# RADIO WORLD

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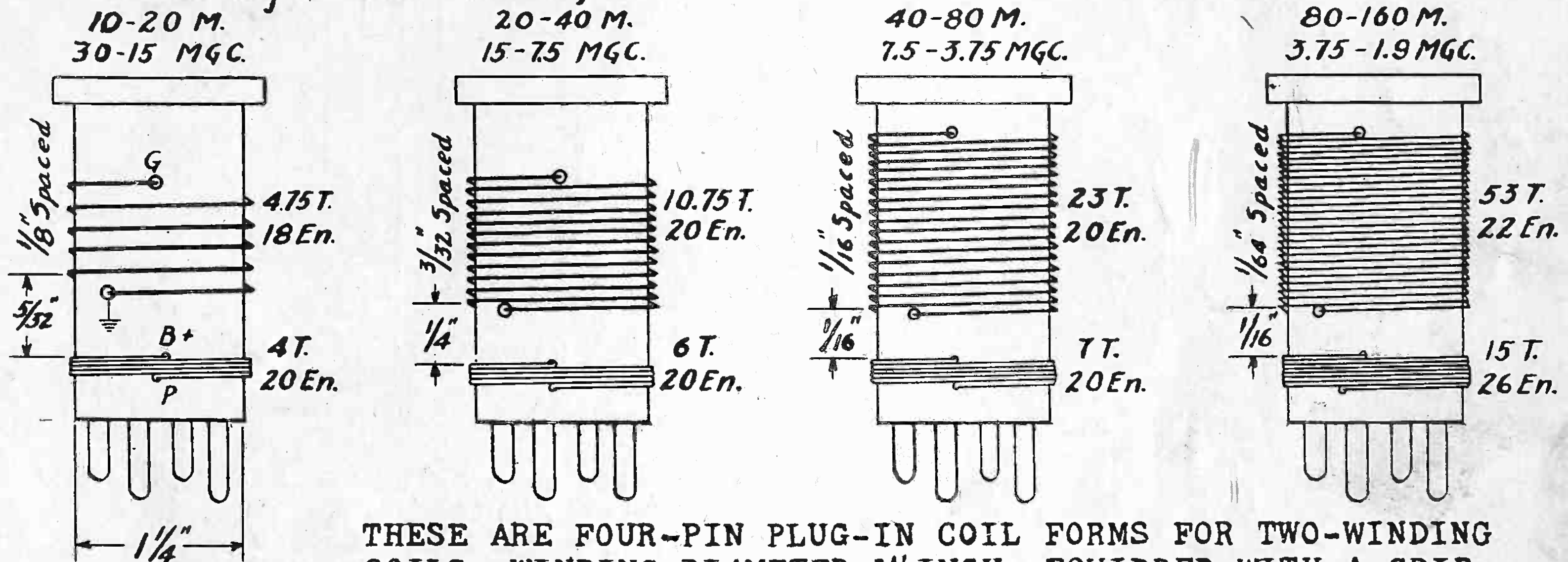
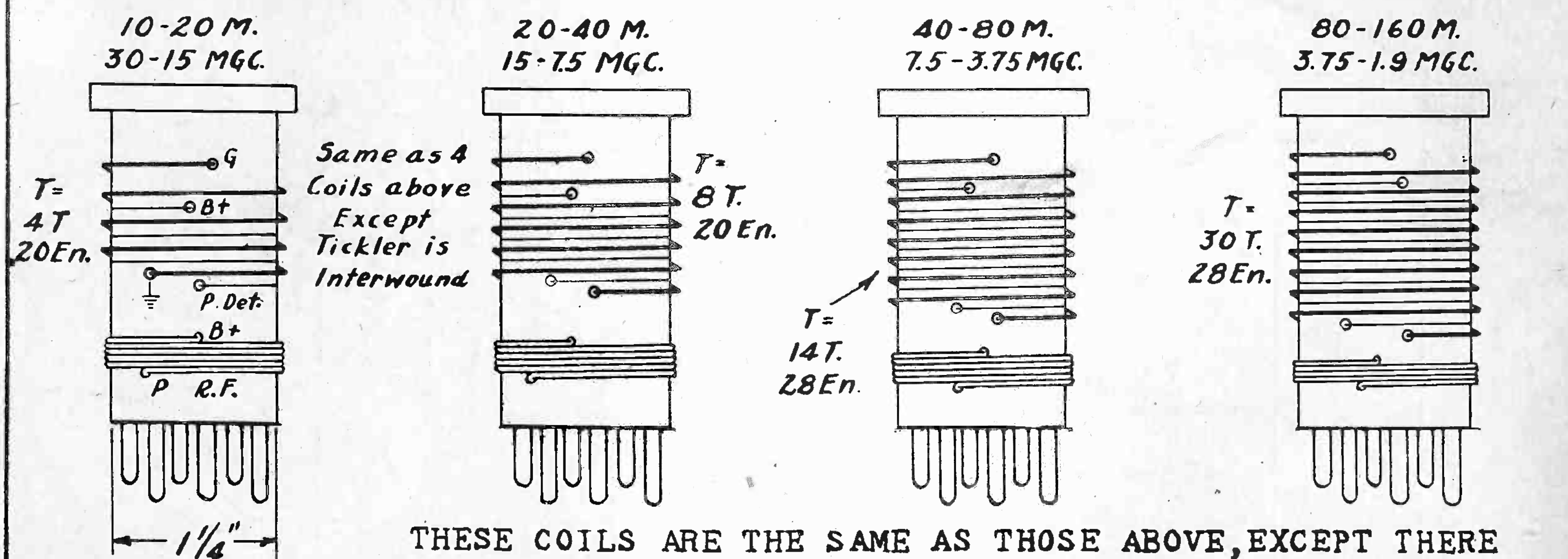
# A SHORT-WAVE PORTABLE

## Plug-In Coil-Winding Data for 0.00014 Mfd. Condenser




THESE ARE FOUR-PIN PLUG-IN COIL FORMS FOR TWO-WINDING COILS, WINDING DIAMETER 1¼ INCH, EQUIPPED WITH A GRIPPING FLANGE. THE TICKLER TURNS AND COUPLING ARE SUCH AS TO PRODUCE FEEDBACK FOR REGENERATION ON ANY BAND.




THESE COILS ARE THE SAME AS THOSE ABOVE, EXCEPT THERE IS A THIRD WINDING. THOSE ABOVE MAY BE USED FOR TRF, WHILE THOSE BELOW ARE FOR INTERSTAGE COUPLING USES. THE TICKLER IS WOUND BETWEEN THE SECONDARY INDUCTANCE.

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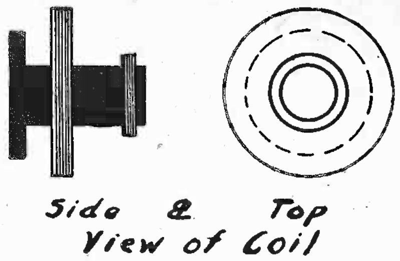
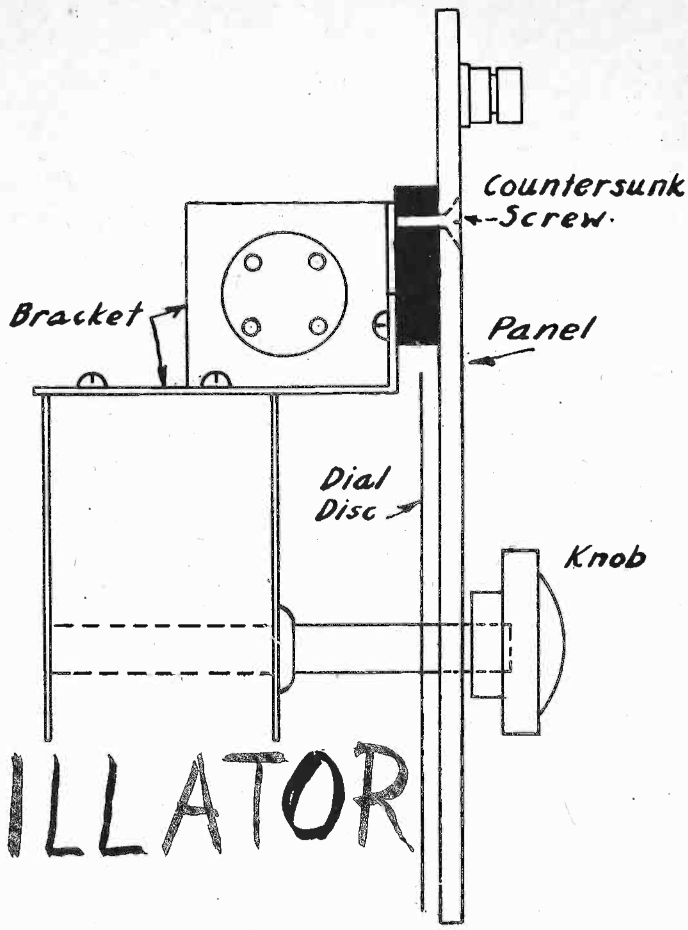
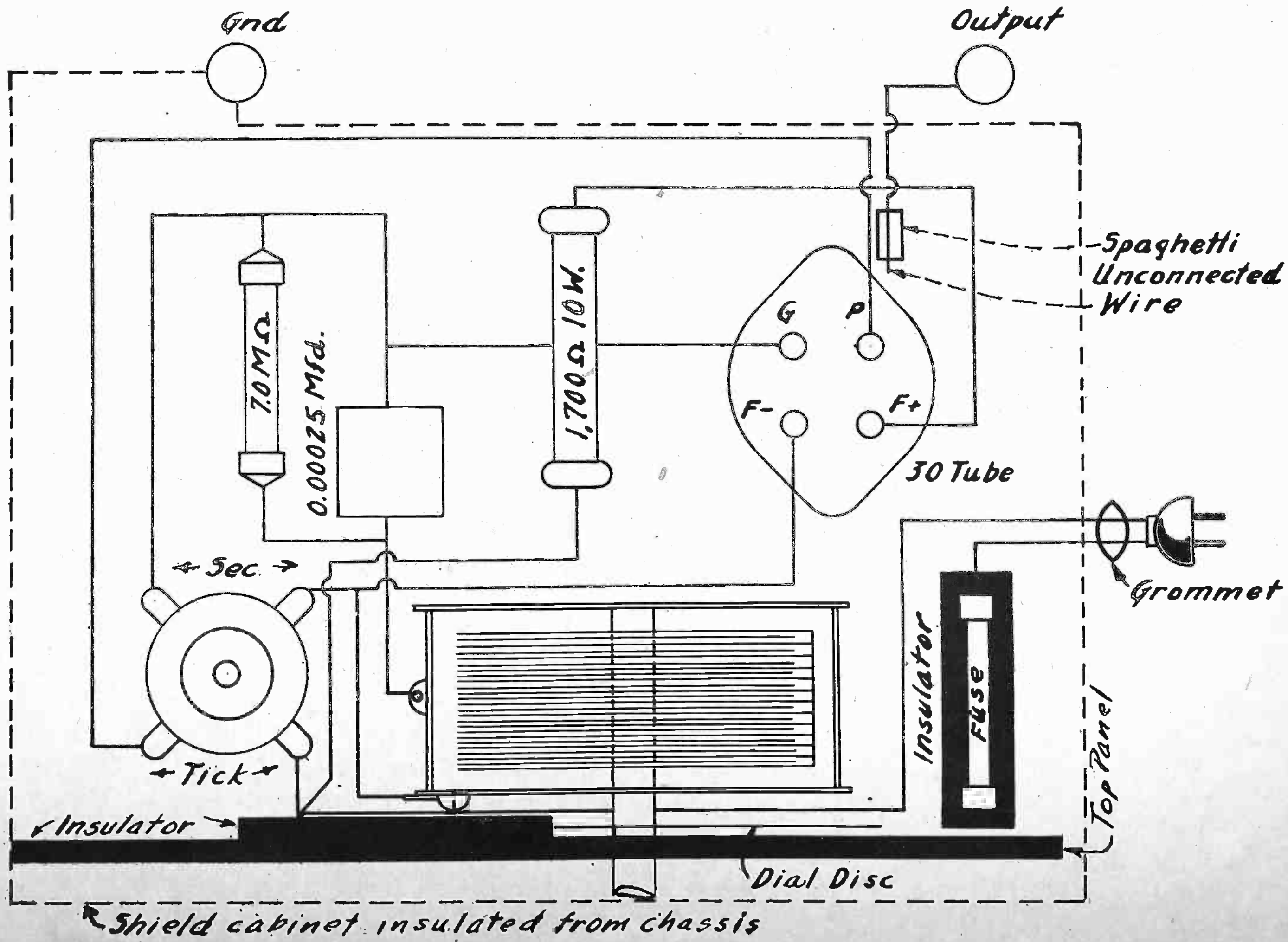



# MODEL 30-N TEST OSCILLATOR




THE 30-N TEST OSCILLATOR, OR SIGNAL GENERATOR, IS COMPLETELY BUILT ON AN INSULATED PANEL. THUS THE COMPLETED DEVICE IS PUT INTO A METAL CABINET WHICH IS CONNECTED TO A SHEET OF COPPER FOIL, PROPERLY PUNCTURED TO PASS LINE-GROUNDED PARTS, SO EXTERNAL GROUND CAN NOT SHORT THE LINE. THE FOIL IS GROUNDED EXTERNALLY BECAUSE CONNECTED TO THE METAL BOX BY SCRAPING OFF THE FINISH AT ONE OF THE FOUR CORNER HOLES AND TINNING IT WITH SOLDER. WHEN THE CORNER SCREW, OF THE SELF-TAPPING TYPE, GETS SCREWED DOWN AT THIS POINT THE CONTACT WITH THE BOX IS MADE.



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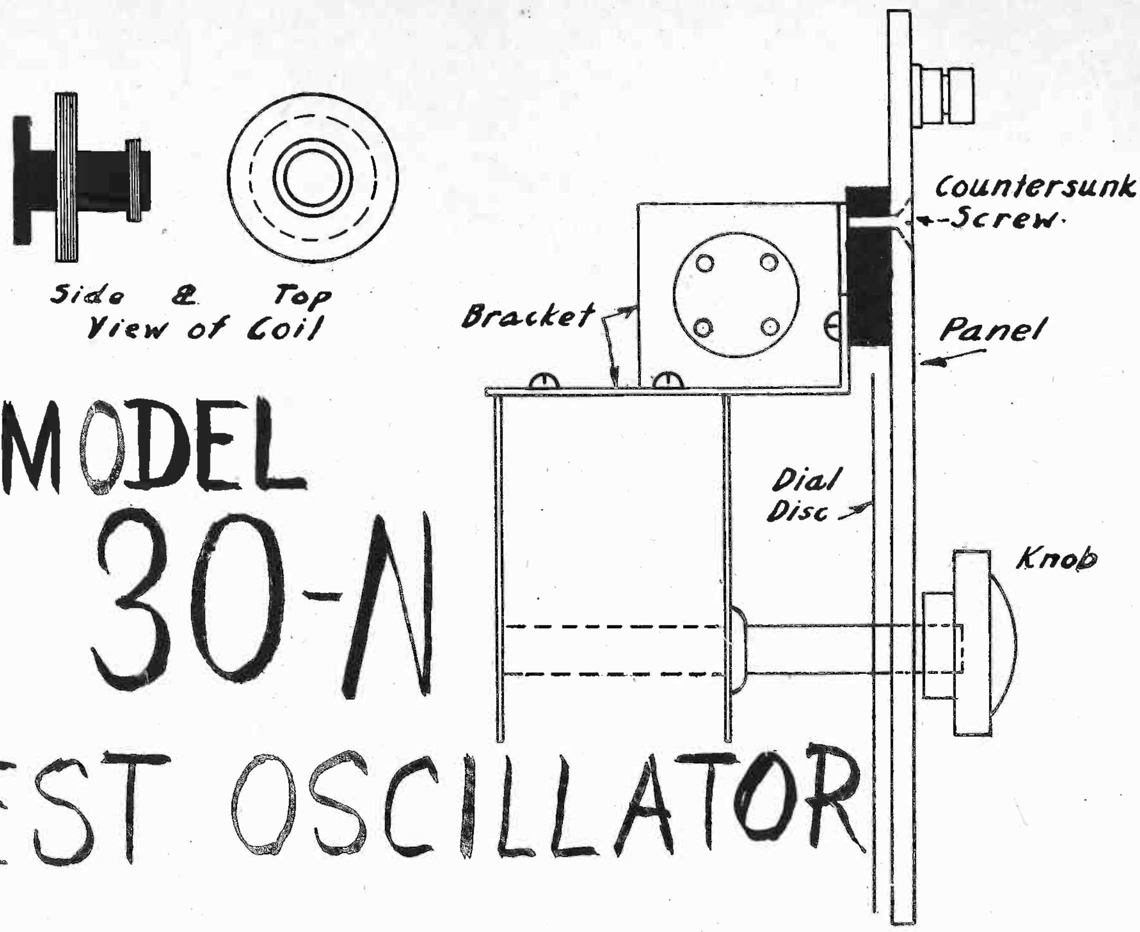


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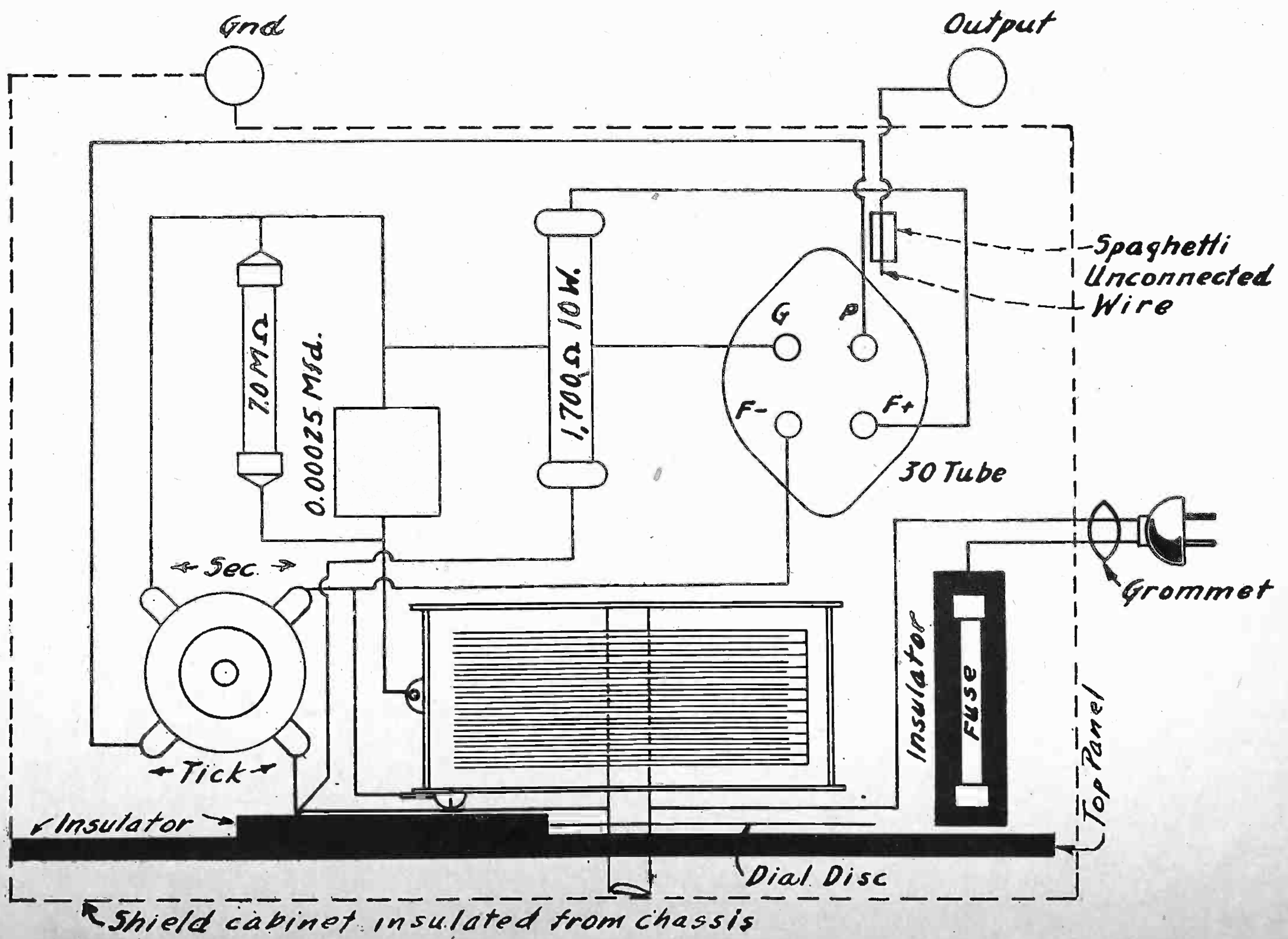

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*THIRTEENTH YEAR*

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# Summer Reception

## Is It More Free of Static on Short Waves Than on Broadcasts?

### *By Elmer Windham*

THE news commentator sponsored by a radio manufacturer, and heard regularly on a chain, said the other night that short-wave reception was relatively free from static in summer. Therefore, supposedly, short waves offered a greater summer attraction than broadcast waves. But this is not quite so.

