relay of this kind should be combined with a thermostat. Suppose the thermostat is heated by the current that results from the operation of the signal. It will then take a definite time for the thermostat to function, and hence for the second circuit to close. Almost any time delay can be introduced in this manner, for not only can the travel of the thermostat be varied but also the heating current. Perhaps the gravest trouble would be to make the time short enough. The delay time and the current to be controlled should be known before making any decision as to the type of delay relay is necessary.

* * *

Preventing Condenser Break-down

IS THERE any way of preventing a condenser from breaking down as a result of momentary high voltages? Certain static-like crashes appear in the signal frequency and very often break down the condensers.—R. J. L.

If there is very little quantity in the crashes, the condensers can be protected by a resistance across them. The value of this resistance may range from 20,000 ohms to 2 megohms, depending where it is placed and what the capacity of the condenser is. The resistance will prevent the voltage from rising as high as it would without the resistance.

* * *

Series Filament Resistor

I NOTICED DIFFERENT values of resistance specified for battery-operated short-wave sets, using 2-volt tubes. Is this a mistake, or is the value not so critical?—K. G.

There is some leeway in the resistance value, especially as the tubes do not have filaments of exactly the same resistance, time and again. Some reliance probably is placed on the fact that the batteries will have a little resistance. The best practice is to adjust the series resistance value until the voltage across the filament reads exactly 2 volts. This may be measured on any low-range d-c voltmeter.

Resistance-Coupled Audio
In a Two-Tube Short-Wave Set Using Low B Battery Power
By Herman Bernard

The screen of the 34 in this two-tube set is used for feedback in the detector to hold up the effective plate voltage. Thus 45 volts suffice for the stated constants.
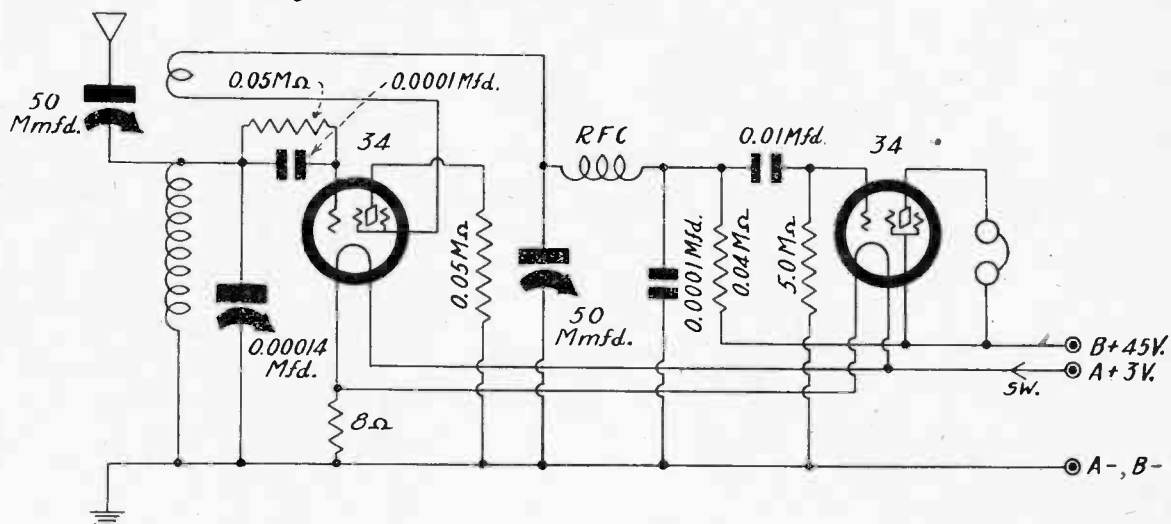
THE two-tube battery-operated short-wave set may have resistance-coupled udio, if the constants are properly chosen, and there will be excellent and smooth regeneration. In fact, resistance coupling is known to afford an absence of certain types of troubles, such as fringe howl, which causes a roaring noise in the phones when the detector tube is in its most sensitive condition. This trouble is due to feedback through some common coupling, which may be the batteries or other B supply, and is generally absent from resistance-coupled circuits because of the relatively high resistance between the detector plate and the voltage source.

