RADIO WORLD

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The First National Radio Weekly

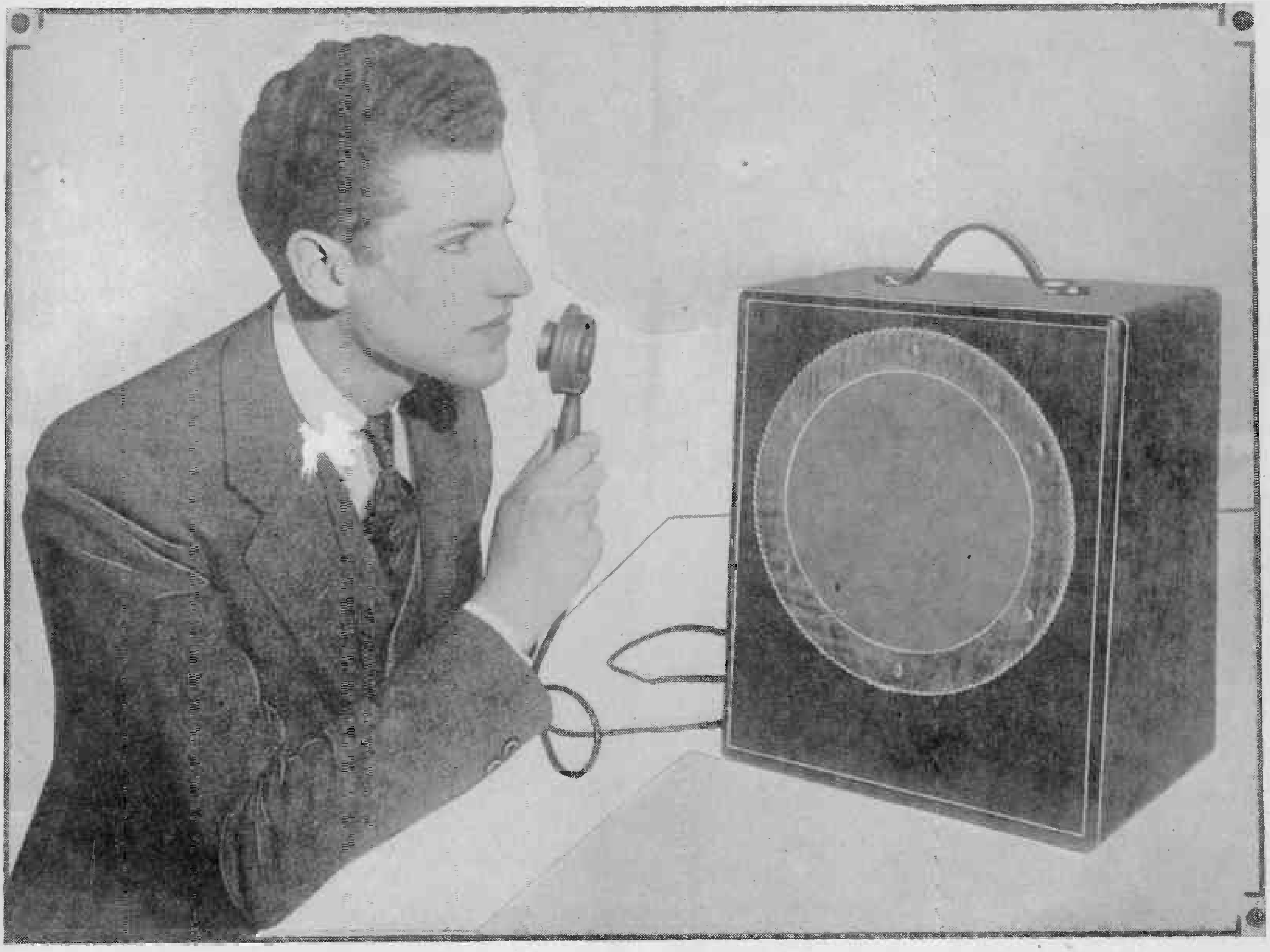
636th Consecutive Issue *Thirteenth Year*

How to Calibrate Your Short-Wave Set

A Simple Circuit for Cathode-Ray Tubes

Short-Wave Propagation

A PORTABLE P-A SYSTEM



A portable public address system, weighing 23 lbs. and having an output of 3½ watts, using a 59. Everything is self-contained excepting the hand mike. Sydney Bass, one of the authors of the article on page 16, is shown.