There can be no general statement as to whether short waves are less static-laden than broadcast waves in either summer or winter, or in spring or fall, because the static aspect of the transmission and reception depends a great deal on the local conditions and on the frequencies of the short waves.

Besides, taking broadcasts alone, since mostly local stations are tuned in, and these deliver the greatest field strength at the receiving antenna, the signal-to-noise ratio is in general better for broadcasts than for any of the short waves, excepting frequencies so high as to be in the ultra class.

### Natural and Unnatural Static

The static referred to probably was of the natural type, and consists of electrical disturbances contributed by nature. In all its activities nature is charging bodies positively, and by collision, adjacency, rarefaction and other means, discharge takes place, and it is this discharge that constitutes natural static. The other type of static is unnatural, but just as objectionable, and is man's contribution to interference, another classification perhaps of man's inhumanity to man. But it is scarcely intentional. It is due to the charging and discharging arising from the operation of electrical and even some mechanical devices. Motors of all kinds, generators, commutators, what not, contribute to this local noise.

Whenever there is an electrical storm there is some static, usually plenty of it, especially if the storm is close at hand, or, as one says, one is in the midst of it.

The most familiar form of this disturbance is lightning, which represents the accummulation of sufficient voltage in the clouds to cause the rarefied atmosphere to strike, just as a neon lamp strikes when the voltage becomes high enough to break down the neon gas in which two elements are placed.

The discharges in nature are not always accompanied by a breakdown, for at lower than striking voltages there are weaker phenomena, with no illumination, or at least, none that has been recorded.

When the clouds move at their swift pace in the upper atmosphere where condensation is taking place, we have the incipient condition for production of rain, therefore lightning storms always are accompanied by rain, or by rain conditions.

### Starts With Small Sphere

During the early stages of condensation the spheres are extremely tiny, and the electrical charge that arises from friction of molecules, including the rubbing of the cloud against the slower-moving media above and below it, or against stand-still media, produces the charge just as rubbing a piece of amber produces a charge, which can be released by touching the amber with the finger (grounding).

The tiniest imaginable drop has a certain electric charge on it, and more and more of these molecules become electrically charged as the activity in the upper strata increases. The charge is proportional to the radius of the water sphere, or tiny globule. We start with one sphere. But then unison of spheres takes place. In the rapid process of combination, one tiny sphere will unite with another, and these two with another, or with single or combined ones, etc., until the spheres acquire the proportion of "drops."

In the beginning each tiny sphere has the same quantity of electric charge, the same electrical capacity, and the same voltage. The capacity is proportional to the radius. If two tiny spheres of equal value unite, the charge is doubled, the voltage is doubled, but the radius is less than twice that of one sphere alone, therefore the voltage has increased more than proportionately to the radius or capacity, and the spheres acquire a greater potential for unit value of capacity.

### The Lightning Strikes

When the potential has accumulated sufficiently, it breaks down the rarefied air, and the lightning strikes periodically, between the charged particles and the earth, the period being determined by the same laws as those governing the oscillation of gas-discharge vapor tubes. Also, it may be noted, the giant tube thus created, consisting of the gas or ether, with the clouds as one plate and the earth as the other, has a negative resistance characteristic, that is, the resistance decreases with current increase.

When sufficient voltage is grounded, or expended, the oscillation or lightning stops.

Thus we see how we have natural static at its worst. It is not to be assumed, however, that it affects radio equally on all wavelengths. We find that somewhere below 10 meters the lightning crashes are not heard. Also, much weaker disturbances create more noise and interference at lower radio frequencies than a seemingly imponderable lightning phenomenon. So we must think of static in terms of the frequencies of transmission and reception.

Moreover, location on the earth's surface has much to do with the static conditions, especially as static-type storms abound at certain seasons of the year in tropical and semi-tropical locations, and there are fairly well-defined static areas about the globe that are especially active at certain seasons of the year.

### Key to Long Distances

Static, or atmospheric disturbance, is worst of all on the long wavelengths, those used for some trans-oceanic telegraphy, and occupying channels that those who listen for pleasure never hear, as sets do not tune that low in frequency. Then as the frequency is increased the static sensitivity is decreased, until 17 meters are reached, when the trouble from static practically disappears, although there are many instances where severe static has been suffered even down to 10 meters. The rule is, however, that the stoppage is at 17 meters.

So, if one is tuning an all-wave or a short-wave set, he may find that the static is particularly bad in one band, becomes less

*(Continued on next page)*

# Short-Wave Transmission

## The Causes of Fading, Skip Distance and Other Phenomena Treated in Second Instalment of "The Short-Wave Authority"

### *By J. E. Anderson and Herman Bernard*

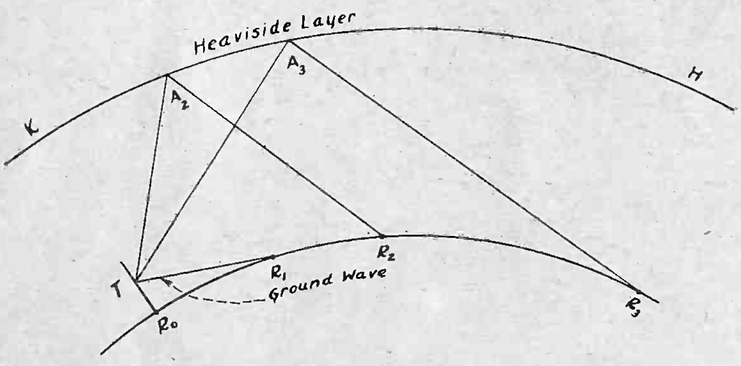


**FIG. II-1**
**The Kennelly-Heaviside layer, or ionosphere, as it affects radio waves, particularly short waves.**

[*The first instalment of the serial publication of "The Short-Wave Authority" was published in last week's issue, dated May 12th. The third instalment will appear next week, issue of May 26th.*—EDITOR.]

HOW does a radio signal travel from the transmitting antenna to the receiving antenna? By a wave, of course. That fact is universally known. But is it a fact? There are many, many who understand radio so thoroughly that they doubt this wave motion theory, and who are not afraid to say so publicly. Some who have investigated phenomena of this kind, such as heat radiation, light radiation, gravitational force, and radio radiation do not even attempt to offer an explanation of how the effect is transferred from one place to the other. They merely say that something happens here at this moment and at the next moment the effect happens at the distant point. They do not postulate a wave motion and no "ether" as the medium in which the wave motion takes place.

The existence of an ether is very doubtful. Hence the existence of waves in the ether must be at least equally doubtful. With such a doubtful foundation how can we be sure that radio signals travel from one point to another by waves? We cannot be. However, we know for a fact that energy from the transmitter travels to the receiver in a manner just as if it were carried by a wave. Therefore we are justified in saying that the radio signal is a form of wave motion in space. This does not postulate an ether, neither does it deny the facts pointing to wave motion.

#### Transmission

When alternating current of high frequency flows in a conductor part of the energy involved leaves the conductor and travels away in free space. It moves away just as light moves away from a luminous source or as heat moves away from a hot body. The energy that leaves is said to be radiated, and the process of leaving is called radiation.

After the energy has left the conductor it travels out into space in all directions, but not necessarily equally in all directions. As it travels away from the starting point it spreads out, or thins out, because the same amount must continually cover more space. The decrease in intensity of the wave due to this spreading out is called attenuation. But it is not attenuation alone that accounts for the decrease in the intensity. Some of the energy changes into other forms, such as heat, and this energy is lost to the wave. Therefore the intensity of the wave decreases both because of loss and because of attenuation.

The propagation of a radio wave depends on the nature of the ground over which it travels. It travels better over level ground than over hilly ground, better over moist ground than over dry ground. It travels best of all over water, especially sea water. It travels well along a river or along valleys, but not well across the ridges and mountains separating valleys.

#### Ground and Sky Waves

If the transmitting conductor, or antenna, is grounded at one end and is vertical, most of the energy leaves the aerial in an earth-bound wave, and this is called the ground wave. By ground wave is not meant that the wave goes through the ground but that it follows the ground. Part of the ground wave may enter the ground but it is not called the ground wave merely because it does so. If a portion of the wave enters the ground the loss is usually greater than when it does not. A perfect ground is a ground that is a perfect conductor, and such a conductor would prevent any part of the ground wave from entering that conductor. Broadcasting in the 540-1,600 kc band is mostly carried on by the ground wave.

Part of the energy that leaves the transmitting antenna is directed upward at an angle. This part of the wave does not contribute anything to reception in the usual service range of a broadcast transmitting station, for it passes over all the receiving antennas in the immediate vicinity of the transmitter. It very quickly reaches high altitudes. This part is called the sky wave.

#### Skip Distance

When the sky wave has reached a certain altitude it meets the Kennelly-Heaviside layer, a region in the atmosphere where free electrons exist. The layer was named for the two men who announced its existence at practically the same time, but more recently has been called the ionosphere, and the region is now known to consist of several layers. The ionosphere is conducting, or, at any rate, it behaves differently toward a radio wave than free space behaves. The wave will suffer a change in direction, just as a ray of light suffers a change of direction at the boundary between air and water, or between air and glass. The wave may bend just a little and then continue through the layer and out into space beyond. If it does, it is forever lost to the earth. But the wave may also bend so much that it actually comes back toward the earth. In other words, it may be reflected toward the earth. It will then reach the earth at a point remote from the sending antenna.

Fig. II-1 illustrates this reflection. T at lower left is the transmitting antenna, KH, upper left to right, the Kennelly-Heaviside layer, and RoR3 the surface of the ground. A radio wave may leave the antenna in the direction TA2 and strike the reflecting layer at the point A2. It is reflected to the earth at point R2. A receiver located here will receive the signal. The wave may also leave in the direction TA3 and ultimately reach R3. As a mat-

# Nature Quenches Static Below 10 Meters

(*Continued from preceding page*)

the higher the frequencies, and then practically disappears at around 17 meters (17.64 megacycles). But then one is tuning in a spectrum that is most suitable for daylight or twilight-zone transmission, and the station to be brought in should be sending its wave through daylight, or twilight mostly, otherwise long distances will not be received.

In tropical and semi-tropical countries the milder form of static referred to merely as noise level is extremely bothersome at the longer wavelengths such as mentioned for trans-oceanic telegraphy, above 10,000 meters (below 30 kc.), in fact ten times as troublesome or as strong as on lower wavelengths in temperate zones such as in the United States, where natural static is not really severe and persistent. In thickly populated small countries, where much machinery, particularly electric motors, is in operation, man-made static must be expected to be greater than in sparsely-populated countries, or in rural parts of large countries, like the United States. And, of course, around the congested activities of great cities the local or unnatural static must be expected to be worst.

At the shorter wavelengths, 10 meters and below, even man-made static is quenched by nature, as if in compensation for the trouble nature itself causes on lower frequencies, so that frequency, and location on the globe, rather than the season of the year, have most to do with the presence or absence of static.

ter of fact, the sky wave will cover the entire angle between A2TA3 and therefore if a receiver is anywhere between R2 and R3 the signals will be received.

The ground wave is represented by the line TR1. If a receiver is anywhere in the region between Ro and R1 the signals will be received, and the closer the receiver is to Ro the stronger will be the signals. R1 represents a point beyond which the signals cannot be received by the ground wave because they have become too weak by attenuation and losses. Therefore there is a space R1R2 where the signals cannot be received by any receiver. This is called the skip distance.

For a broadcast station this region is actually a ring on the earth limited by the radii RoR1 and RoR2. Outside this ring of no reception is another ring limited by the radii RoR2 and RoR3 in which signals can be received by reflection from the Kennelly-Heaviside layer. These rings, of course, are not perfect circles, for the propagation is not the same in all directions, neither is the reflecting layer perfectly symmetrical about the point directly over the transmitting antenna. Moreover, the rings do not remain stationary but move from hour to hour, from day to dark, from season to season.

The sky wave is the principal one relied on for short-wave reception, particularly over great distances.

## Fading

At certain times when a receiver is tuned in on a station about 400 miles away, or more, the intensity of the received signals will rise and fall, sometimes very slowly and sometimes with great rapidity. This variation in the intensity is called fading.

Fading can be explained with the aid of the reflecting layer. Suppose that a receiver is located near either edge of the reflected beam, say either near R2 or near R3. If now the layer changes its height or its inclination, the reflected beam will also change its position. For example, R2 will move either toward R1 or toward R3. If it moves toward R1, a receiver previously lying just inside the skip-distance zone will effectively move inside. A signal that was very weak or inaudible before will become strong. The next moment the layer may change so that the beam will move in the opposite direction. The receiver will now move outside the signal zone, back into the skip distance, and the signal will fade out. The same thing may occur at R3.

The phenomenon of fading may be explained on still another basis. Suppose that the receiver is located at a point where the ground wave is weak but receivable. At the same time suppose that the reflected beam reaches the receiver. In other words, we are supposing that the sky wave is reflected back to earth so close to the transmitter that the ground wave still has receivable intensity, and that our receiver is located in this dual signal zone.

If it should happen that the phases of the ground and reflected waves are such that the two signals add up constructively, the received signal will be much stronger than if only one of the waves were present. On the other hand, if the phases are such that the two waves add up destructively, the signal will be much weaker than if either wave were present alone. In case the two waves are equally strong at the receiver, the greatest possible variation in the resultant of the two waves is from zero when the two are out of phase, to twice either, when the two are in phase. If the phase difference between the two did not change, reception would be either excellent or it would be exceedingly poor. This would suggest that an automatic phase-shifter might work a cure for fading. Unfortunately, the phases do not remain constant, especially the phase of the reflected wave, for it depends on the height of the reflecting layer as well as on the inclination. It is highly probable that the inclination of the lower edge of the layer, which is really the reflecting surface, changes rapidly. Thus the point at which the ray comes down changes also. This means that the phase of the reflected wave changes at the receiver. Now it is very unlikely that the ground wave changes much. Therefore if there ar any changes in the height of the reflecting layer or in its inclination, there will be phase shifts at the receiver, and fading will inevitably result.

There is as yet no authenticated remedy for fading, although some means are employed, such as automatic volume control to reduce its effect.

## Dual Path Propagation

Fading and kindred phenomena may occur even when the sky wave is absent, provided that the same signal can reach the receiver by two different routes. An illustration of this was obtained in New York when broadcasting first started. A station was transmitting near the lower end of Manhattan Island. The tall steel buildings just north of the antenna effectively prevented the radio waves from traveling in that direction. The waves did, however, travel up the Hudson and East Rivers with comparatively little attenuation. Radio energy flowed into the shadow of the tall buildings from both sides, and at points about 15 miles north of the transmitter considerable fading was experienced because the signal reached those points from two directions and because the effective distances varied.

## Directed Transmission

By suitable arrangement of the transmitting antenna it is possible to prevent the radiation of the sky wave and to concentrate all the energy in the ground wave. This will increase the intensity of the signal at every point in the regular service area of the station and it will also increase that area. Since the sky wave is prevented from radiating, there will be nothing to reflect down at some distant point and there will be no fading. It will be absent because either the signals will come in by the ground wave alone or not at all.

It is also possible to arrange the antenna so that the ground wave is practically eliminated. When this is done all the energy radiated is concentrated in the sky wave, and improved reception results in the zone where the sky wave returns to ground.

Besides directing the radiated energy either in the ground wave or in the sky wave, it is also possible to direct it along a narrow beam, and this beam may be directed either horizontally or at some angle with the horizontal. That is, the beam may either be a ground wave beam or a sky wave beam. Beams are used only when the transmission is to be to a particular receiver.

## Polarization

Sometimes we read about the polarization of a radio wave. Let us explain what is meant. Suppose that a conductor is mounted vertically. It may be grounded at the lower end or it may be left ungrounded, in which case we shall assume that the lower end of the conductor is at some distance above the ground. Let this conductor be excited by means of an electromotive force so that an alternating current flows in it. Regardless of the direction in which the current may flow at any given instant, the magnetic lines about the conductor will be circular and the plane of the circles will be horizontal. The electric force is always at right angles to the magnetic lines. Hence the electric force will be vertical. A wave in which the electric force is vertical and in which the magnetic lines are horizontal is said to be vertically polarized.