The conventional circuit has been changed in some respects, principally to use the 34 tube as the regenerative detector, with the screen serving as the effective plate, the conventional plate being grounded through a resistor.

Screen Used as Feedback Plate

The reason for this selection is as follows:

If the regular plate is used as plate, that, tickler winding put in that circuit, the plate current will be rather high, considering the low B voltage source of 45 volts. It was not deemed expedient to boost that voltage to 90 or 135 volts, because of 45 volts of B battery constitute something consistent with a small receiver like this.

When the plate current is relatively high, the voltage drop in the load resistor is relatively high. Therefore, the effective plate voltage, which is the applied B voltage less the drop. is low, and this makes it more difficult to attain regeneration. While the circuit might be made to oscillate, there would be failure of oscillation at the higher frequencies of any band of tuning, specially using standard plug-in coils, which have definite values of tickler and coupling.

In screen grid tubes the screen circuit resistance is about three times as great as the plate circuit resistance, and therefore with that proportion holding when the screen is used as effective plate, the voltage drop would be only one-third as much in the load resistor, or, the load resistance could be three times as high, thus making for better transfer of audio frequencies to the amplifier tube.

Regeneration Prevails Throughout

So it proved to be, although the load resistor was 43,000 ohms. This is an odd value, so that 40,000 ohms (0.04 meg.) is the specification. Then it was possible to get regeneration at any and all settings, and it was the smoothest regeneraton control that the author has ever had the pleasure of using, besides requiring only a small condenser, 50 mmfd., not the more usual 140 mmfd. to 250 mmfd. The only provision is that the radio-frequency choke should have a high inductance and a low distributed capacity, and a choke of 20 millihenries inductance and 1 mmfd. distributed capacity suits the requirements. These are inexpensively obtained. If nothing fancy is required of the choke in the way of appearance it can be bought for around 20 cents.

The other semi-critical resistor is the grid leak. It is customary to specify leaks of the order of megohms, and in some circuits of course these work all right, and it is true that the higher the leak value the higher the sensitivity. However, there is a limiting factor, which at least in the present circuit limited the value of the leak, and that was determined experimentally by using the receiver as a steady oscillator, that is, regeneration condenser plates remaining totally enmeshed. In the phones a high-pitched whistle could be heard when leaks of 5 and 2 meg. respectively were tried, and this was due obviously to grid blocking, so that the resistance was reduced in gradual steps until there was no sign or possibility of blocking, and this required 50,000 ohms (0.05) meg.

Series Antenna Condenser

Therefore, it can be imagined that some forms of interference that may be attributed to air conditions are directly ascribable to a receiver, in that grid blocking occurs over part of the tuning, when one might suppose that some mechanical or electrical device in the neighborhood was causing the trouble.

It was necessary to use this leak value, also, for smoothest control of regeneration, and the plop was not pronounced but gradual, and there did not have to be a great deal of finicky adjustment to get just the right amount of regeneration. That is, some of the critical aspects of tuning this or any other type of regenerative receiver were eliminated.

It will be noticed that there is a series antenna condenser for manual control from the front panel, and while this particular topic has been stressed time and again in these columns, the warning is repeated that it must be included if one is to be sure of reception at any and every point on the dial, no matter which plug-in coil is used. Some of the better types of commercial all-wave receivers suffer from dead spots, due to absorption effects or trapping in the antenna circuit, but this little series condenser enables one to shift the antenna's natural period to get away from any such encountered dead spot, and besides enables great improvement of the sensitivity for any frequency in the higher brackets that is to be received. At the lower frequencies, particularly when using the largest-winding coil for the intermediate short waves, this series antenna condenser does not have so much effect, but the results begin to show up in the second coil a little, are pronounced for the third coil and for the fourth and final coil are extremely marked.