JUNE 2d
1934

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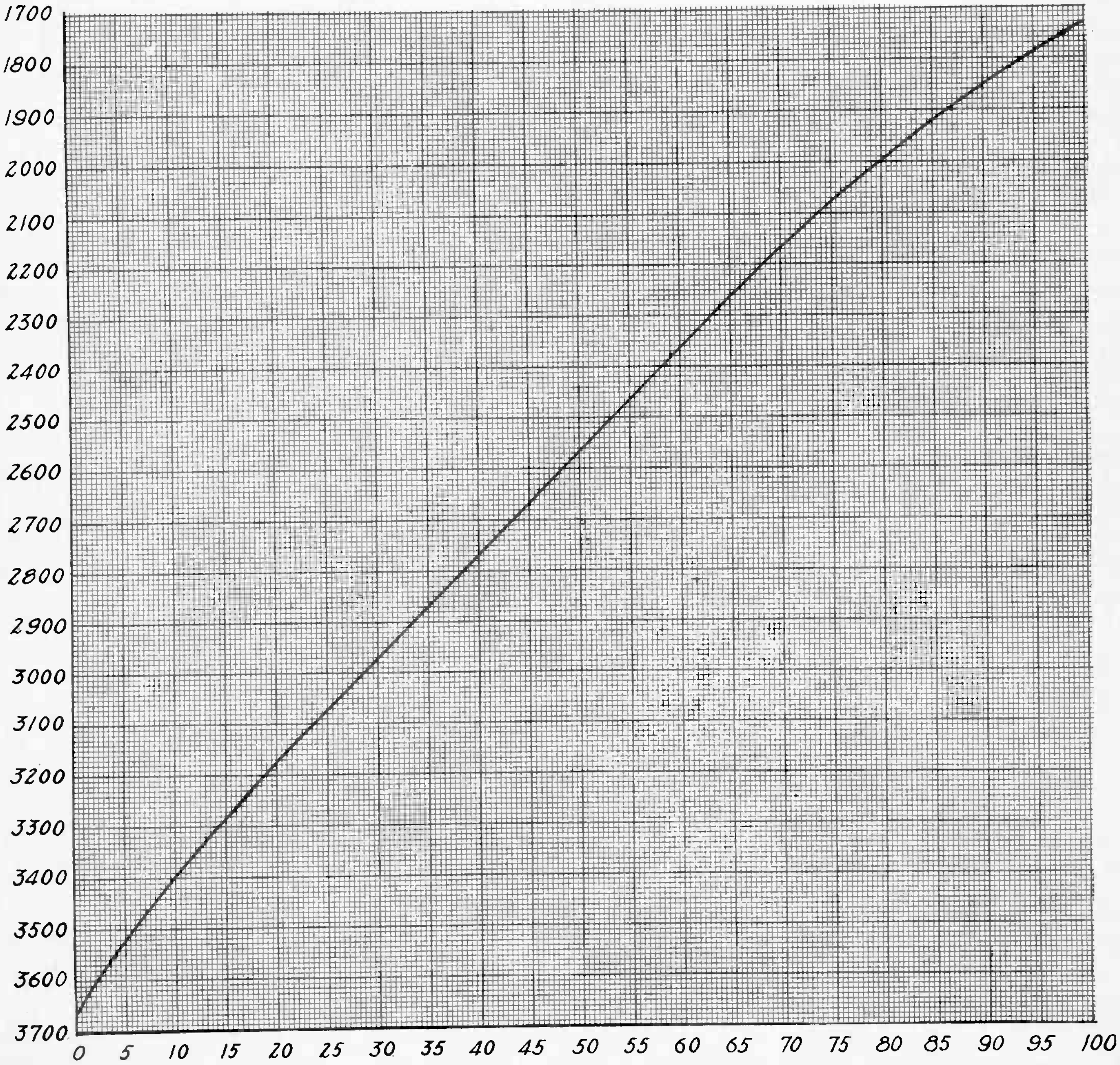
THIS week publication is begun of an important series of charts which enable frequency determination of short-wave sets. First, if the same parts are used, the receiver will follow the curves closely. Second, no matter what receiver is used, an oscillator may be built according to the universal signal generator circuit shown on page 12, and the generator, if coupled to the antenna of any set, will serve as station finder, using a.c. for modulation, and zero beats in addition. On d.c. only zero beats would be used. All the popular condenser and plug-in coil combinations will be covered in the series of more than a score of charts.