If we mount the same antenna, or conductor, so that it is horizontal, the electric force will be horizontal and the magnetic lines will be vertical. Such a wave is said to be horizontally polarized.

A vertically-polarized wave is received with a vertical antenna or with a loop the plane of which is vertical. A horizontally-polarized wave is received with a horizontal antenna or with a loop the plane of which is horizontal. Most transmission is done on vertical polarization.

Even if the transmission is entirely vertically polarized, the polarization at some distance away from the sending station is not necessarily polarized vertically. Usually the polarization is intermediate between vertical and horizontal. The wave front has a tendency to topple over forward so that it seems to be coming from the sky even when only the ground wave is involved. The reasons for this are that the part of the wave that enters the ground travels at a slower speed than that which remains in the air and that there is more absorption or loss in the ground.

The manner in which a vertically-polarized wave topples over and tends to become horizontal is illustrated by the manner in which a water wave approaches a shore line on a beach. Suppose that the wind is such that the waves are vertical to the shore and the motion is parallel to the shore. Where the water is shallow near the shore the wave troughs drag on the bottom, slowing the motion. Farther out the waves move at the regular rate in deep water. Therefore the waves tend to become parallel with the shore line, or as we might say, shore-polarized. This effect can be observed at any beach at any time. With the proper apparatus we could also observe it on any radio wave at any time. It is not likely, however, that the change in the plane of polarization of a radio wave amounts to 90 degrees, which would be necessary to change a vertical wave into a horizonal wave.

## Frequency Effects

All radio waves are not propagated in the same way over the same territory at the same time, because they differ in one important particular, namely, frequency or wavelength. All waves probably attenuate at the same rate under similar conditions, but waves of high frequency, or short length, decrease much more rapidly than waves of low frequency because losses are greater. Displacement currents are induced in dielectrics over and through which they pass and these currents give rise to losses. Also, currents are induced in conductors by the passing wave, and these currents give rise to losses. While these effects are present for waves of all lengths, they are greater at the higher frequencies.

Another fact that limits the waves of higher frequencies is that they tend to travel in straight lines more than do waves of lower frequency and therefore do not follow the curvature of the earth as well. They shoot off at a tangent to the earth and soon they are above any antenna of practical height. For the very shortest waves it is necessary that the transmitting and receiving antennas be in the line of sight. That is, on a clear day and with the aid of suitable instruments, it should be possible to see the antenna of the transmitter from that of the receiver. Exceptions to this rule have been observed.

It is mainly on the waves between about 200 and 10 meters (1.5 and 30 mgc.) that the Kennelly-Heaviside layer comes into play. These waves do not have a wide ground-wave range, but at times they have a world-wide range by the sky wave.

Waves of 10 meters and less are not reflected from the ionized layer and for that reason long-distance communication on these waves has not been accomplished.

# A Short-Wave Super With Beat Oscillator

*By Einar Andrews*

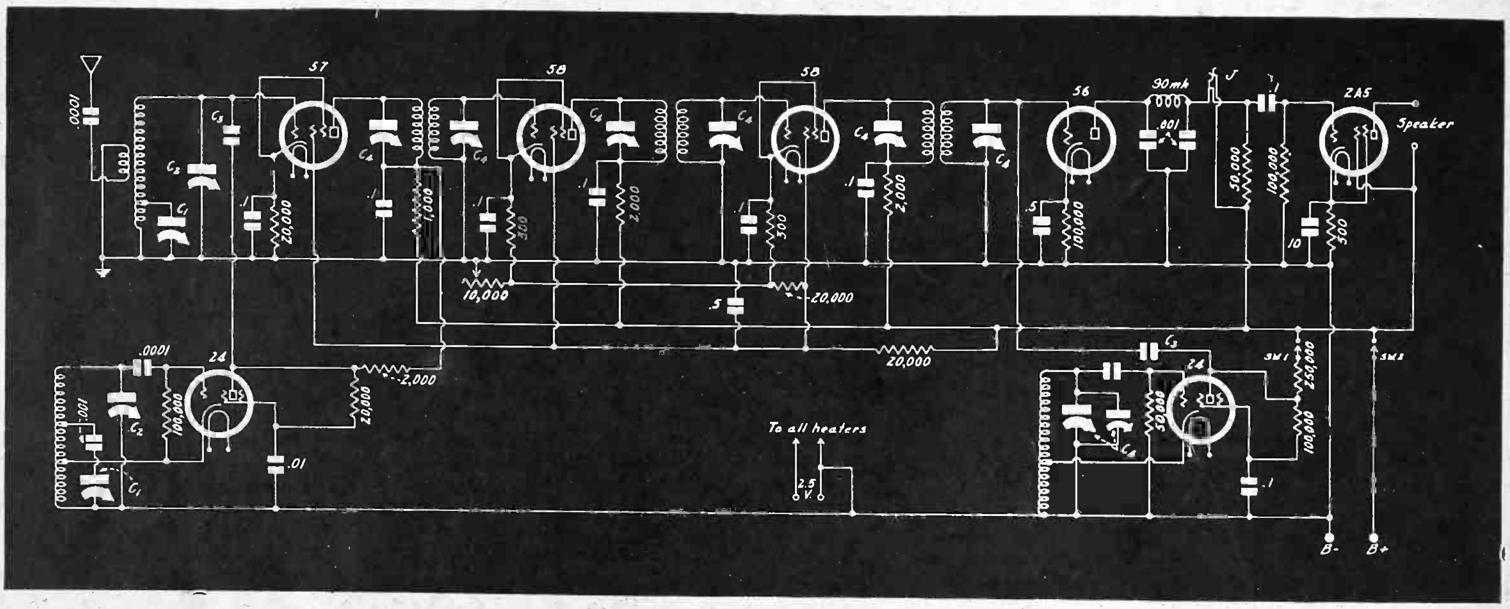


**FIG. 1**
**The circuit of a seven-tube short-wave superheterodyne equipped with separate oscillator as well as beat frequency oscillator.**

THE first question we have to decide before building or purchasing a short-wave receiver is whether it shall be a superheterodyne or a regenerative circuit. The superheterodyne costs more but it is more reliable and more easily tuned, noce it has been adjusted. It does, however, suffer from drifting to a much greater extent than any other reieiver. The regenerative circuit is inxpensive to build and to maintain. Perhaps it should be added as an aid in making a choice, that sooner or later the short-wave enthusiast will get a superheteroyne unless he abandons the short waves for something else.

We just mentioned drifting. What is it? Well, suppose a far-away station is tuned in "right on the nose." After a little while the intensity of the signal will fade away. Yet the cause is not fading, for by retuning the receiver, the station comes in just as well as it did before. The signal may go out again and it may be necessary to retune to bring it back, and this time the tuning may have to be done in the reverse direction. The indications are that the frequency is drifting so that the receiver is thrown out of tune when the dials are left untouched.

## Cause of Drifting

There are two possible causes for this drifting of the signal. First, the frequency of the transmitter may vary as a result of changes in temperature, filament current, or plate voltage. Second, the tuning of the receiver may actually change as a result of changes in the same factors. Now it may be that the transmitter is crystal-controlled, in which case the frequency would not change by an amount sufficient to account for the drifting. Or it may be that a master oscillator not crystal-controlled is used at the transmitter. In this event at least part of the drifting may be attributed to the transmitter, but a minor part.

Since the transmitter is not likely to be the cause of the drifting we must look to the receiver for the explanation. Only a change in the tuning can account for the difficulty. But how can there be a change in the tuning when the controls are left alone? Well, changes in temperature will change the tuning slightly, but hardly enough to account for the large changes in signal intensity accompanying drifting. Changes in the voltages applied to the tubes will change the capacities in the tuned circuits slightly, but once more we must say that these changes are not large enough to account for the fluctuations in the signal.

As stated above, the drifting difficulty is most severe in superheterodynes. The greater part of the total selectivity in a superheterodyne is obtained from the intermediate frequency selector. Hence we suspect that the drifting is caused by detuning of the intermediate frequency circuits. How? They are permanently tuned and are not touched. Yes, they are permanently tuned to a particular frequency and it is just this fact that causes the trouble, for the frequency impressed on the intermediate amplifier and tuner is not fixed. The variation in this frequency is due to changes in the frequency of the local oscillator employed for beating with the signal frequency.

## Lack of Frequency Stability

That fluctuations in the frequency of the local oscillator can account for the drifting of the signal can easily be demonstrated. Suppose we have a signal of 6,000 kc which does not vary. Also let us assume that we have an intermediate amplifier tuned to 450 kc. It is then necessary to set the local oscillator at 6,450 kc in order that the desired signal should come in. Now let us assume that the local oscillator may change its frequency by 2 per cent. Two per cent. of 6,450 kc is 129 kc. If the oscillator frequency changes by this amount, the beat frequency also changes by the same amount. But this represents a change of 129 kc out of 450 kc, or a change of nearly 30 per cent.

When even a moderately selective circuit is detuned by this amount the signal is almost entirely tuned out. In a tuned network such as is used in a good superheterodyne the selectivity is so high that even when the signal is detuned by one per cent, there is an appreciable suppression of the signal. The wonder then is not that there is drifting in a short-wave superheterodyne, but that there is so little of it.

## Remedies for Drifting

The direct cause of the drifting is lack of frequency stability of the high-frequency oscillator. The frequency changes because of changes in the supply voltages, and these change may amount to several per cent. of the frequency of oscillation. We have seen that two per cent. when the intermediate frequency is 450 kc and the signal frequency is 6,000 kc will amount to a 30 per cent. detuning. We have also seen that a selective circuit will not tolerate more than about one per cent detuning. What, then, should the frequency stability of the oscillator be if drifting is to be avoided?

One per cent. of 450 kc is 4.5 kc. That is the maximum drift permissible. But the 4.5 kc out of 6,450 kc is approximately 7 per cent. of one per cent. In other words, the oscillator must be kept to a constancy of better than 7 parts in 10,000. It would be desirable if it were ten times better than that. But such constancy cannot be achieved in any short-wave oscillator without special treatment of the circuit, and such treatment is likely to render the circuit unpractical.

In any oscillator circuit the stability is improved if the resistance

## LIST OF PARTS

### Coils

One set of antenna plug-in coils.
One set of oscillator coils.
Three doubly tuned intermediate frequency transformers (465 kc).
One beat oscillator coil for 465 kc, with tuning condenser.
One 90-millihenry choke coil.

### Condensers

C1—One gang of two 100 mmfd. tuning condensers.
C2—Two sets of trimmer condensers attached to coils.
Two 0.0001 mfd. condensers.
Three 0.001 mfd. condensers.
Eight 0.1 mfd. by-pass condensers.
Two 0.5 mfd. by-pass condensers.
One 0.01 mfd. condenser.
One 10 mfd. electrolytic by-pass condenser.

### Resistors

Two 300-ohm resistors.
One 500-ohm resistor.
One 1,000-ohm resistor.
Three 2,000-ohm resistors.
One 10,000-ohm volume control.
Four 20,000-ohm resistors.
Two 50,000-ohm resistors.
Four 100,000-ohm resistors.
One 250,000-ohm resistor.

### Other Requirements

Five grid clips.
Two sockets.
One 57 socket.
Two 58 sockets.
One 56 socket.
One 2A5 socket.
One phone jack, closed.
A separate power supply giving 2.5 volts for filaments and 300 volts for plates.

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in the plate circuit is high and also if the grid circuit resistance is high. It is theoretically possible to make the grid crcuit resistance high, and that would make the frequency fairly stable, but practically it is difficult to make the grid circuit resistance very high due to blocking. Both the plate and the grid resistances are increased by the use of grid stopping condenser and a grid leak, and the higher the grid leak resistance the higher the internal resistances. Unfortunately, the grid leak cannot be made very large, usually not over 100,000 ohms because of blocking of the grid.

### Hints for Stabilizing

Another way of improving the frequency stability is to use a large condenser and a relatively small coil for the frequency-determining circuit. If the ratio of L/C is made too low, the circuit will not oscillate. Hence there is a limitation on this method of stabilization. Still another method of improving the frequency stability is to use a very ogod oscillator coil. It is often said that it makes no difference whether the oscillator coil be good or poor just so it oscillates. This is true only when frequency variations are of no importance. When the frequency must be held constant, one of the best ways of doing it is to make the radio-frequency resistance of the oscillating coil, or circuit, as low as possible. A quartz crystal resonator is stable as a frequency standard because the losses in the crystal are extremely small. Were they as small in a coil-condenser resonator this would be just as good as a crystal.

### Beat Oscillator

In many short-wave receivers—in most of them, in fact—there is a beat oscillator working at a frequency very close to the intermediate frequency. The frequency stability of this oscillator need not be very great, for a variation of several hundred per cent. in the beat note is permissible, assuming that the frequency normally is of the order of 1,000 cycles per second. Since almost any oscillator will be constant to a few per cent., there will be no appreciable variation in the beat note due to variation in the beat oscillator frequency.

The use of a beat oscillator at the intermediate frequency level is no assurance against drifting because if the high frequency oscillator changes its frequency, the intermediate signal frequency changes by a large percentage and the audible beat between this signal and the beat frequency will vary by about 30 per cent., as we found before. This is enough to throw the signal out of the audible range many times over. The most important thing that can be done against drifting, then, is to stabilize the high-frequency oscillator

### A Typical Short-Wave Super

In Fig. 1 we have the diagram of a typical short-wave superheterodyne in which the high frequency oscillator is separate from the first detector and in which there is a beat oscillator. Both oscillators in the circuit are of the Hartley type. While this type of circuit is entirely satisfactory for the beat frequency oscillator, it is not of the beat for the high frequency oscillator. No apparent attempt at stabilization has been made, and it is quite certain that there will be drifting on the higher frequencies if there is any fluctuation in the supply voltages.

While there is no apparent stabilization in the oscillator, there is a stopping condenser and a 100,000-ohm grid leak. These two help stabilize a little and they may confine the frequency fluctuation to less than one per cent. The stopping condenser can be used in this circuit as a partial stabilizer because a Hartley is stabilized by negative reactances. If the grid condenser is made equal to the tuning condenser, the circuit will be stable. Of course, it is not possible to select a fixed condenser such that it will be equal to a variable condenser, but it is possible to select the fixed condenser such that it shall be equal to the variable one at some particular setting. Now, when the variable condenser is large, that is, when it is set for the low-frequency end of the tuning range, the circuit is relatively stable because the L/C ratio is low. Hence if we select the stopping condenser so that it is equal to the tuning condenser at some frequency near the higher frequency limit, the circuit will be fairly stable throughout. In the diagram the stopping condenser has a value of 100 mmfd. If the maximum value of the tuning condenser is 140 mmfd., which is the usual value, the greatest stability would occur near the low frequency end. Hence the stopping condenser might be made only about 50 mmfd. If it is made too small, though, the circuit will not oscillate.

### Tuning of Circuit

The tuning condenser has a capacity of 100 mmfd. plus a small amount of distributed, and it is represented by C1 in the drawing. It will be noticed that this condenser is connected across only a portion of the coil in each case. In the oscillator circuit there is a 0.001 mfd. fixed condenser in series with the variable. Condensers C2 are trimmers for the coils and they are parts of the coils. There are two condensers marked C3 in the circuit, one connecting the plate of the high-frequency oscillator and the grid of the first detector and the other the plate of the beat oscillator and the grid of the second detector. Each of these condensers consists of the capacity between two insulated leads twisted together for about one inch.

Condensers marked C4 are the tuning condensers for the intermediate frequency coils, and there are seven of them, one for the beat oscillator and the other for the three intermediate frequency transformers. In the best short-wave superheterodynes these condensers are of the air dielectric type and they are mechanically arranged so that once they have been set at a given capacity they will remain at that value. In other words, the circuit will not become detuned by changes in the capacities across the windings of the intermediate frequency transformers.

### Shielding

Success with short-wave receivers demands that coils, condensers, and tubes be well shielded. A sheet of metal placed between two coils or other pieces of apparatus does not constitute a shield, even though it be grounded. There should be two metallic partitions. A coil and a tube might be placed inside one metal box, and another coil and tube in a second box. While these metal boxes may be grounded there should be space between them. It will do no harm if there is a shield around the tube inside the metal box. A sheet of metal separating two coils couple the coils rather than uncouple them.

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# Grid Condenser Aids the Local Oscillator

Frequently trouble is experienced in the local oscillator of a short-wave superheterodyne, due to poor tracking. The padding condensers and coils may be all right. But the grid current is erratic and introduces the effect of a large parallel capacity, thus upsetting the tuning ratio, and changing it from day to day.