This condenser must be insulated from any metal panel, as it is not to be conductively related to ground.

Calibrate for Both Condensers

The tuning is somewhat affected by this condenser, particularly at the higher frequencies, so that a calibration will not strictly hold, unless made with a particular antenna, and in reference to some approximate designation of the setting of the antenna condenser, as well as the main tuning condenser. For this reason a numerical plate was used, which had divisions sufficiently definitive for the purpose. Then if a calibration is made, and the setting not only of the main tuning condenser, but also of the series antenna condenser, is noted, the calibration will hold, so long as the antenna is not materially changed. That is, with the same aerial the same frequencies will come in at the same main dial positions time and again, except for the slight detuning effect of the tickler condenser.

While the circuit in its fundamental form is a familiar one, the use of the 34 with screen as effective plate is new for this purpose, and so is the inclusion of the 34 as amplifier.

If the phones are of high enough impedance it is possible to get quite a wallop out of the receiver, but the common 2,000-ohm phones do not give as much volume as would phones of much higher impedance. A likely selection, readily obtainable commercially, is 4,000 ohms, while phones of still higher impedance would give even more volume. It is possible to get phones of an impedance of even 20,000 ohms, but these are made by a high-class institution and are of the precision type and rather expensive. It is not necessary

to use them, as 4,000 ohms will suffice, and 7,000 or 8,000 ohms would be splendid.

Double-Biased Detector

It will be noticed that the detector has a double bias: first, a fixed bias of 1 volt negative, due to the fact that the grid is returned to B minus (A minus). The bias is to be reckoned in respect to the negative filament. Thus, going from negative A, up the negative toward the negative filament leg of the first tube, we find a resistor of 8 ohms, and the upper part of this resistor is in the direction of positive filament, as by going through the entire filament from the resistor we come finally to positive. Therefore, negative filament is positive in respect to A minus, or grid return, or grid, by the voltage drop in this resistor which, due to a pair of tubes having their filament current flowing through it, is 0.06x2x8 volt, or 0.96 volt, or, approximately, 1 volt. Hence, there is a 1-volt negative bias on the detector, and by the way the same bias on the audio amplifier for the same reason

But the detector has another bias adjunct, the grid leak. When the regeneration is introduced the voltage in the grid circuit becomes large, and exceeds by far the fixed bias voltage, though the two are cumulative. The grid leak is 50,000 ohms, and therefore for the only 1 microampere of grid current there is 0.05 volt additional negative bias.

Why Result Is Negative Voltage

The result is a negative rather than a positive value because of the peculiar action of the grid condenser-leak circuit, whereby the condenser charges up positively on the left-hand side, negatively toward the grid, and more negative quantities of electricity, or electrons, are at the grid than formerly, so the grid is negative, to a value depending on the r-f amplitude, the grid condenser and the grid resistor. The resistor figures in the scheme because it determines largely the rate at which the electrons are to be permitted to leak off. If that rate is too slow, the frequency becomes audible, as already noted.

But 1 microampere of grid current, even in such a modest circuit, isn't much at all, and so small a quantity is usually ignored when the question raised has to do with elimination of grid current for special reasons extraneous to this article and subject. The grid current may be such, at the lower frequencies of tuning, largest coil, that the voltage resulting will be a few volts anyway. Nor is this very much, although purposely the quantity has been limited.

A fact sometimes lost to view is that while a high leak value is more sensitive, the circuit suffers nevertheless as to selectivity, because grid current represents power consumption, and power has to come from somewhere. It comes from the cathode, in this instance the filament, and its consumption has the equivalent effect of the introduction of a relatively low parallel resistance.

Modulation Is Downward

Since any receiver has to be some sort of compromise between selectivity and sensitivity, it is far better to gain all the practical selectivity, and let the sensitivity go a bit, because that is very high as a first consideration, and will stand attrition. When two or more stations are butting into one another, and one wishes for more selectivity, and it isn't there, he feels disappointed. But if the selectivity is there, he benefits by it, and knows the sensitivity is of only secondary consideration, because, first, regeneration is used, which is a sensitive system, and second, earphones are in service, and these constitute one of the most sensitive instruments used in radio.