1,730-3,660 kc Chart for Bud 0.00014 mfd. and Red Insuline Plug-in Coil



The lowest-frequency range of the Insuline short-wave plug-in coils, using a Bud 0.00014 mfd. condenser, is plotted on this curve. The charts for the three other frequency ranges are printed on pages 13, 14 and 15. Thus receivers built of these capacities and inductances will follow the curves closely, and the charts will serve as station-finders. The Bud condenser is of the frame type, not the small-sized one for single-hole panel mount.

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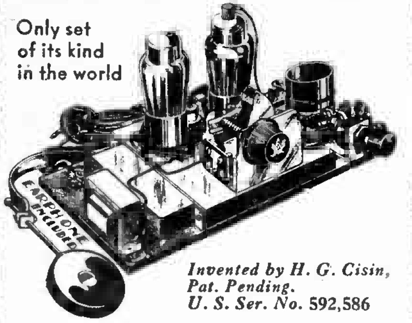

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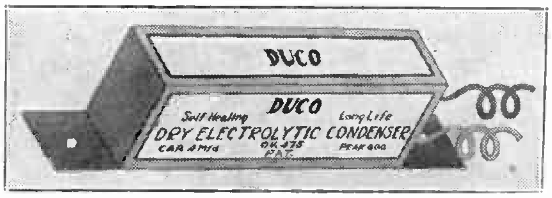

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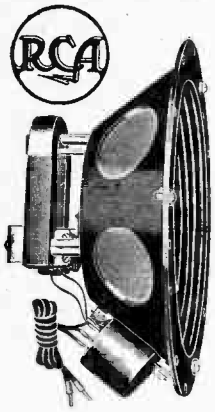

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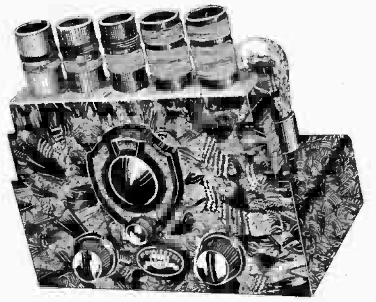

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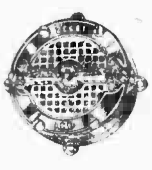

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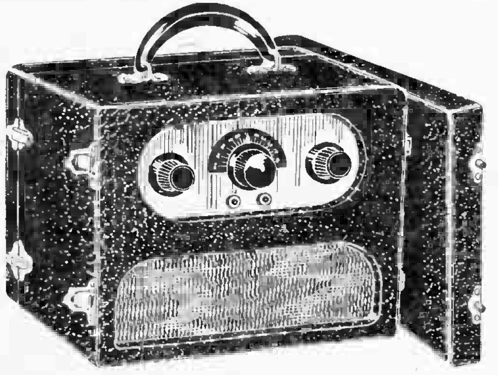

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THIRTEENTH YEAR

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Aerials for Short Waves

Types Used for Propagation and Reception—Tuned and Untuned Feeders

By J. E. Anderson and Herman Bernard

[*This is the fourth consecutive instalment of "The Short-Wave Authority," begun in the May 12th issue. Another instalment will be printed next week.*—EDITOR]

FOR the transmission of short waves, the Hertz horizontal aerial is used in most instances, although the Marconi vertical aerial is used also. If any aerial is to radiate, power must be supplied to it, and this process is sometimes referred to as feeding and sometimes as exciting.