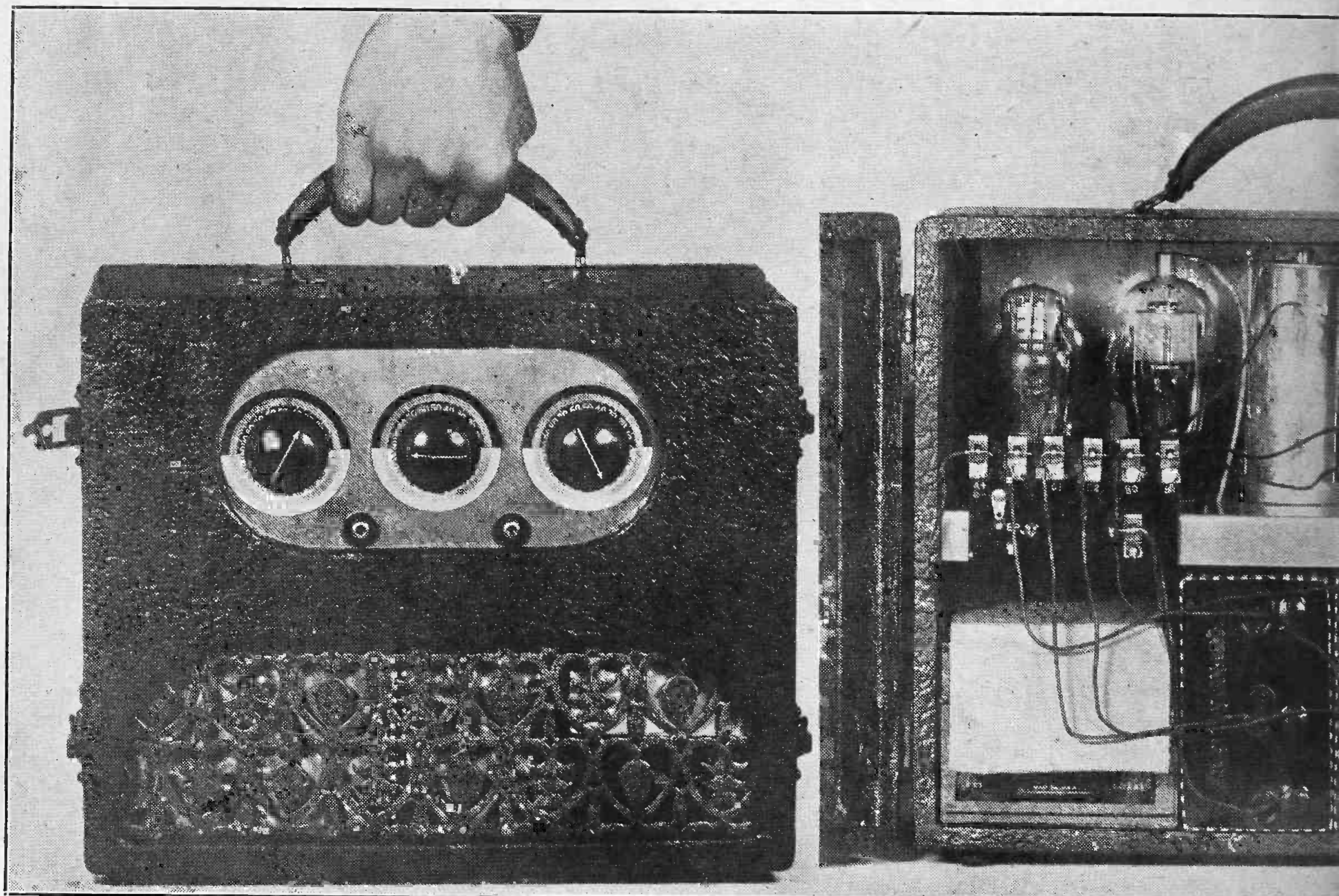
The remedy is to put a grid leak and condenser in the oscillator circuit. The condenser, between grid and coil, may be 50 mmfd., and the resistance as high as practical, consistent with absence of blocking.

### A THOUGHT FOR THE WEEK

*SHORT-WAVE interest has grown to such an extent during the past year that there isn't the slightest doubt it will take radio right through the coming summer months with a bang. Already sponsors on the big chains are signing up contracts for the hot weather period in a way that indicates their faith in radio as a big summer asset in the sales of their goods—and, of course, those sales would not materialize unless the public continues to listen in. Incidentally, the sales forces of the networks and smaller groupings are quite convinced that they are going through the hot weather period without enforced vacations or cuts in salaries.*

# AShort-Wave Ea[r]
# Weight, Complete, 21

*By Le*
*Leotone*



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Therefore one of the first considerations to merit the attention of the prospective portable owner should be: "Does the receiver include enough to guarantee results?" That is, the weight need not be considered first, and in reality should come probably third, since results are first, price should be second, and then may come weight.

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It is to be noted that a more or less accepted circuit, or standard hookup, is used, and this should be encouraging, as experimentation is put aside. It has been found that an r-f stage, even if untuned, will help a lot in stabilizing the calibration you make, so that the same frequencies will come in time and again at the same spot on the dial, and also this method of pickup allows for a healthy signal delivered to the detector. It is true that the selectivity is not so high as it would be if the stage were tuned, but one should consider the fact that the aerial, a short piece of wire strung between insulators at tree branches, or in some other elevated position, is not likely to have great effective height, and this compensates for the omission of r-f tuning, because it constitutes looser coupling between the set and the station being received, and looser coupling spells increased selectivity.

Moreover, the portable is not expected to be used near broadcasting stations, for one will be driving somewhere in his car, paddling a canoe, established at camp, hotel or leafy bivouac, presumably far from broadcasting centers, and therefore trouble from close-at-hand broadcasting stations will not be experienced.

### Smooth Detector Action

The untuned r-f stage feeds a regenerative detector in which the regeneration is controlled by adjustment of the screen voltage on the detector. It will be noted that peak screen voltage is low, being 22.5 volts, the lowest B voltage used in the circuit, but the selection is made thus because of smoother and better results. The 32 detector has a 200,000-ohm plate resistor, and the voltage drop in this is so considerable, as it should be, that the screen voltage has to be maintained appreciably lower than the effective plate voltage for best detecting conditions. Besides, the run of plug-in coils has feedback winding of such inductance and coupling co-efficient that the 22.5-volt screen voltage serves admirably.

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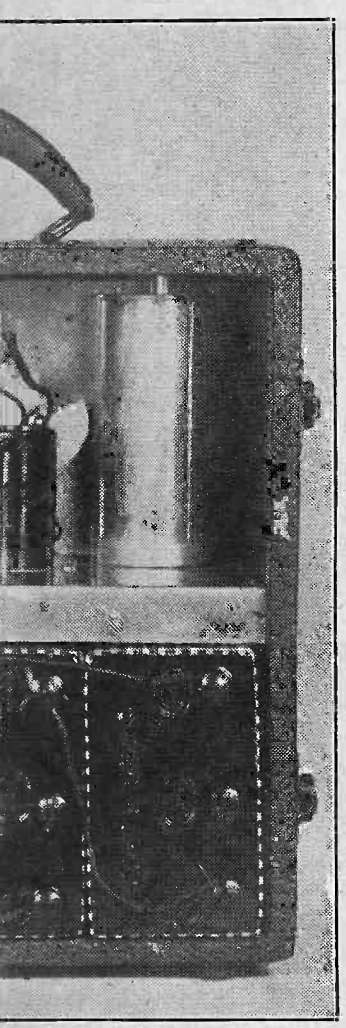
# hone Portable Set; Lbs., Sensitivity Good

*haron*
*Company*



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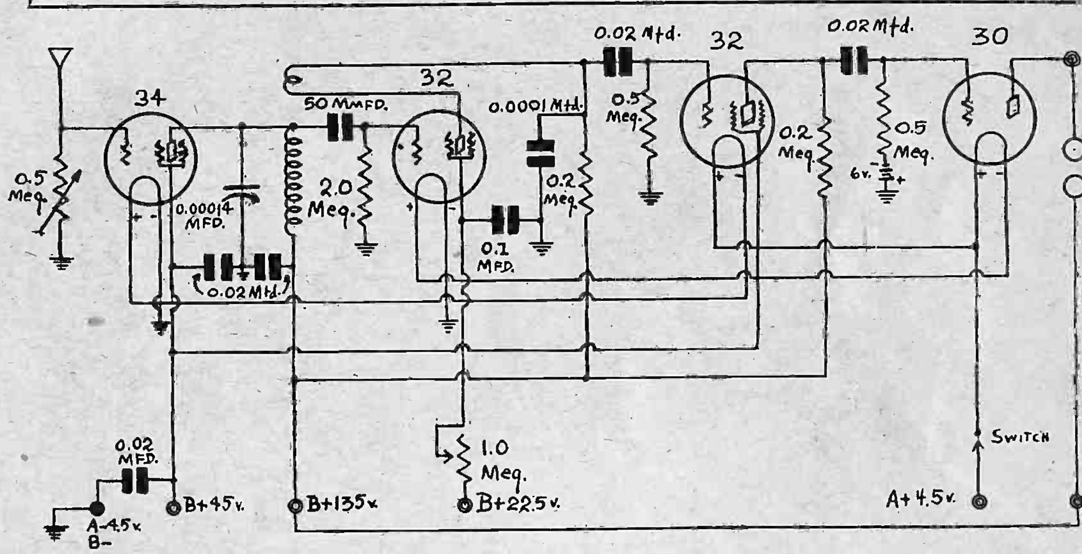


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The filaments are in series parallel, and the connections of grid returns are such that for the first audio amplifier and the output ube advantage is taken of a drop of 2.25 volts across the filament n each of these two instances. Therefore 2.25 volts comprise the negative bias on the first audio amplifier, although at first blush it might appear there was no bias; moreover, add to the 6-volt battery bias for the output tube the 2.25-volt filament drop of the associated ube in the series chain, and you have the 8.25 volts, near enough o the prescribed 9 volts of standard bias.

The 6-volt biasing battery consists of small cells, possibly two small batteries of the 3-volt flashlight type in series, as there is no current drain, only voltage derivation, from this particular source. The carrying case is of wood, with leatherette finish, and houses the compact unit, in a manner best illustrated by the rear view herewith. The arrangement of the principal batteries is shown, while the other and smaller batteries are inside.

The front panel has at left a potentiometer at the input which may be used as volume control, since it is advantageous to have such a control rather than rely only on regeneration to yield the desired volume. It is indicative of the high-volume output obtainable that an additional volume control is recommended, for where regeneration control is solely relied on for volume adjustment, it is an indication that the volume is never too much, which means that foreign stations are not likely to come in with sufficient volume for satisfaction, if locals don't play some sort of havoc with the phones.

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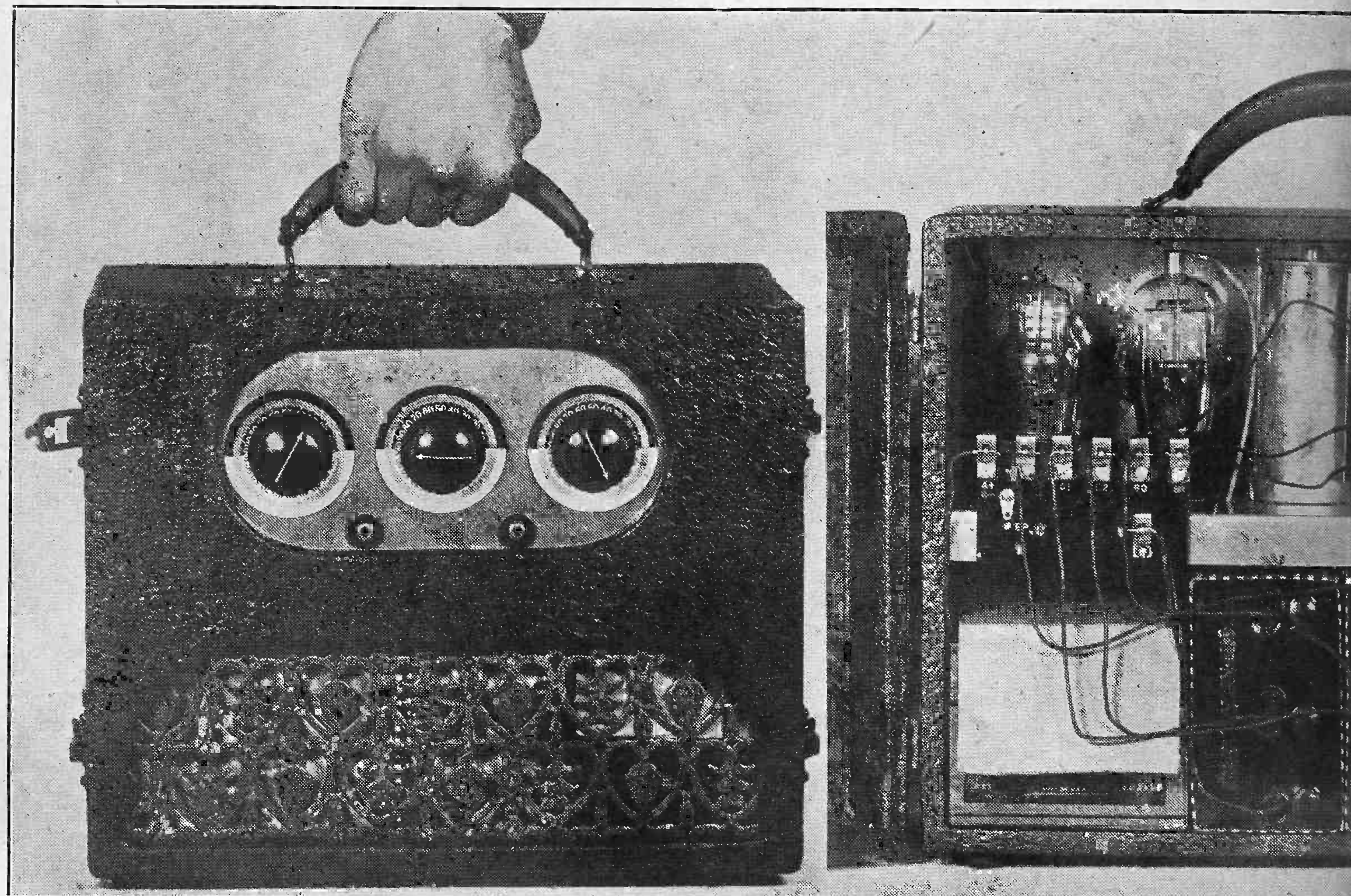
# AShort-Wave Ear
# Weight, Complete, 21

*By Le*
*Leotone R*



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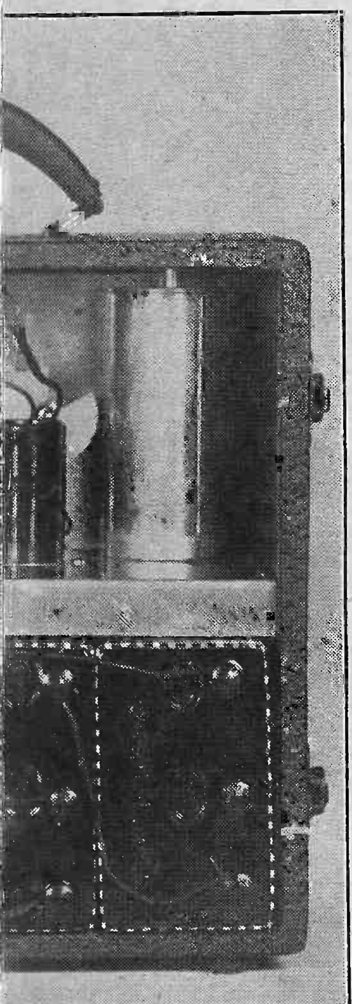

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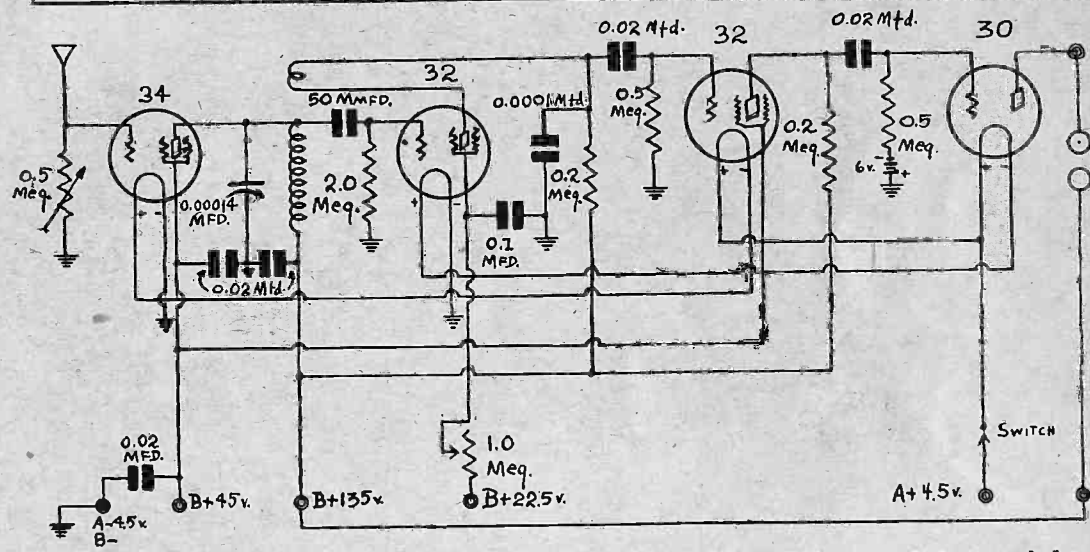


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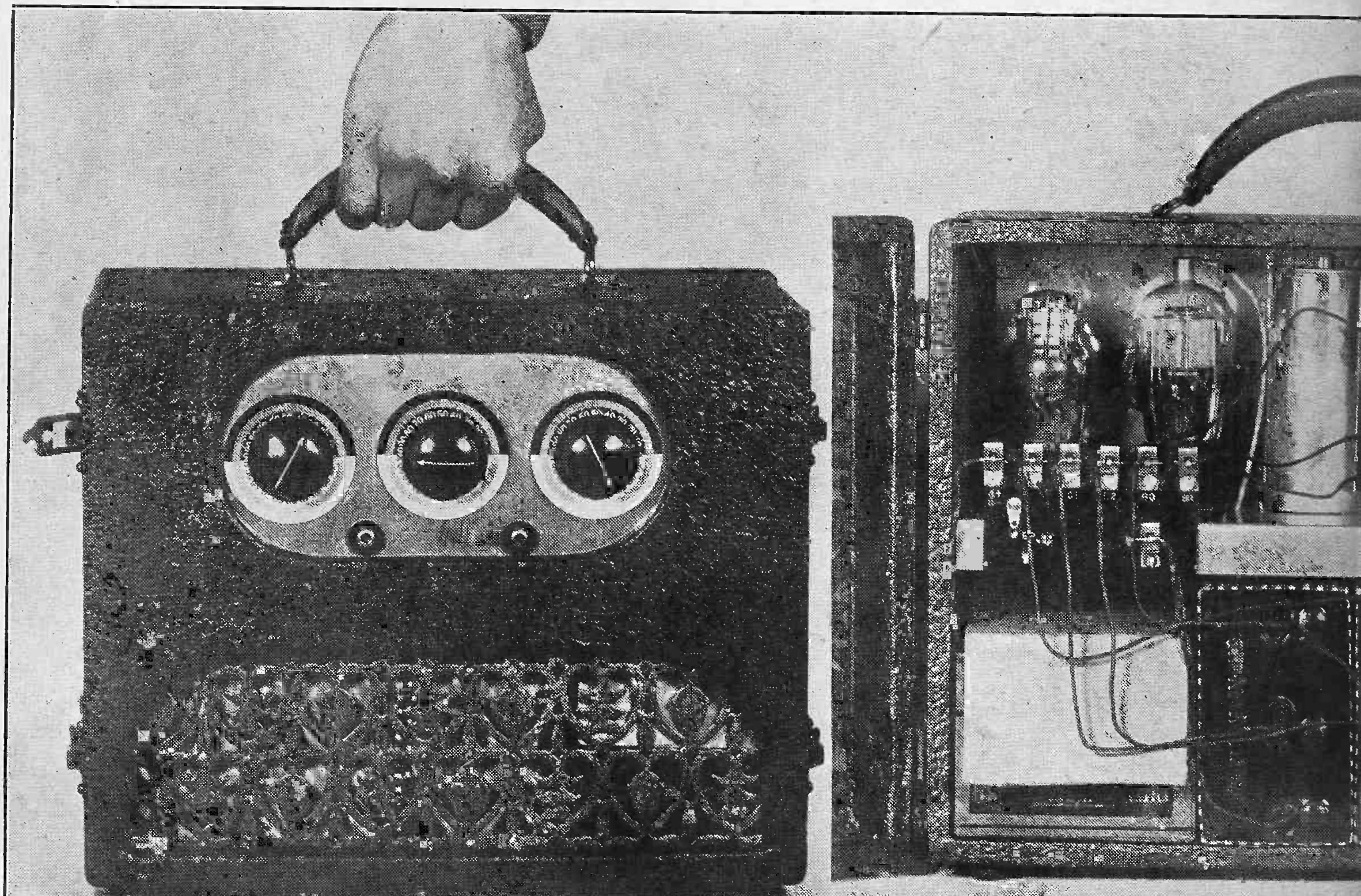