Why Phones Are Sensitive

When it is considered that a 0-1 microammeter is rated as a very sensitive d-c current meter, and then realizes that when 1 microampere of signal flows in the phone circuit, where without a signal there would be no audio-frequency component in the phones, one can realize that phones, as to sensitivity, rate in the 0-1 microammeter class.

The detector modulation is downward, therefore the stronger the original the less plate current, the higher the effective plate voltage, and the less power consumed in the grid circuit.

The Audio Circuit

The detector circuit, it is trusted, has been sufficiently analyzed. The load on the effective plate (normal screen), is 50,000 ohms, and the stopping condenser, looking into the audio tube is 0.01 mfd. The value of this condenser may be practically anything, and the higher the better, except that mica dielectric is preferred, and that usually means you can not conveniently go to higher values than 0.04 mfd. in a single unit, which of itself is not obtainable at all supply houses and stores, although of course larger capacities may be built up by paralleling mica condensers for this purpose. The practice is not recommended as necessary, for 0.01 mfd., with a high value of grid leak, proves sufficient. The leak should be 5.0 meg. or higher, if obtainable.

Practically across the plate load resistor and also the audio grid resistor is the 0.0001 mfd. condenser. The inclusion of this capacity often improves the detecting efficiency, and moreover completes the filtration, so that radio frequencies are kept out of the audio amplifier. It is advisable to have such filtration, because otherwise
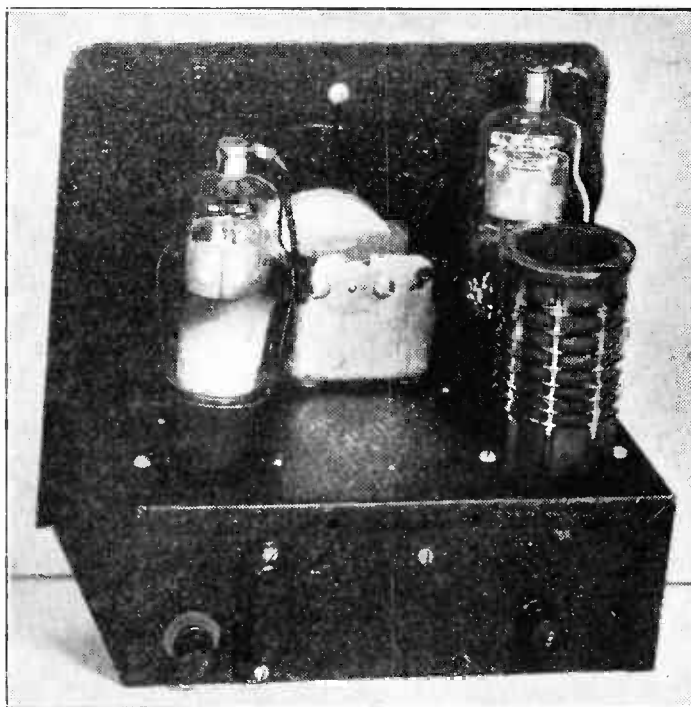
View of the receiver.

the phones might be subject to body capacity effects, and if they still are, a radio-frequency choke of almost any value may be put between plate of the second 34 and the upper phone lead.

How to Connect Phones

By the way, connect the phones the right way. The tip that carries the cord with a tracer goes to B plus, and the other tip goes to plate. Since most phone cords are covered practically all the way, look at the short projections between covering and tips, to read the identification of the leads. The volume is usually noticeably greater when the phones are connected the correct way. The tracer is often green, sometimes red. The common covering is usually black or brown.

If the circuit is to be built in a metal box, which is entirely prac-

LIST OF PARTS
Coils

One set of four short-wave plug-in coils, two-winding type (primary and secondary).
One 20-millihenry radio-frequency choke (RFC).
One set of earphones.