An aerial may be either current-fed or voltage-fed. When it is current-fed the power is introduced at a current loop and voltage node; when it is voltage-fed, the power is introduced at a voltage loop and a current node. The main difference between the two cases is that when the aerial is current-fed the impedance offered to the source of power is low and when it is voltage-fed the impedance is high.

An aerial may be fed either directly by the tank circuit of the oscillator or power amplifier, or it may be fed through a transmission line, in which case the tank circuit may be located at some distance.

In Fig. IV-4 is a half-wave horizontal aerial, current-fed from the tank circuit LC. In the middle of the aerial is a series combination of two condensers and a coupling coil. This combination is tuned to the same frequency as the tank circuit and also to the frequency of the aerial. The total length of the aerial is one-half wave, one fourth wavelength being on each side of the coupling coil. One of the condensers may be omitted if the remaining part of the circuit can be tuned.

Since the coil and the condensers in the middle of the aerial circuit are tuned, there is no appreciable fall of potential across them. The arrangement is equivalent to a half-wave aerial cut in the middle, with an impedanceless generator inserted. The current is maximum in the middle and zero at the two ends. The voltage is maximum at the two ends and zero in the middle. Therefore the aerial is current-fed.

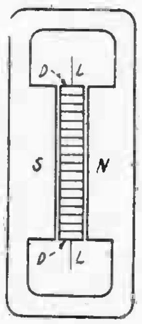
When an aerial is current-fed, the power must be introduced so that there is an odd number of quarter wavelengths each side of the point of power introduction, and in the entire aerial there must be a whole number of half wavelengths. The case illustrated in Fig. IV-4 is the simplest possible that will satisfy these conditions. A half wavelength could be added to either side, or to each side, without upsetting the necessary conditions.

Voltage-fed Aerials

In Fig. IV-5 is shown a simple form of voltage-fed Hertz aerial. LC is the tank circuit in the transmitter and L1C1 is a similar coupling tank in the aerial. At each side of the coupling tank is a half-wave wire. This antenna is voltage-fed because there must necessarily be a voltage loop at the middle and one at each end. Since the impedance to a generator inserted at a voltage loop is very high, the tank coupling circuit must be parallel tuned.

FIG. III-12

The ribbon or velocity microphone is a variation of the dynamic. Instead of a coil in the magnetic field there is only a light, corrugated ribbon, D, which is part of a single-turn primary of a step-up transformed. This transformer is usually mounted on the magnetic structure.



It is permissible to drop either half-wave wire in Fig. IV-5 without materially changing the conditions, for when this is done the impedance setting of the coupling tank is not changed. It is also permissible to put the coupling tank at one end of a whole wavelength aerial, or to add any whole number of half-wave wires to either side.

Transmission Line Feed

We said that the aerials in Figs. IV-4 and 5 were horizontal, they cannot be, because part of the aerial must be outside and elevated while part of it must be led into the station where the oscillator is located. The Hertz aerials, then, will be part horizontal and part vertical, and there will be both vertical and horizontal radiation. To prevent the vertical radiation, the power may be supplied the horizontal aerial by means of a transmission line that does not radiate, or one that radiates a negligible amount.

A transmission line consists of two parallel conductors comparatively close together. Most lines are uniform, that is, they have the same characteristics throughout. A line is usually rated in terms of its resistance, conductance, inductance, and capacitance per unit of line length, not of conductor length. In most instances the resistance and conductance per unit length are negligibly small, leaving only the inductance and capacitance per unit of length as the important factors. The ratio $(L/C)^{1/2}$, where L is the inductance per unit of length and C is the capacitance per unit of length, is known as characteristic impedance of the line. It is a pure resistance.

The value of the characteristic impedance depends on the size of the two conductors, the distance between them, and on the nature of the dielectric around the conductors. When the two conductors are in air, only the dimensions enter. In practical lines it may vary from 50 to 1,000 ohms.