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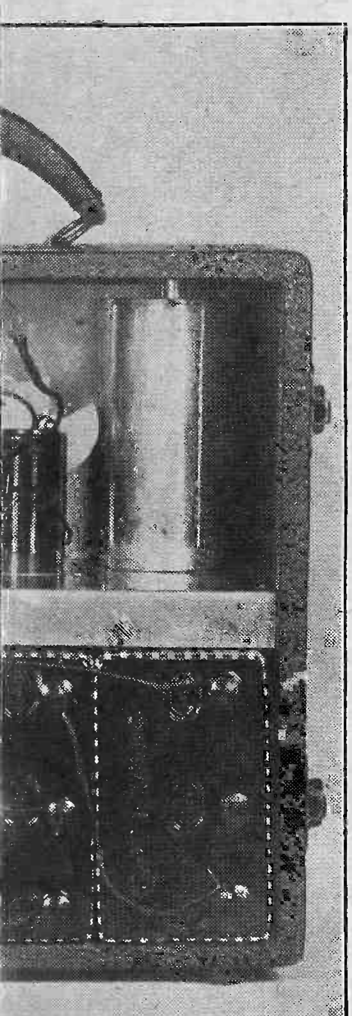

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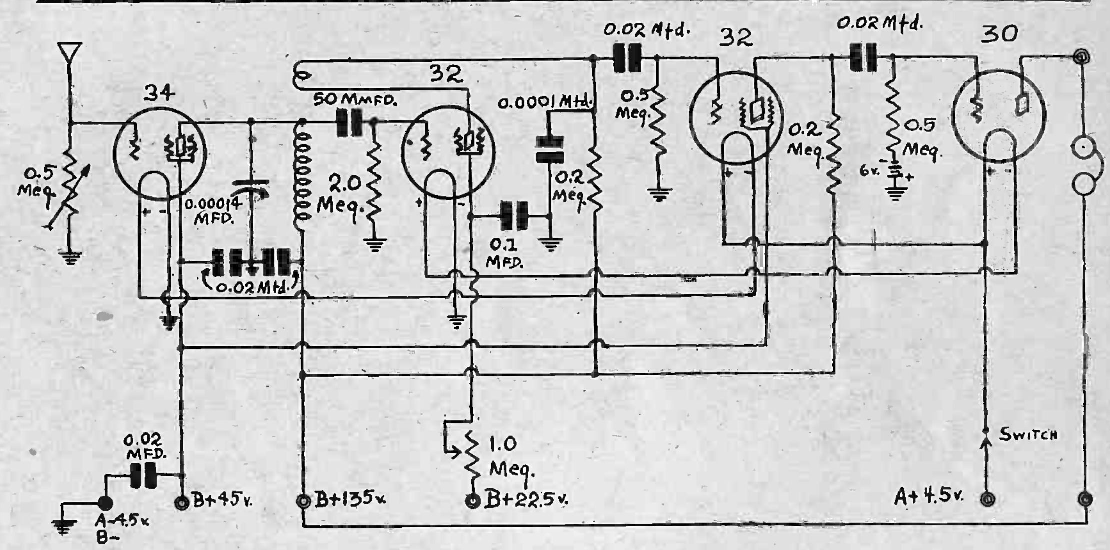



**A short-wave portable for earphone operation. The dials are, left to right, antenna rheostat, tuning control and regeneration. The switch is built into the regeneration control. The whole set is in a carrying case 12½" wide x 8½" front to back x 11 inches high. The weight, everything included, is 21 lbs. The other photograph reveals the rear view. The circuit diagram used is shown herewith.**

in portable construction such as this for catch-as-catch can aerials and tree-surrounded listening posts, although some stations will come in with what passes for speaker volume with those whose ambitions are more pronounced than their conservatism.

### Phone Rattle Nuisance Avoided

The 30 tube, with 135 plate volts, and an effective negative bias of 8.25 volts, is voltaged practically in standard fashion, and moreover, will stand a great deal of output, considering the fact that earphones are used. It is a common failing to assume that if one uses earphones the B voltage and bias may be low on the output tube, but the tube should be treated the same whether speaker or phones are intended, as a good pair of phones will stand a heavy swing, too, without rattling. It is the better part of wisdom to get rid of the phone rattle by saner circuit design and voltaging, then to have practically no bias and practically too little B voltage on the output tube. Moreover, the bias being practically as high as it should be, the plate current is low.

The filaments are in series parallel, and the connections of grid returns are such that for the first audio amplifier and the output tube advantage is taken of a drop of 2.25 volts across the filament in each of these two instances. Therefore 2.25 volts comprise the negative bias on the first audio amplifier, although at first blush it might appear there was no bias; moreover, add to the 6-volt battery bias for the output tube the 2.25-volt filament drop of the associated tube in the series chain, and you have the 8.25 volts, near enough to the prescribed 9 volts of standard bias.

The 6-volt biasing battery consists of small cells, possibly two small batteries of the 3-volt flashlight type in series, as there is no current drain, only voltage derivation, from this particular source. The carrying case is of wood, with leatherette finish, and houses the compact unit, in a manner best illustrated by the rear view herewith. The arrangement of the principal batteries is shown, while the other and smaller batteries are inside.

The front panel has at left a potentiometer at the input which may be used as volume control, since it is advantageous to have such a control rather than rely only on regeneration to yield the desired volume. It is indicative of the high-volume output obtainable that an additional volume control is recommended, for where regeneration control is solely relied on for volume adjustment, it is an indication that the volume is never too much, which means that foreign stations are not likely to come in with sufficient volume for satisfaction, if locals don't play some sort of havoc with the phones.

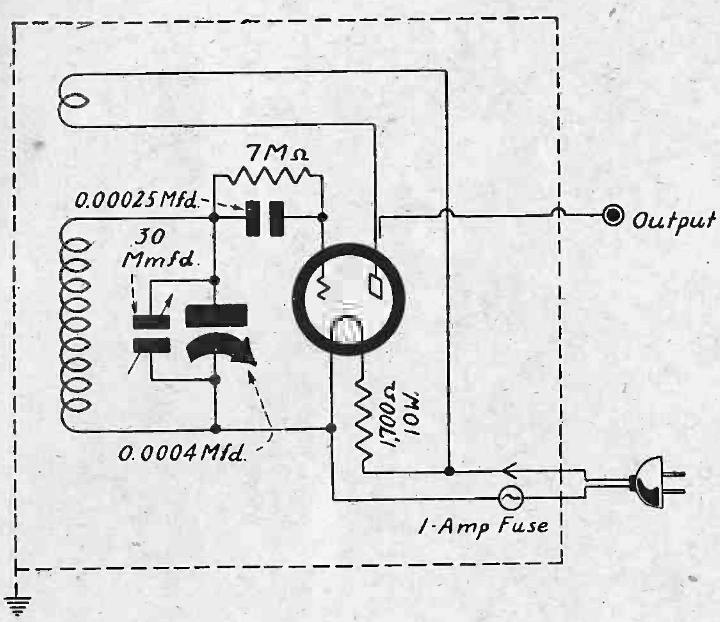
Besides, if regeneration is relied on for volume control, then to get less volume one also must get less selectivity, and the wedding of the virtue with the vice would seem to be against the code, would it not?

The batteries and other points requiring bypassing are properly treated in the circuit, the tubes are suitably selected for the purposes to be served, and the whole outfit is meant to be one that will give excellent satisfaction to those who want to take their short-wave yearnings with them on vacation, even if the vacation is not the main one, but a week-end trip to the country. Where portage becomes necessary, the 21-lb. weight will not be found to be excessive, nor will the drain on the batteries be such that after you've just begun to enjoy your fun you find that there's a 10-mile hike ahead of you to the nearest village to buy the batteries the keeper of the general store is sorry to relate he does not stock. but next week can send to the city for them.

# The 30-N Oscillator

## Inexpensive Signal Generator Works on A.C., D.C., or Batteries—Always Modulated

### *By Randolph Faulkner*




**Circuit diagram of the 30-N Test Oscillator. See the pictorial diagram of the wiring on the inside front cover. This instrument is easily constructed to an accuracy of 2 per cent. on the direct-reading scale, and in commercial production this accuracy is improved on.**

THE Model 30-N Test Oscillator, or Signal Generator, as such devices are now more commonly called, is shown herewith in wiring diagram form, and is illustrated as to pictorial wiring on the inside front cover (page 2). This device is useful for lining up channels from 135 to 1,520 kc. and is direct-reading, due to use of a pre-calibrated scale. The important higher intermediate frequencies, 400, 450, 456 and 465 kc., are registered separately on the scale at the second-harmonic positions of 200, 225 kc., etc. Also 175 kc. is especially imprinted. Thus the model will give service in lining up intermediate and broadcast frequencies, and is popular with home constructors, being inexpensive.

The location of the wires is not actualy on page 2, although the connections are correct. The reason for showing the parts separated from their actual position is that most of the small ones are in a limited space on one side of the tuning condenser, the side the tube base is on, and some are on top of others, though not touching of course, therefore it would be confusing to show the literal placement.

### Size Is 5½ x 5½ x 3 Inches

However, due to the extreme compactness, for the cabinet size is 5½ x 5½ x 3 inches, there is only one place really to put each part, and that will suggest itself, or, if the kit is obtained, will be obvious from the drillings of the pieces.

The parts are mounted completely on the insulating top panel, and then the wiring is completed, the only detail being that the a-c cable is passed through the box hole, where the grommet is, for connection of the two bared terminals inside the oscillator, one terminal to chassis, other to an insulated lug, as part of the construction.

Although noted on page 2, the warning is repeated here that the oscillator proper, or its chassis, if that word brings home the fact better, is completely insulated from the metal box. It is advisable, but not necessary, to ground the box externally. Since the line may be grounded, identical connection to opposite potentials could result, hence a short circuit, if the oscillator were not isolated from the box. Three insulating pieces are used, some of which is the full top panel, another an odd-shaped piece to which the tube bracket is attached, which bracket holds also the condenser, and the third insulator is used for the fuse. One side of the fuse goes to the chassis, and that is the reason why the metal box must be insulated.

### Completion of Shielding

The shielding would not be complete, however, if the insulated panel also were not backed with suitable foil, so copper is used. There are four corner brackets to the box, each bracket with a mounting hole in it. If the finish is scraped off one of the holes, and the scraped part is tinned with solder, using a quite-hot iron, the copper foil will make the conductive shielding connection when the self-tapping screw is tightly inserted in the hole in this one metal bracket of the box or cabinet.

This model has not the line blocked, therefore some radio-frequency energy from the test oscillator will get into the r-f level of the set, without any other coupling. However, for intermediate frequencies the output coupling has to be used.

A good way to use the test oscillator on a super is to short the local oscillator of the super when lining up for intermediate frequencies, while for broadcast frequencies open the short and uncouple the oscillator output and rely on coupling through the line, though if need be, for stronger output, the lead may be used for broadcast levels, too.

### Constantly Modulated

The Signal Generator uses a 30 tube. The oscillation is strong and there is always modulation present, if the leak is of the right value. Since the Signal Generator is useful on a.c. (any frequency), on line d.c. and on batteries, with source in any instance 90-120 volts, the a-c hum is the modulation on a-c uses due to a.c. on the plate, but for d-c uses (line d.c. and batteries) there would be no modulation, unless specially provided.

This is done by using a leak of a value that will introduce grid blocking. While 7.0-meg. is the specification, if there is no modulation on d-c uses, try a somewhat higher leak value. It may be that there will be modulation only over part of the tuning, whereupon use more grid condenser capacity or increase or decrease the leak value, depending on which method produces the result. Proper experimenting will yield infallible modulation if these suggestions are followed, for in production there never has been a model that did not modulate well on d.c. Moreover, the output is very strong, around 4 volts. If it is not desired to use the device on d.c. or batteries, use 0.5 meg. for the leak.

### Weighs Only 2½ Pounds

The test oscillator itself, in its metal or shield box, with tube included, weighs only about 2.5 lbs., and as it is very small it is just the thing to carry about. It has no output attenuator, and as stated the line is not blocked, nevertheless its usefulness for those engaged in home construction, and even professionally in none too remunerative service work, is of a high order, and the coil-condenser system can be adjusted to the scale to an accuracy of 2 per cent. without trouble, though in manufacture this is exceeded favorably.

Only one adjustment need be made to line up this oscillator and have this excellent tracking prevail. Tune in a broadcasting station on a set, around 760 kc., not much more or less, and divide the known frequency of the station by 2. Then turn the dial to read that number. Say the station is 760 kc., so the test oscillator fundamental to be aligned is 380 kc. Adjust the trimmer for zero beat and the work is done.

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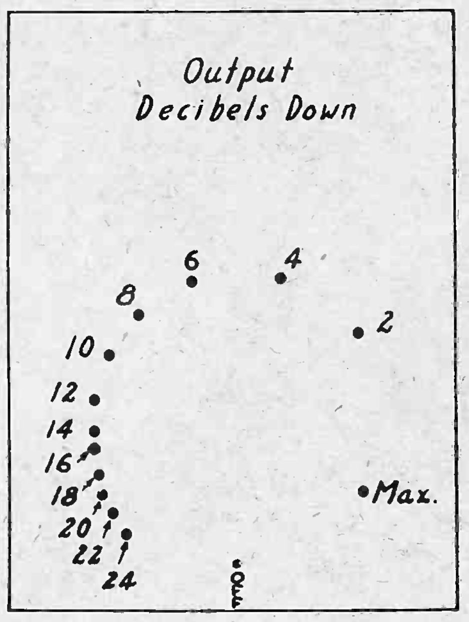
## NOTES OF THE STUDIOS

Bill Paisley, of the NBC music library, is getting quite a few good breaks on the air with his song, "Beautiful Dreams." Jimmy Melton sang it recently and declared he would do it again and again, he likes it so well. . . . The Landt Trio and White have a novel idea; they have organized what they call "The Worst Joke of the Week Club" and it meets every day during their broadcast at 9:15 a.m. EDST, over an NBC-WEAF network. They are hunting for bad gags; so if you have any, send them along. . . . Peter Dixon and his family are hard at it up in Bronxville, getting the new garden into shape. Whenever Pete is seen in New York these days his arms are full of shrubs, garden tools, seeds, et al. . . . Congratulations are in order for Powell Crosley, Jr., upon his magnificent achievement. He has realized his dream of a half-million watt transmitter. More power to you, Mr. Crosley, and this is not meant as a pun.

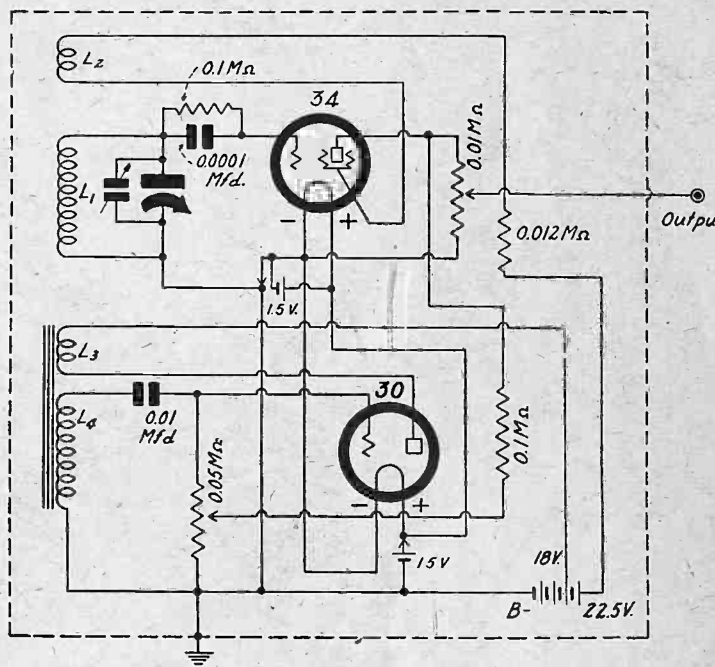
# "Decibels Down"

## The Calibration of Output of the Model 3430-S Signal Generator

*By Herman Bernard*




**Calibration for a straight resistance potentiometer in the output of the Model 3430-S Signal Generator. So long as the resistance is straight, that is, not tapered, the calibration holds for this instrument even if the resistance is much higher than the specified 10,000 ohms, for the decibel attenuation simply compares the levels of two powers.**




**The diagram of the Signal Generator, Model 3430-S.**

THE Signal Generator, Type 3430-S, described in the May 5th issue, was a battery-operated test oscillator for lining up intermediate and broadcast frequencies, using a 34 tube as r-f oscillator and a 30 tube as separate modulator, with the feedback from the screen of the 34, the conventional plate being used merely to take off the electron-coupled voltage. That is, the plate was connected to ground through a 10,000-ohm resistance, an arm sliding across the resistance constituting the attenuation. This potentiometer was of the "straight" resistance type, that is, no taper.

With these conditions in mind, the output attenuation in decibels is as shown in the drawing, which is a copy of the output attenuation plate of this test oscillator.

### Powers Compared

Assuming equal impedance and phase, the formula for obtaining the decibel attenuation, in view of the use with receivers wherein the power output is mainly concerned, is as follows:

$$-\text{DB} = 20 \log_{10}\left(\frac{\text{R1}}{\text{R2}}\right)$$

where R1 is 10,000 ohms and R2 is the resistance between arm and ground. Therefore the attenuation, decibels down, is merely on the basis of the resistance values, total power being constant. The power formula, as stated, is acceptable particularly because of the inclusion of electron coupling. Thus the impedances concerned are those of the pickup circuit (plate to ground) and the r-f oscillator screen circuit. It will be found that the frequency of generation is not varied no matter what the setting of the arm in the output, and this is confirmatory of constant impedance within the acceptance of that term, though a strictly constant impedance probably never exists anywhere.