Condensers

Two 50 mmfd. straight-capacity line variable condensers, ¼-inch shafts.
One 0.00014 mfd. variable condenser, ¼-inch shaft.
Two 0.0001 mfd. fixed condensers, mica dielectric.
One 0.01 mfd. condenser, mica dielectric.

Resistors

One 8-ohm filament resistor, wire-wound.
One 0.04 meg. pigtail resistor.
One Two 0.05 meg. pigtail resistors.
One 5.0 meg. pigtail resistor.

Other Requirements

Three sockets, all of four-hole type. One is for coil receptacle.
Two grid clips.
One phone-tip jack assembly.
Two binding posts, for antenna and ground.
Insulators for regeneration condenser and antenna binding post.
One 4-inch dial.
One threaded bushing for 6/32 screw, so lug may be cut to point and used as dial indicator.
Two bar handles (one for regeneration, other for antenna condenser).
Two plates to be used for 0-100 indication of bar-handle parts.
Two No. 6 dry cells, to be series-connected for 3 volts; one 45-volt B battery.
One chassis, 7x5x2 inches; front panel, 7½ wide x 7 inches deep.
One switch.

Tested Battery Set for Short Waves Uses Resistance-Coupled Audio
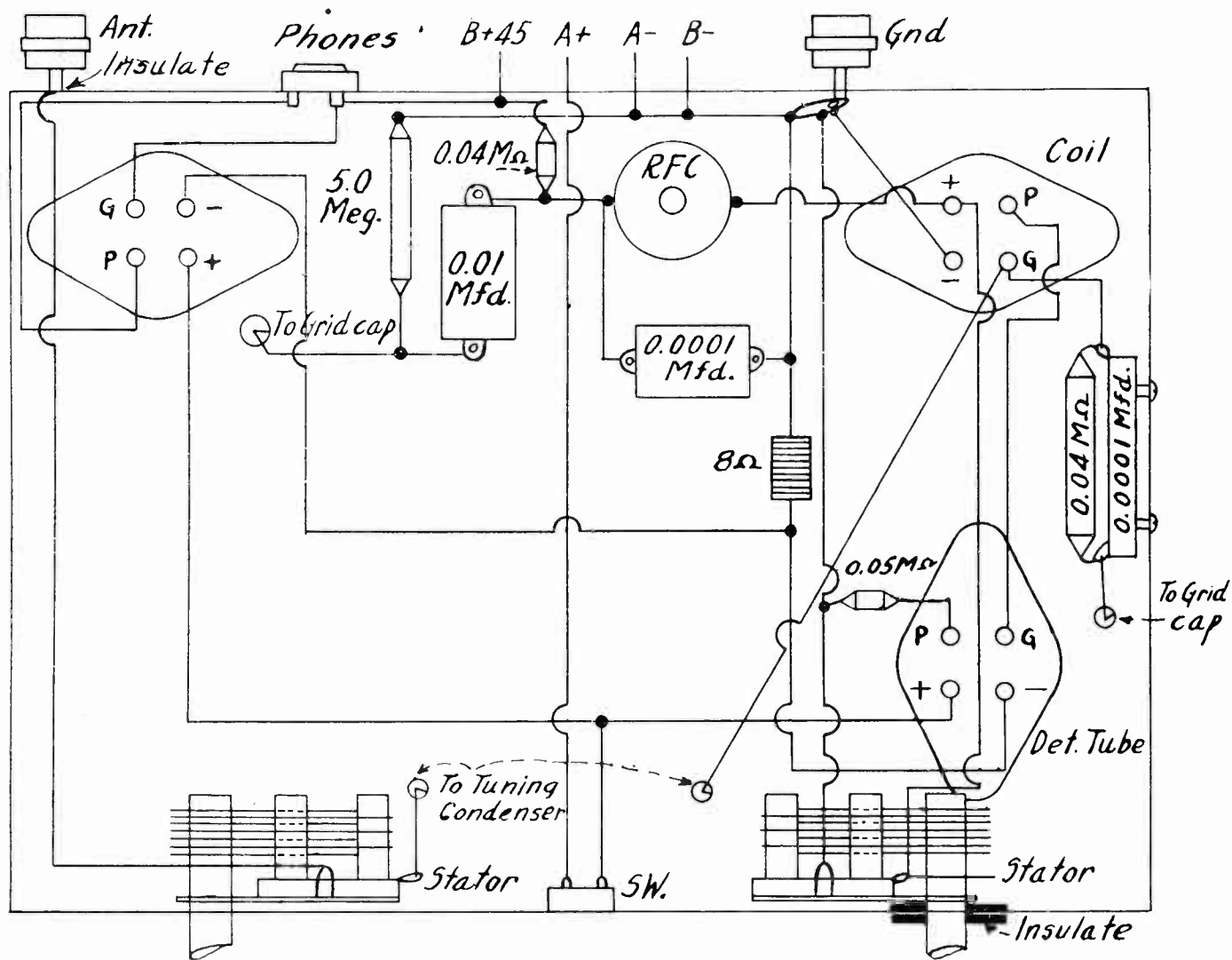
Blueprint of the wiring of the two-tube short-wave battery receiver.