(*Continued on next page*)

Field Strengths Vary Greatly Even Near Transmitter

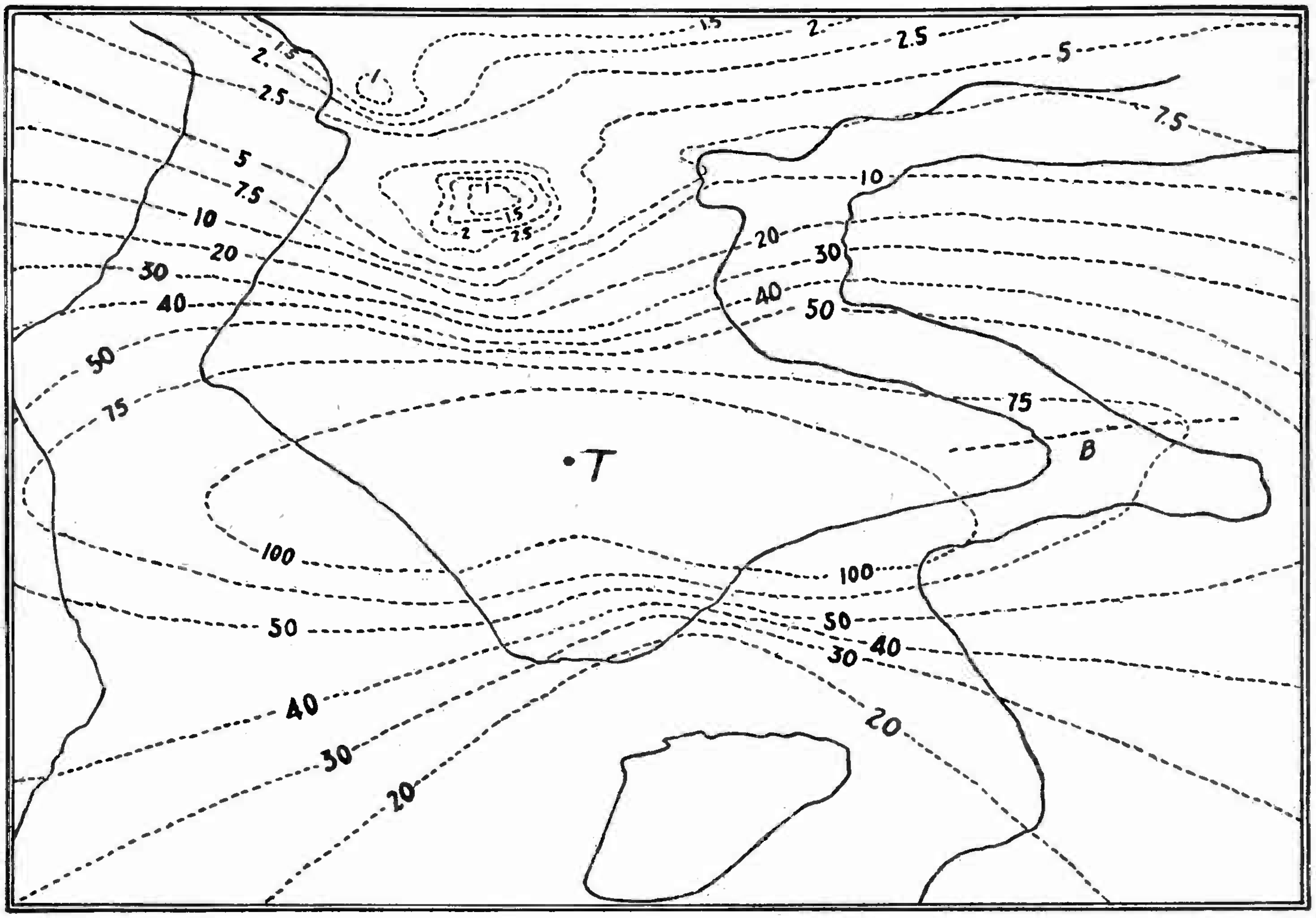


FIG. IV-3

Radio field map of a station (T) located among the skyscrapers of New York City. The tall steel buildings cast shadows in both direction, one being in the foreground over the bay and the other in the background over Central Park.