### 0 to 24 DB Down

Therefore the attenuation is plotted in decibels down, from 0 to 24 decibels, in steps of 2 decibels, and the spreadout is excellent for the smaller values of attenuation, and pretty good even for the higher values.

The decibel rating comes in handy when one is testing a receiver. Suppose the selectivity curve is to be run. This may be plotted at various oscillator output values, from maximum almost to zero, though of course never completely to zero, as zero output means no input to the set. How wide the band is, therefore, for various values of attenuation, may be measured.

### Value of Decibel Rating

It is true that the absolute value of the signal generator output is not known, but if the oscillator is used at maximum output then at least the voltage is the same for all frequencies generated, due to frequency-stabilization, and the same for all equal orders of harmonics, though not the same of course for fundamentals as for harmonics, because harmonics are weaker than fundamentals. If the receiving system will respond to a fundamental and harmonics, the measurement may be made of the fundamental and of every harmonic of the test oscillator to which the all-wave receiver does respond, and to this extent the relative intensities of the harmonics, compared to the fundamental and to one another, may be determined.

### Zero-Beat Accuracy 0.25%

Besides the output attenuation in decibels, the percentage modulation may be plotted, as is done in the commercial model. This serves a relative purpose, too, but is not quite so accurate at the output attenuation calibration, due to the strong modulation voltage, compared to the r-f oscillation voltage, although of course the r-f output even with no modulation is sufficient for all testing purposes likely to arise in service work or advanced radio experimenting and study.

The advantage of being able to remove the modulation completely enables very accurate checking by the beating method, because the zero beats are establishable to an accuracy of better than 0.25 per cent.

# Coupling Affects Resistance of Transformer Primary

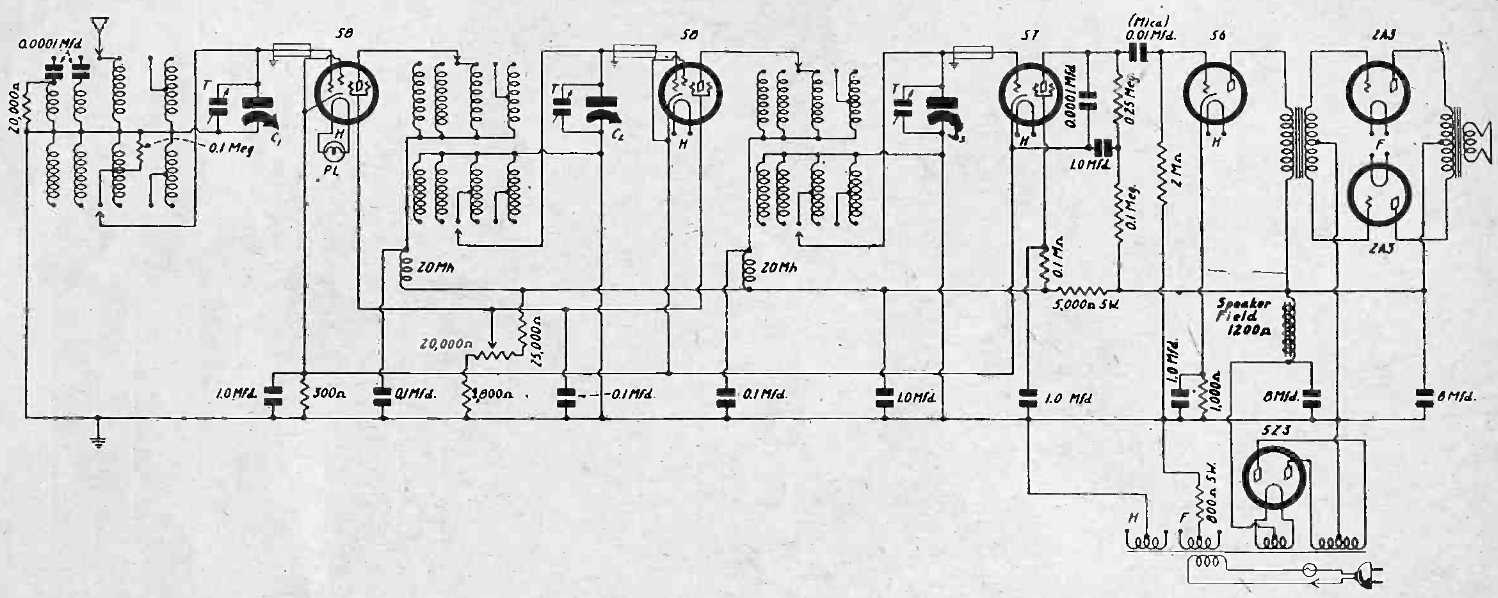
Is the resistance of the primary of a transformer in any way affected by the coupling between the primary and the secondary and by the resistance in the secondary circuit? If the primary has an appreciable reactance, is this increased or decreased by the secondary?

The resistance of the primary is augmented by the coupling and the resistance in the secondary. The increment is proportional to the square of the mutual impedance, inversely proportional to the square of the secondary impedance, and directly proportional to the secondary resistance. If the secondary is tuned to the signal frequency, the resistance increment is proportional to the square of the coefficient of coupling, directly proportional to the primary inductance, inversely to the capacity in the secondary, and inversely proportional to the secondary resistance. Thus the lower the secondary resistance, the higher is the primary resistance at resonance of the secondary. The reactance of the primary may be either increased or decreased by the secondary, depending on which side of resonance the impressed frequency is. At resonance there is no change.

# A Laboratory Set

## Covering 50 kc to 4,000 kc for Listening and for Wavemeter Work

### *By Clarence L. Osgood*




**A tuned-radio-frequency receiver that covers from 50 kc. to higher than 4,000 kc. The broadcast-band coils are shielded, but the next highest frequency band is tuned with the aid of part of the broadcast-band secondary, so this is shielded, too. The other coils are not shielded. The circuit is useful not only for listening but also for test oscillator calibration.**

THOSE experimenters who build test oscillators and also who engage on all-wave construction, including lower frequencies than those normally found in commercial sets, will find a tuned-radio-frequency set extremely handy, if it covers a wide range of frequencies, say, from 50 to 4,000 kc. If there are two stages of t.r.f. it is not practical to go much higher, unless elaborate precautions are taken. Besides, for most constructional work done on commercial chasses, there would scarcely be room for the rest of the coils and other apparatus. The purpose is mainly to have a source of measuring low frequencies.

A tuned-radio-frequency set is the only thing for the purpose. A superheterodyne would prove baffling, due to multiple responses, often met under circumstances when it becomes almost impossible to tell what is the frequency one is "measuring."

The circuit shown was built, using a six-pole, five-throw switch, the smallest coils, extreme left in each instance, not having been included that way, but being used as tapped broadcast secondaries. A seven-tube commercial t-r-f set of old vintage, but good performance, was taken apart, so that the wide coverage could be introduced.

This set had shielded broadcast coils on a shelf, below the tuning condenser, inside the chassis, but the coils were removed, and since their shields were large enough, the smaller shields containing new commercial coils were inserted instead. Since the condenser was 0.00035 mfd. four-gang, coils for 0.00035 mfd. were used, but only three of them, as the original set had a so-called band-pass filter input that did more filtering in the rejectional direction than in the acceptional direction. The new commercial coils were tapped for the police bands, so the coil system was simplified to that extent, except that the primaries were a bit too large for this band in a t-r-f set, and a resistor of 0.1 meg. had to be put across tap to ground on the first coil so there would be no oscillation at the higher frequencies of the band above broadcasting. Only three sections of the condenser gang were used.

The same tapping principle was worked at the lower frequencies, using a commercial honeycomb coil of 1,300 turns, tapped at 500 turns. The tap is in exactly the right place for overlap. The low-frequency tuning, with the full secondary inductance of 25 millihenries, was from 50 kc. to 140 kc., while the next band was from 130 kc. to 364 kc.

#### Low-Frequency Coil

Since the broadcast band starts at 540 kc., there was necessity for an intermediate band here, say, 364 to 550 kc., but the frequency ratio of 2.8-to-1, prevailing in the other instances, would prevail here, and there would be extra overlap, say, 540 to around 1,000 kc. in the broadcast band being included, but that doesn't harm any, either, and double checking of broadcast frequencies from 540 to 1,000 kc. becomes possible, and at opposite portions of the tuning capacity, thus rendering certain frequencies much more easily read.

The low-frequency coil is a single tapped winding, of about 1 inch outside diameter, but has no primary, but any small r-f choke of a few hundred turns will serve as primary, separated from the secondary about 1 inch or so. Chokes of 200, 300 or 400 turns are suitable. If the chokes are wound on an insulating dowel, usually putting them on a plane facing each other results in the dowel affording good coupling distance. The insulating material is roughened at the end with a file, and then cementing or gluing becomes practical. Besides, if stiff wire is used, such as No. 18, or regular busbar, the connections to the circuit will add further to the rigidity, and there will be no danger of the coils becoming displaced.

Since there is to be multiple switching it is not practical to connect any coil permanently to the grid and slide the stator, but the grid and tuning condenser have to be slid to the desired connections on different windings. Thus, for the low-frequency band just mentioned, the few-hundred turn primary is in the circuit, and the full secondary inductance is tuned. For the next band, 130 kc. up, the larger part of the secondary is left disconnected and the grid and condenser pick up the tap. Still, the same primary is used as in the first instance, and that is the reason this primary should not be very large, compared to the secondary, or too closely coupled.

#### Broadcast Band

The coils for the next band, to take in the gap between low frequencies and broadcasts, and include a good part of the broadcast band as well, have to be prepared by the constructor, but 200-turn honeycomb coil secondaries, with 50 to 75-turn primaries, also honeycombs, put on as for the lowest-frequency band, will serve the purpose nicely, or even a transformer from an old intermediate coil of 400 to 500 kc. rating may be used, with condensers removed of course. Then the turns ratio would be 1 to 1, as primary and secondary were tuned in the coil, but because of this double tuning the coupling distance was large, and as primary now will not be tuned, in this instance the 1-to-1 transformer may be used. This extra transformer for each stage is not shown in order on the diagram, but the extreme left-band coil may be sandwiched in here for the purpose.

The broadcast-band coil is standard, except for the tap that allows coverage also from about 1,500 to 4,000 kc. It so happens that considerable trimmer capacity was used, but the constructor need not follow just that course, and using less such capacity can get a ratio up to about 3-to-1, which would change the figures previously given. The low-frequency coil will strike 50 kc. even with the 3-to-1 ratio. Then the tuning would be 50 to 150 kc., 140 to 420 kc., for this tapped coil, with only a small gap to close up, 420 to 540 kc., for the next band, but the overlap being used as found, while the broadcast band would be 540 to 1,620 kc., and the last band 1,600 to 4,800 kc.

### Calibration

When the circuit is built it has to be calibrated, and perhaps the easiest way is to calibrate the broadcast band first, because stations of known frequency are readily brought in. This work is done with as good a numerical dial as you can get, and as many points as possible are registered. There are six calibrations to be made. So get six pieces of plotting paper, as large as practical, squares of ten preferably, and on the bottom write in the dial numbers, 0 to 100, either direction, and up and down write in frequencies 1,700 to 500 kc., either direction. This should be done so that one line is not more than 10 kc. removed from either adjoining line, or 120 lines up and down would be required. Across there would be one line for each dial division, so of course, 100 lines would be needed, and the used part of the paper is approximately square. Actually the paper purchased may not be, but there should be enough to spare, so that the preceding division advice may be followed.

Say that twenty well-distributed points are obtained. These are recorded with a hard pencil as fine dots. It is obvious that the result will be a curve, if a line is drawn through the dots. This line should not be put in until as many as possible points are obtained, and if there is any difficulty in the high-frequency region of the broadcast band, a broadcast-band test oscillator should be built, and adjusted to several low frequencies, say, 570, 660, 710 kc., etc., using stations and beats, and second harmonics used for locating 1,040, 1,320, 1,420 kc., etc.

Thus, one broadcast-band chart is prepared for drawing the curve. When the points are sufficiently numerous and well distributed, a piece of soft uncored solder is bent the shape of the curve, or bent the shape of a part of the curve at a time, and a hard pencil used for actually drawing the line, with the solder as ruling edge. When the line is completed in hard pencil it is carefully inked in, using preferably India ink, a very fine pen-point and a light touch.

### The Other Bands

Now the other charts are prepared the same way, except that the curves are tentative and not inked in. However, the shape of the curve will not be any different, except to a trivial extent later on, and that will take care of itself, as will be explained.

The next lower frequency band starts highest from around 1,000 kc., and since a good part of the broadcast band is included, the lightly-pencilled frequencies at the sides, representing broadcasts, and put in because necessary to duplicate the first or broadcast curve are erased in favor of the newly-determined values. When the band is covered as far as 540 kc. the rest of the curve may be taken as following the broadcast band curve, and all that is necessary is to write in the frequencies. Where they were 1,700, 1,600 kc., etc., for squares of ten they would become approximately 1,000, 900 kc., etc. The appropriation is merely in the light of the discussion, and does not apply to the actual result, since the result will be obtained experimentally, and will be accurate.

The factor that might change the curve a little will now enter, and applies to the next pair of frequencies, somewhat to the smaller part of the secondary of the low-frequency coil, more so to the full inductance of that secondary. The reason is that honeycomb coils have a smaller distributed capacity, the greater the number of turns, due to the capacities of the turns being in series, and so to a small extent the curve shape at the higher frequencies of each of these two bands may depart just a little from what has been recorded. No particular attention need be made to this for first-approximation calibration of these two bands, and the tentative curves may be prepared in pencil on the basis of the broadcast curve, since a few check-ups will rectify the curve.

### Using Beats

Now, since the frequency ranges have been stated, that is, 50 to 150 kc., and 140 to 420 kc., and the curve shape is known, only one frequency need be spotted, and the rest will follow the curve, at least to a close approximation. If one has a low-frequency oscillator, one may use a broadcast set and beat an oscillator harmonic with a broadcast station fundamental, and spot many points, especially if the test oscillator is direct-reading. Such an oscillator, for instance, might be the 30-N, as described elsewhere in this issue, which has fundamentals of 135 to 380 kc. In that case, for accuracy check. divide the broadcast station frequency by 4 and beat the test oscillator's fourth harmonic with the station fundamental, putting the beat into the set you have just built.

The band higher than the broadcast band is most readily calibrated by using harmonics of a broadcast band oscillator, but again, as the tuning curve is known, and the approximate identities of extreme frequencies from the text (for a 3-to-1 ratio, 1,600 to 4,800 kc.), the work is greatly simplified. Getting a single police station of known frequency will give an excellent first-approximation. Other checks may be made along the line.

This would complete the calibration, and if it is all right with you, the numerical dial may be retained, and the charts referred to, or, by protraction, a large-scale dial on which india ink takes, may be used, and the frequencies actually written in, waterproof ink being used, so that differently colored washes may be put on to identify the six bands, and the switch points colored accordingly, or the six colored washes may be put on first. Thus, whenever the switch is set at any given position, the pointer indicates the color, and the frequencies are read on the scale that has on it a wash of the same color.

Now that the set is completed and calibrated, what is one to do with it? Well, first of all, it is a receiver, and it will respond to the calibrated frequencies. If it did nothing else that would be sufficient.

Now, suppose you build a test oscillator for low frequencies. It is always rather difficult to spot the frequencies properly, but the present receiver is used for that purpose as follows: The test oscillator is set at maximum capacity, and coupled to the receiver input, the set being tuned starting at lowest frequency, then switching, starting again at the lowest frequency, if need be switching again, until the first response is heard. The frequency read is the fundamental of the test oscillator's lowest frequency. Then keep going after the test oscillator is put at its highest frequency. Now that is found exactly the same way. As in both instances one can start low enough in frequency, no harmonic confusion is possible, unless the test oscillator fundamental is less than 50 kc., which is extremely unlikely.

An output meter may be used as a resonance indicator, if the test oscillators are modulated, otherwise a tuning meter somewhere in the tuner proper, even in the detector circuit, would be applicable, and add just that much more advantage to the use of the set as a wavemeter.

# STATION SPARKS

## BY ALICE REMSEN

FRANK BLACK is directing the new springtime series of symphony broadcasts, heard each Saturday at 3:30 p.m. over an NBC-WEAF network. Noted soloists appear in support of Mr. Black. . . . Captain Henry's sister Maria is going to have a matinee series of her own which will bring many of the stars of Captain Henry's Maxwell House Showboat troupe to afternoon listeners over an NBC-WEAF coast-to-coast network, beginning Friday, May 18th, at 3:00 p.m. Maria's Certo Matinee, as it will be known, will be on the air for a full hour each Friday under the sponsorship of General Foods Corporation. . . . Paul Whiteman has brought a new masked mystery singer to the air, a baritone, heard with Whiteman every Thursday, at 10:00 p.m. EDST, over NBC-WEAF. . . . There is a new Love Story program on WJZ each Wednesday at 9:30 p.m. Celebrated screen stars are heard in these dramatizations.

Ernest Cutting's "Airbreaks" program has discovered another singer in the person of Mary Phillips, who has been given a regular spot of her own, each Thursday at noon, over WJZ and network. . . . A bevy of radio stars support Max Baer on his Goodrich Rubber Company program over WJZ and network, three times weekly. They are lucky folk, for Baer is training at Asbury Park, and the artists will live there for at least six weeks, as the programs will be broadcast from that resort. . . . Jan Rubini is the master of ceremonies and orchestra leader of the new Hollywood-on-the-Air series, which is presented every Sunday night from the film capital, over an NBC-WEAF network, from 12:15 to 1:00 a.m. EDST. . . . It is good news that the famous "Headline Hunter," Floyd Gibbons, will be back with us again on a series of broadcasts for the Johns-Manville Corporation, commencing May 12th, over a nationwide NBC-WEAF network, at 7:30 p.m.; there will be an orchestra on these half-hour broadcasts, under the direction of Nat Shilkret. . . . Morton Gould is at last receiving some recgonition for his clever piano improvisations. No less a person than John Erskine, the noted novelist-musician, has given Gould a chance to demonstrate his remarkable talent. . . . Ed Lowry, popular vaudeville, singer, comedian and master of ceremonies, is now doing a regular radio series on Thursdays at 7:15 p.m. over WJZ and network. He is also heard as the master of ceremonies on the Kaleidoscope program each Sunday at 8:00 p.m. over the same station. . . . Edwin Franko Goldman and his band return to the air via NBC late in June.