(Continued from preceding page)

tical, especial attention should be paid to the ground lead, and the box itself should not be used as the common connection for any radio frequencies, although entirely suitable for audio frequencies. The method to pursue is as follows:

Where the ground binding post is to be connected scrape off the paint or other finish from the inside of the can, clean this spot thoroughly, and apply a thin coating of solder. Then put the binding post in place, put a lug between the post's shank and the soldered part of the chassis or box, and solder the lug to the box. Tighten down with a nut. Then when the return of the tuned secondary coil is to be made to ground, this is done by running a wire, say, No. 18 size, which may be bare, from the coil socket return (usually equivalent of negative filament, if a tube were to be used instead of coil), to this lug, and carefully soldering, using rosin flux, not with acid. Do not use any acid solvents in soldering short-wave sets.

Outgoing Connections

Now the tuning condenser has to be considered, as its rotor or frame also is grounded. Do exactly the same thing. Often the condenser has a lug or other small piece intended for this cautious grounding. Solder a careful connection to this lug, using No. 18 insulated wire, and run the other end of the wire to the ground-post lug, where some careful soldering is done again. These two precautions take care of the coil and condenser in the tuning system, and only one further precaution exists, the regeneration condenser, the rotor or frame of which is treated the same way, with a wire run to the ground-post lug. The rest of the circuit may use chassis as ground or A minus or B minus.

The wires to be brought out are as follows: A minus, B minus, A plus 3 volts, B plus 3 volts, antenna and ground. A tip-jack dual assembly is used for the phones, so no leads are needed externally. A minus, B minus, and ground may be consolidated, as the connection is common, so a wire is soldered to the ground-post lug, and carried out to A minus, a short piece of wire at the batteries connecting A minus and B minus. B plus 45 volts and one side of the phones are common, therefore a wire from the lug on one of the tip jacks may be brought out for B plus.

The theory of the circuit has been presented in the foregoing, and the illustrations are intended to convey most of the practical constructional information.

Coils and Coverage

The coils used may be any of those for 0.00014 mfd. tuning, winding directions for which were printed in last week's issue (dated May 19th). Commercial plug-in coils, which are wound on the same forms as those considered last week, may be used. The frequency ratio will be a little in excess of 2 to 1, so there is assurance of full frequency coverage from this viewpoint. The coverage from 15 to almost 200 meters is practically assured using any of the standard commercial-wound plug-in coils. The frequencies approximately reached at extremes, as well as the wavelength equivalents, were given last week.

The circuit is an exceptionally good one, represents a few innovations, but these are in the nature of improvements, not tricky and untried gadgets, the set has been built and carefully tested, and is recommended to any who would like to try for numerous foreign and overseas stations on short waves at very small expense.