The Ford Motor Company dealers have renewed their contract with the Columbia Broadcasting System, and will continue to present Fred Waring and his Pennsylvanians each Thursday and Sunday at 9:30 p.m. EDST. . . . Summer concerts will be broadcast over the Columbia System by musicians of the Philadelphia Orchestra from Robin Hood Dell in Fairmont Park, Philadelphia, beginning early in July and continuing through August. . . . Singin' Sam (Harry Frankel), is now a happy married man. He was united to Helen "Smiles" Davis, well-known vaudeville artist, on May 3rd, in his home town of Richmond, Indiana. Good luck, Smiles and Harry! You deserve to be happy! . . . Glenn Rowell, the "Glenn" of Gene and Glenn, and Helen Strubel, of Cincinnati, Ohio, were married recently. Loads of happiness to you both, also! . . . Ray Heatherton comes to the studios tanned from tennis.

# 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.***

### Air Gap in Transformers

IN NEARLY ALL transformers utilizing iron cores there is an air gap. What is the function of the air gap? It seems to me that it merely reduces the effectiveness of the transformer.—W. R. J.

The purpose of the air gap is to prevent saturation of the core. Yes, it does reduce the effectiveness of the transformer for very small loads but it makes the transformer practical.

* * *

### A Station Monitor

WHAT IS THE MEANING of a station monitor? Does every station have one, including amateurs' stations?—O. L.

Sometimes a monitor is a frequency-checking device which every station has. Sometimes it is the modulation checking device. All broadcast stations have one. Sometimes the monitor is the man who watches the modulation. For several years the government maintained a monitor station at Grand Island, Neb., at which the frequency of any station in the world could be measured. The station was used primarily for checking the frequencies of stations under the control of the Federal Radio Commission.

* * *

### Physical Dimensions

YOU HAVE STATED that resistance has the dimensions of velocity. Will you kindly explain what you mean by dimensions of such a dimensionless concept as resistance? Incidentally, do reactance and impedance also have the dimensions of a velocity?—W. E. J.

In physics there are three fundamental concepts: mass, length, and time. These are represented by the letters M, L, and T. These are called the physical dimensions and every physical quantity can be expressed in terms of them. The main use for these dimensions is to check the accuracy of formulas. If an expression has been worked out for a certain quantity and if the dimensions of the expression are not the same as the dimensions of the quantity, we know for certain that we have made an error. The dimensions are also very convenient for checking during the progress of analytical work. If, for example, we have a complex expression of many terms, and one term does not have the same dimensions as the other terms, we know that the term is wrong, and it is necessary to check back to trace the error. In doing this it is not necessary to reduce to the fundamental dimensions of M, L, and T, but we can simply note that every term is the same power of some quantity, say, that every term is the cube of a resistance, or the square root of a volume, or some other combination. In making the checks it is often necessary to know the fundamental dimensions of quantities in order to recognize the terms. For example, suppose one term in a formula is L/C and another term is $R^2$, L being inductance, C capacity, and R resistance, all measured in the electromagnetic system of units. Is the formula consistent so far? If we know that L/C is the square of a resistance we do not have to go any further. If we do not know that but if we do know that R has the dimensions of a velocity, we have to convince ourselves that L/C is the square of a velocity. In the fundamental dimensions we have to show that L/C can be expressed as $L^2T^{-2}$, which expresses the dimensions of a velocity squared. This is easily done with the aid of the frequency formula $F^2=0.0253/LC$, remembering that F has the dimension $T^{-1}$ and L has the dimension L. We need only eliminate C. Pure numbers such as 0.0253 can be thrown out for they do not affect the dimensions. Yes, impedance and reactance also have the dimensions of a velocity if they are measured in the electromagnetic system of units. Therefore, in formulas if one term is made up of impedance squared, say, another of resistance squared, and still another of L/C, the terms are consistent.

* * *

### Reception on Harmonics

EVERY OSCILLATOR generates harmonics and plenty of them. Yet we cannot often pick up broadcast stations on the harmonics no matter how sensitive the receiver. Can you explain these facts?—W. E. L.

Yes, every oscillator generates harmonics but not many transmitters transmit harmonics. There are means for suppressing the harmonics generated by the tubes. But suppression of all the harmonics except the fundamental is no assurance that the signal will not be received on one of the higher harmonics. Just as every oscillator generates harmonics so does every amplifier tube generate them, and after the first tube in any set they are present. Hence, they can be selected from the many different frequencies present and amplified until they are strong enough to make themselves heard in the loudspeaker.

* * *

### Response Crevasses

WHAT IS THE meaning of a response crevasse in relation to a quartz crystal?—B. B.

Suppose a simple wavemeter circuit consisting of a coil, a condenser, and a thermo-milliammeter is hooked up and a resonance curve taken by varying the frequency impressed on the circuit. That curve will have the regular shape, rising to a maximum at resonance. Now suppose that a quartz crystal be connected across the tuned circuit, say across the condenser, and another resonance curve is taken. The shape of the curve will not be the same as before, but there will be a dip in it, assuming that the natural frequency of the crystal resonator is about the same as that of the coil-condenser circuit. That dip is the response crevasse of the crystal. In order to detect the dip it is necessary to vary the frequency very slowly by means of a vernier condenser for otherwise it will be missed entirely. The crevasse is the inverted resonance curve of the crystal and it is superposed on the resonance curve of the electrical circuit. The selectivity of the crystal is so great that the entire crevasse will not cover more than a few cycles. The Q of the crystal, that is, the ratio of the inductive reactance to the resistance, may be as high as 30,000. A very good radio frequency circuit composed of a coil and a condenser may have a Q of 250 but more likely it will have a Q of only 125. The selectivity is a measure of the stability of an oscillator when the resonator is used to control the frequency.

* * *

### Resistance Wire

OF THE MANY different resistance wire alloys, which is the most suitable for heating elements; which is the most suitable for voltage multipliers and current shunts? What properties should be taken into consideration when a coice is made?—W. E. J.

It is customary to use Nichrome wire for resistance elements, because it has a very high resistivity and it will also stand fairly high temperatures. For current shunts and multipliers it is customary to use manganin because this does not change appreciably as the temperature changes. It is also used for resistance standards, and for the same reason. Still another reason why manganin is used for standards is that it has a low thermal electro-motive force against copper. There are many considerations when selecting resistance wire, and for that reason there are also many different resistance wire alloys. Some must resist high temperatures, some must resist oxidation, some must have low thermal electro-motive force against copper or other good conductors, others must have a low temperature coefficient of resistance, and some simply must be cheap.

* * *

### Half-Wave or Full-Wave Detection

IS THERE ANY marked advantage in using full-wave detection over half-wave detection? That is, is the detection more efficient, or is the quality better, or is it easier to filter the output of the detector?—E. J. L.

There is very little difference between half-wave and full-wave detection. The problem of filtering does not enter for the ripple is at radio frequency and could not possibly interfere with reception. As far as efficiency is concerned the advantage is with half-wave detection, if by efficiency we mean the greatest output for a given signal voltage input. There is no difference in quality. If there is any reason for using the two anodes in the detector tube like the 55 for two different purposes, such as detection and a.v.c., it is better to separate the functions and using one anode for each than to combine the two just to have full-wave detection.

* * *

### Range of Tones

WHAT ARE THE frequency ranges of the various musical instruments and the human voice? Is there any instrument that goes higher than 5,000 cycles per second?—H. L.

The organ goes as low as 16 cycles per second and as high as 16,000 cycles, that is, some organs do. Most adult people cannot even hear 16,000 cycles per second. The piano goes up to around 5,000 cycles and slightly over and it goes down to about 30 cycles. A bass viol goes to about 40 cycles and a piccolo up to about 4,500 cycles. A basso goes as low as 80 cycles per second and a soprano as high as 1,100 cycles.

* * *

### Output Filter

SUPPOSE we have a radio receiver with a single 2A3 in the output stage and we wish to arrange the circuit so that there is the least possible feedback to cause motorboating or suppression of the low notes. How should the output circuit be arranged, assuming that we have an output transformer between the tube and the loudspeaker?—W. G.

First connect the primary of the output transformer in series with a condenser of not less than 8 mfd. and then connect unused terminal of the condenser to the plate of the tube and the unused side of the primary to the filament of the tube. The best place to connect is to the center of the 2.5 volt winding that serves the filament or to the center of the resistor used across the filament for the purpose of balancing the circuit. The point is that the primary should be returned to the source of electrons. The plate should be fed through a high inductance choke, and this choke should be built on generous proportions so that there will not be much drop in the inductance due to the plate current. This arrangement is effective because the a-c current will flow through the primary and the condenser directly to the filament and thus will not have a chance to stray into the supply circuit. Also, the high inductance choke will prevent any signal current from entering the plate supply directly.

* * *

### Production of Radio Harmonics

WILL you kindly state what are the best circuits for the production of radio-frequency harmonics of high value and of considerable intensity? I should like to go as high as the 1,000th harmonic if possible with a fundamental of 10,000 cycles.—T. L. K.

Perhaps the best of the harmonic generators is the multivibrator, which requires two tubes to produce oscillation. It is especially suitable when the fundamental is low. There are many single-tube oscillators which generate strong harmonics provided that the tickler is large and the ratio of L/C in the tuned circuit is high. Make the circuit oscillate violently and there will be plenty of harmonics.

* * *

### Wave Traps

IS IT possible by means of wave traps to tune out all stations except the one desired? To tune out only one but do it completely? If so, please explain how it may be done?—T. M.

There are two ways of tuning out one station almost completely and then permit the reception of any one other station. One is to connect a series-tuned circuit between the antenna and ground, across the primary of the input transformer, and then tune this circuit to the frequency that is to be suppressed. If the series tuned circuit is provided with a variable condenser it can be tuned to any desired frequency and thus any interfering frequency can be eliminated. The other way is to connect a parallel tuned circuit in series with the antenna and to tune that to the frequency that is to be suppressed. A combination of these two methods is to couple the trap circuit inductively to a small coil in the antenna circuit. In this case the condenser and the coil of the trap are in series and the circuit is closed. The method of eliminating all frequencies but one is to connect a parallel resonant circuit from the antenna to ground across the input to the receiver. This trap must be tuned to the frequency that is desired, for only the frequency to which the circuit is tuned will be transmitted.

* * *

### Matching R-F Impedances

IF a parallel tuned circuit has too much resistance to match the internal resistance of a tube, what can be done to effect a matching without using a transformer? I presume there is a way.—F. R. G.

If the plate is connected to a tap on the coil and if this tap is placed at a suitable point, a match can be effected. This tapping in effect makes the coupler an auto-transformer. This method is nearly always used in transmitting circuits. Not only is the plate lead moved but even the B supply lead is moved. The proper match can be effected by moving either lead. The same method of matching is employed in crystal oscillators.

* * *

### Suppressed Carrier

SOME ONE TOLD ME that it is possible to transmit with carrier suppressed, and that the method is more efficient than sending out the carrier and sidebands. Will you please explain what suppressed-carrier transmission is, and if the efficiency of one method is greater than that of the other, why this is true?—J. S. C.

The suppression of the carrier is a well-known method, but is not practiced much. A television station in the West has been using this method, and in some commercial uses, in connection with message transmission, particularly keying, the same stunt is worked. The situation is best illustrated in connection with a single tone. Suppose the carrier is 1,000 kc and the modulating tone is 1,000 cycles. Then the upper sideband will be 1,001 kc and the lower sideband 999 kc. The transmission may be considered as that of three frequencies simultaneously sent, the carrier and the two sidebands. Now, if a filter is inserted in the transmitter, the 1,000 kc carrier may be eliminated, and two radio frequencies separated by 2,000 cycles are sent out, e.g., 999 and 1,001 kc. Since the receiver now is not required to get rid of the carrier, the power of which is a waste, the efficiency of the suppressed-carrier method is much greater. Besides the carrier-suppression method, there is also a sideband-suppression method, where either sideband is eliminated in favor of the other, and perhaps the carrier to boot is ruled out. The close filters in short-wave supers for telegraphic reception pass such a narrow band that one sideband is wiped out and much of the other, as well as the intermediate-frequency carrier.

### Getters

ON WHAT principle do getters in tube manufacture operate? I understand that certain metals are used for the purpose, but I do not see how metals can remove any gas from a tube.—W. K. L.

The metals used for getting the last trace of gas in a vacuum tube are magnesium, sodium, and caseium, all of which are easily volatilized. A very small piece of one of these metals is placed inside the envelope to be evacuated. When the evacuation has proceeded as far as it can with pumps, the tube is heated until the getter metal is volatilized. When the tube cools the metal condenses on the walls of the envelope. The freshly deposited metal has the property of absorbing the gas that remains in the tube.

* * *

### Free and Forced Oscillations

WILL you kindly explain the difference between free and forced oscillations in a circuit? Are the oscillations in a radio circuit free or forced?—W. H. C.

Let us illustrate the difference with the pendulum. Suppose we take the bob and pull it to one side and then let it go. It will swing for a while. These oscillations will be free. But suppose we move the pendulum back and forth by force at the same or at approximately the same rate as it moved when free. The oscillations are then forced. A circuit consisting of a coil and a condenser can swing freely after having been shocked or it may be forced to move by an electro-motive force in the circuit. The swinging, whether free or forced, consists of back and forth movement of electric quantity and of periodic changes in voltage. Oscillations in a radio circuit may be either force or free. In a receiving circuit they are usually forced by the incoming signal. We may possibly say that the oscillations in a vacuum tube oscillator are free although in one sense they are forced. They do not change in amplitude because energy is continually being supplied. In this sense they are forced. But they continue without any external electromotive force. In this sense they are free. If a condenser is charged to a high potential and an inductance coil is suddenly connected across that condenser, free oscillations will occur in the circuit formed by the coil and the condenser, and they will persist for a period depending on the total resistance in the circuit. The less the resistance the longer the oscillations will persist. Theoretically the oscillations will persist an infinite time but practically they will die down in a very short time. They can be said to have ceased when we no longer can detect them.

* * *

### Audio Filament Voltage

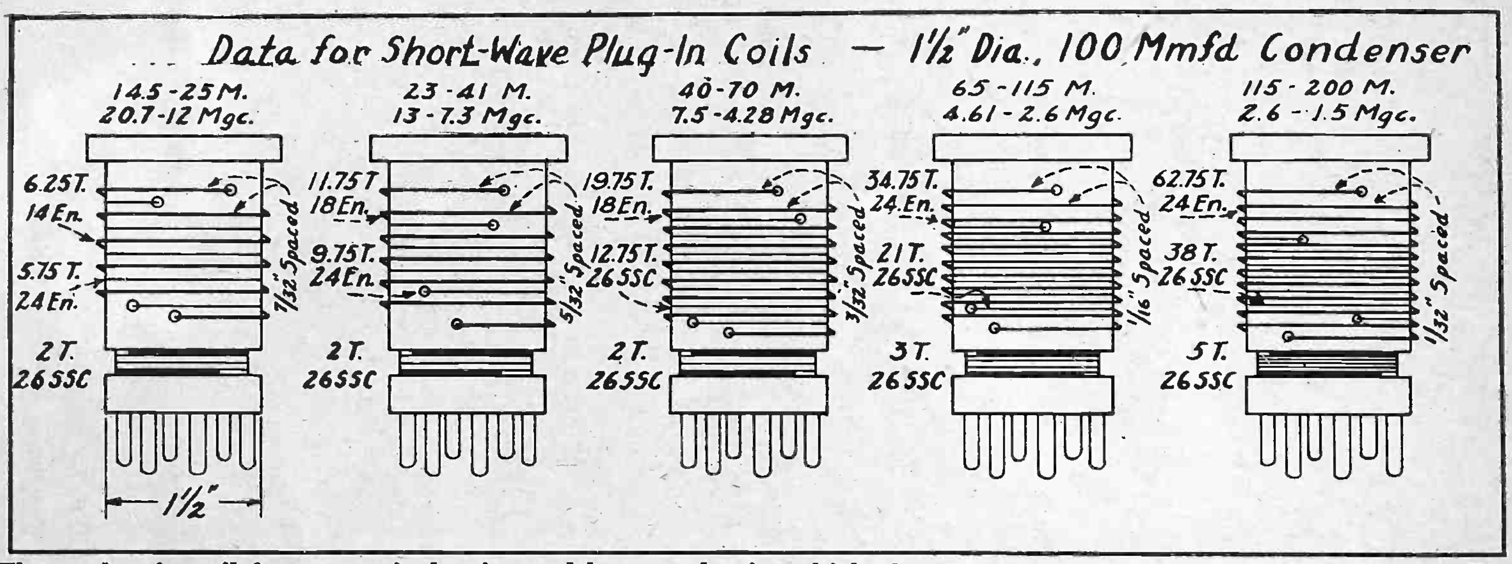
IS IT GOOD PRACTICE to have a rheostat volume control in a battery set change the filament voltage of the detector and the first audio tube at the same time?—K. H.

This practice prevails in some of the lesser important circuits, and while not particularly harmful, is not considered highly acceptable. The filament voltage on the audio tube preferably should not be changed. The method you describe is one that arises principally from economic considerations.

# Short-Wave Coils

## How to Wind Them—Numbers of Turns, Spacing, Wire Sizes, Frequencies Covered with Standard Capacities—Some Chatter on the Forms

### *By Jack Tully*




**These plug-in coil forms are isolantite and have a slot in which the primary is close-wound. Gripping handles are affixed to the top. The form diameter is 1½ inches. If all windings are put on in the same direction the polarities are as marked on the end coil at left. The frequencies covered with 140 mmfd. tuning condenser, as well as the equivalent wavelengths, are imprinted on top of each coil diagram. The abreviation "TPI" means the number of turns per inch used in the winding to accomplish the spacing. The object of using spacing is to reduce the "distributed capacity," and thus slightly to increase the frequency ratio of tuning, compared to what it would be. For three-winding style of coil a tickler is necessary and a six-pin instead of a four-pin base. The ticklers may be wound of any fine wire, located between secondary turns and consisting of one-third the secondary turns for the two coils at right and one-half of the secondary turns for the two coils at left, polarities same as for primary.**

A GREAT number of short-wave enthusiasts and experimenters like to wind their own coils. In general, the coil forms are approximately 1¼, 1½ or 1-9/16 inches effective diameter, the exception being tube-base variety of forms, where there are two sizes, approximately 1⅛ and 1⅜ inches. The tube-base forms are used only in the cheapest efforts, and as the regular coil forms cost little enough, and often have a gripping flange which is indeed handy, the coil-winding data given pictorially herewith apply to the standard forms.

For lower cost the run of moulded insulating material is used, but for a more effective coil special forms are used. These are grouped into high-grade porcelain, sold under various trade names but identified by whiteness, and special insulating materials, otherwise iron-content, from which the iron has been removed. In the ordinary powder used for moulding there is a sufficient iron content, as well as some other none too acceptable ingredients, to affect the coil somewhat, though not enough to deter anybody from building a short-wave set who hasn't the price of the better-grade forms.

### Changes Avoided

There are several requirements to which the coil form is put if it is to be of the highest-possible performance. After the material is moulded, or at least after it has gone through the cooling process, it should stay put. Some moulded products do not follow that requirement. They turn out to be a different diameter finally than the one to which they were moulded. If change is not repeated this is not serious, as some aging will establish the forms satisfactorily, but some of the materials have been noted to change appreciably over a period of years, therefore if there has been any serious calibrating done, the calibration gradually is destroyed.

The absence of iron and other objectionable ingredients from the coil form also improves the coil efficiency, hence fewer turns will produce oscillation. This is merely another way of stating that the radio-frequency resistance will be lower. The coil will have a better selectivity factor. Also, if the iron is present but the quantity is not uniform, and it may not be, the inductance will differ, as the more iron the greater the inductance for a given number of turns, and as the iron causes hysteresis losses, the radio-frequency resistance again finds an excuse to increase.

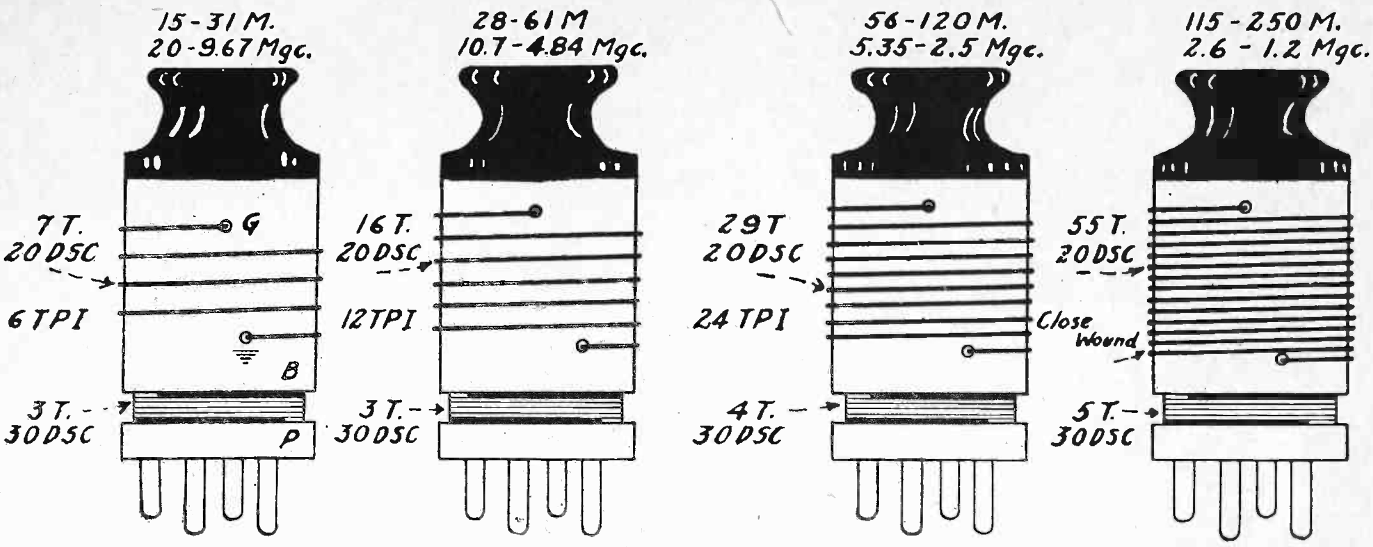
### Other Aspects

Another aspect of shrinkage or enlargement of the form after moulding, especially over a long period, that is, if the change endures, is that the inductance can not be rated on the basis of a given number of turns of a stated size and insulation of wire, close-wound or specifically spaced, on a certain diameter. The diameter, you see, is uncertain. Therefore, the inductance is not the same for an intended identical run. A standard would hold if the diameter were measured each time, but that is not done. It would cost more than original use of a better moulding compound.

The form should have other protective aspects for best results and, moreover, for uniform results. Again we consider the better class of service, the stiffer requirement, rather than just tuning in stations on coils such as we can conveniently make up. Boys experimenting with short waves need not bother about the high-grade coils forms, and parents will thank them for the indifference. If dad has plenty of money even the boy may try his hand at the better-grade materials. But no fun should be missed simply because one wants precision or nothing. Something is better than nothing, and many foreign stations will come in nevertheless.

### The Word Is "Non-Hygroscopic"

Still, we like to find out some facts about coil forms. They should not stretch or shrink, either as part of the post-moulding process or due to temperature. If temperature affects them much, then the inductance may change, and calibrations be upset. Also, when the forms are critical to temperature they also usually are pretty good in their sponge capacity, that is, they retain moisture. They do this really on a small scale indeed, but the moisture changes the nature of the dielectric, and thus changes the inductance, as well as increasing the radio-frequency resistance. The direct-current resistance, of course, does not change, except as due to the effect of current in, through or about the wire, i.e., heating.




**The diameter of the above coil forms is 1½ inches.**

This condition of not being subject to absorption, not being spongey, is called non-hygroscopy. So a coil that does not seriously take in moisture is non-hygroscopic. The word is not "non-hydroscopic," even though "hydro" does refer to water and maybe it would have saved a great deal of typographical errata or what have you had it been what it is not.

### About Fine Wire

As to the wire, it should not be very fine for the higher frequencies, and in general ought to be as large in diameter as is handy. For the run of coil forms there is no necessity for using larger than No. 18 wire for the highest frequencies, unless one goes beyond the normal limit, and dips down to or below 9 meters, whereupon No. 16 or even No. 14 wire may be used, provided you have the means of winding it tightly. This usually requires a machine, as men are not as strong as they used to be, and the torque for such winding of large wire on small diameter is considerable.

There is sometimes a word of caution expressed about using large diameter wire at all for high frequencies, because the eddy current losses are high. To be sure there are eddy-current losses, and what are you going to do about them? The main thing to consider, however, is that at very high frequencies the current flows not through the center or core of the wire, but on the outside,

*(Continued on next page)*

# How to Hook Up Short-Wave Coils

Practically the only way to use the two-winding coils for regenerative detection is to have the larger winding, or secondary, in the grid circuit, and the smaller winding, or primary, in the plate circuit, used as tickler.

Then the circuit is an oscillator. The tickler inductance and coupling are so selected that there will be oscillation at any and all settings of the tuning condenser that is put across the secondary. Some sort of control is then introduced whereby the tube may be operated anywhere between oscillation, which is a condition of generation of radio waves, and complete stoppage of oscillation. Neither of these extremes is valuable for a detector circuit, for under neither conditions can much, if anything, be heard. Oscillation spoils the reception, even unto making the program unrecognizable, and total absence of any feedback makes the circuit broad and insensitive.

### Most Sensitivity

The condition for oscillation is that the feedback be in phase, or positive. This condition will obtain when windings are in the same direction but opposing terminals are connected to equivalent potentials, i.e., plate and aerial, and B plus and ground, are equivalent. Reverse the external connections to either winding if no feedback is obtained. That is, the current in the grid circuit and the current in the plate circuit must be working together, assisting and not resisting. If the feedback is negative there is no oscillation and no regeneration, and the condition that obtains is the same as if a high series resistance were put in the tuned circuit, or a low parallel resistance across it. That is, the radio-frequency resistance is increased. It is desired that the r-f resistance be decreased even below zero, and that is what is meant when it is said that an oscillating or regenerating circuit has a negative resistance.

The resistance then is not a steady value, but changes with current, and in general the larger the current, the lower or more negative the resistance. Therefore it follows that a good quantity of feedback is desired, though not so much as to produce oscillation. Good quantity is usually in mind when it is stated the tube should be operated just below the oscillation or spillover point, for maximum sensitivity.

### Dead-Spot Elimination

Even when the secondary is in the grid circuit, and has antenna input made to it, and the tickler is properly connected for regeneration, feedback may not prevail at the higher frequencies of tuning in any band, and moreover there may be certain dial points where there is no reception. The points where reception is lacking are called dead spots. They arise from absorption conditions, due largely to the natural period of the aerial, or fractions of that natural period, taking the energy that is intended to flow into the receiver. The same phenomenon is usefully applied in wave traps.

The natural period of the antenna is that produced by the inductance, capacity and resistance of the antenna, and may be regarded as a tuned circuit. For high frequencies the antenna easily can have a fundamental frequency of its own which is within the tuning band, or of a lower frequency (higher wavelength). Thus high radio-frequency resistance is introduced by the antenna into the tuned circuit, with which it is substantially in parallel, and will mar results. That is why a series antenna condenser is used, as the net effective capacity then is always less in the total antenna system than the capacity to which the series condenser is set.

### Use of Series Condenser

By providing this manually-controllable capacity element in the receiver, the antenna's natural period may be shifted away from frequencies that cause dead spots, and moreover may be put at such a value, which is not critical, as to make the antenna a highly-favorable pickup for a particular frequency. Usually the correct setting is at some point on the indicator knob or dial representing a span of about 10 numerical divisions out of a hundred. That is, the setting is not critical to less than 10 percent. mechanically.

Since the series antenna condenser affects the antenna which is in parallel with the tuned circuit, naturally it has an effect on the setting of the tuning condenser, for the series condenser is in itself a tuning element. Therefore such a circuit as diagramed. if calibrated, should be calibrated for the settings of both the series and the parallel condensers.

Sometimes constructors wonder how it is that the antenna is in parallel with the tuned circuit, since it seems to be a stretch of wire in series with the antenna winding, with one end usually not terminated.

### The Antenna as a Condenser

However, the antenna may be regarded as a condenser, of which the antenna wire that runs horizontally over the roof is one plate, and ground is the other. Thus the incoming waves fluctuate between antenna and ground, and thus the capacity to ground is ever present. So if one plate of a condenser is connected to one terminal of a coil and the other plate to other terminal, naturally the condenser is in parallel with the coil, and that is the antenna condition that obtains actually.

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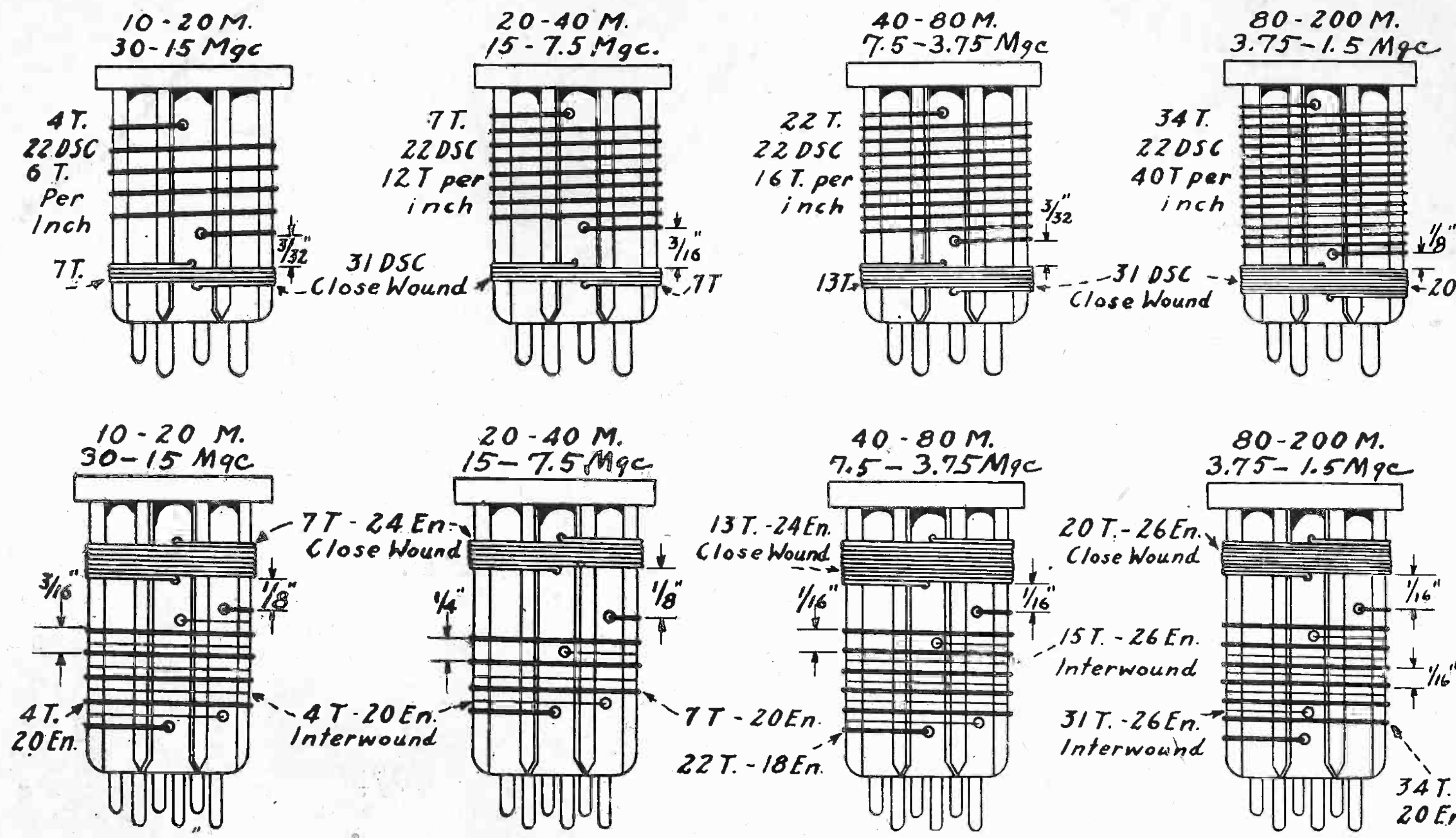



**These coils have gripping flanges and ribbed forms. The effective diameter is a trifle less than the 1-9/16 inches stated, due to the wire not winding in a perfect circumference. This does not affect the performance. The object of ribbing is to have the wire touch as little as possible of the dielectric. The number of turns data given above were taken from "Short-Wave Radio Handbook," by Clifford E. Denton, B.S., E.E., M.E., M.A.**

(*Continued from preceding page*)

or "skin," and therefore the expression "skin effect" has come into general use. The larger the area the greater the conductivity, and the larger-diameter wire has more wire, greater conductivity, less resistance, and even if the eddy-current losses do go up a bit, the increased high-frequency resistance due to use of thin wire would be greater than the increased resistance due to the extra eddies.

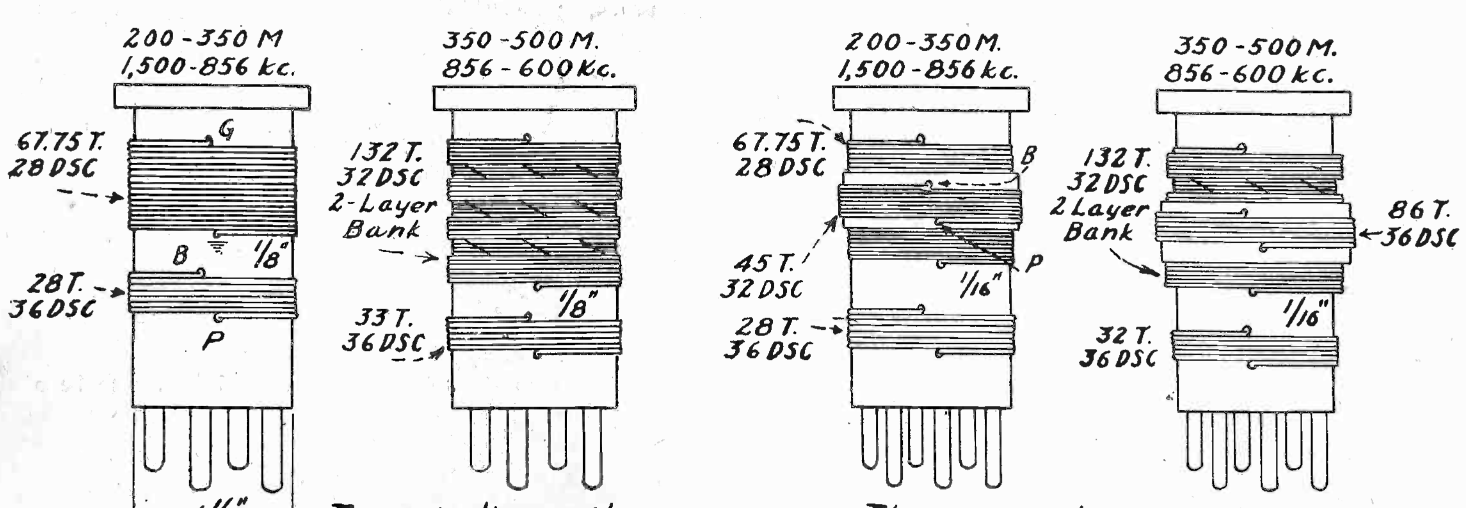
### What a Solenoid Is

Whenever any coils are wound on other than threaded forms it is advisable to use some form of adhesive, particularly as there are several types now purchaseable that introduce no measurable losses. These are practically all fluid and transparent, and they smell like chloroform when you paint the coil lightly with the stuff. The vulgar name for them is "coil dope."

The most accurate method of coil winding is to use threaded forms of high-grade material, requiring no doping, and, so far as the writer knows, it is the only way of getting very high order of accuracy in winding a solenoid for those frequencies for which solenoids are best. It is known, no doubt, that a solenoid is a cylindrically-wound coil, one turn usually put on close to the succeeding turns, or turns equally spaced. It is a single-layer winding. However, there are some who refer to bank-wound coils on cylindrical forms as solenoids, but at that rate honeycomb coils soon would get into the group, and everything except toroids and basketweaves would be solenoids and when a fellow said solenoid nobody would know what he meant, and probably he would not know himself.

### Some Identities

The coil forms using R-39, a special material meeting the requirements previously set forth, are manufactured by National Company, and may be identified as the slot-wound primary or tickler type, and the showing of five coils for 0.0001 mfd. tuning. The high-grade porcelain coils, the material being Isolantite, are those of Hammerland Mfg. Co., and have the black grip-handles on top. The forms on the front-cover illustration are those of Alden Mfg. Co. The ribbed forms are made by Insuline.




**The short-wave coverage with 0.00014 mfd. condensers, using coils wound as shown on the front cover, for 1¼-inch diameter, may be extended through the broadcast band. The two-winding coils for this purpose are diagramed in pair at left above, the three-winding coils in pair at right above. All windings are in the same direction. The polarities are marked on the left coil for all, and for tickler second from right. Windings not specified as spaced are always close-wound.**