(Continued from preceding page)

In Fig. IV-6 is represented a transmission line one quarter wavelength long. The far end (upper) is open and at the close end a source of electromotive force is connected, assumed to be without impedance. The current, I, is greatest at the near end and is zero at the far end. The reason it is zero is that the line is open. The voltage across the line is zero at the near end and maximum at the far end. It is assumed that the frequency of the electromotive force is the same as the natural frequency of the quarter-wave line.

If the generator (e) in Fig. IV-6 is replaced by a coupling coil and a condenser, these have to be connected in series and they have to be tuned so that they are in resonance with the frequency of the voltage induced in the coupling coil. It will be found that a line such as that in Fig. IV-6 is suitable for feeding a half-wave aerial, or any aerial having a whole number of half wavelengths. One way of doing this is illustrated in Fig. IV-7. LC is the series tuned circuit coupled to the power source, E represents the voltage across the transmission line, and I the current in the horizontal aerial. With the variable condenser in the feed circuit, it is not essential that the transmission line be just one quarter wave long, for compensation may be made for small differences by selecting a suitable value for the condenser.

In Fig. IV-8 the transmission line is one-half wave long. Such a line will have a voltage loop at both ends and a current loop at the middle. To feed energy into such a line it is necessary to do so with a high impedance device, such as a parallel tuned circuit. This

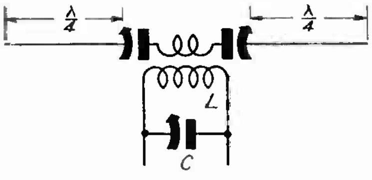


FIG. IV-4

A current-fed half-wave aerial in which the power is introduced into the middle of the radiating wire, at which point is a series tuned circuit.

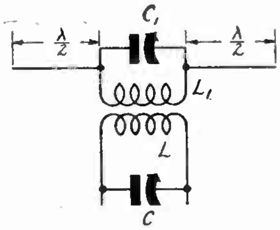


FIG. IV-5

A voltage-fed full-wave aerial in which the power is introduced into the middle of the radiator, at which point is a parallel tuned circuit.

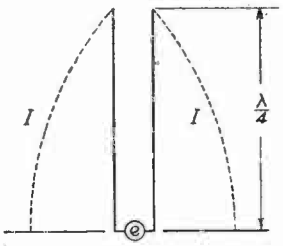


FIG. IV-6

A quarter-wave feeder line showing the current distribution. The current is zero at the top and maximum at the generator.

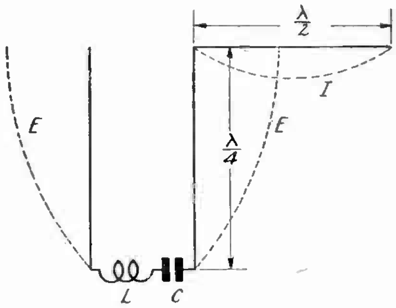


FIG. IV-7

This illustrates a Zeppelin aerial. It consists of a series-fed quarter-wave feeder one side of which is connected to one end of a half-wave Hertz aerial.

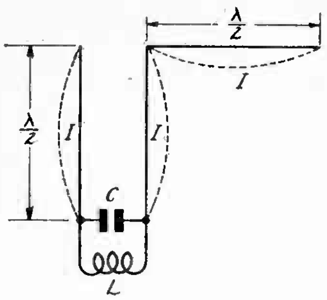


FIG. IV-8
This is another Zeppelin aerial. The feeder is voltage-fed and is one-half wave long. The horizontal portion is also voltage-fed. The dotted lines show the current distribution.

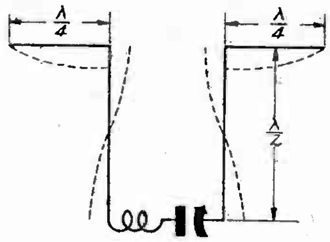


FIG. IV-9
In this case the Hertz aerial is fed at the center by the transmission line. Both the line and the radiator are current-fed, as is indicated by the current distribution curves. (See broken lines.)

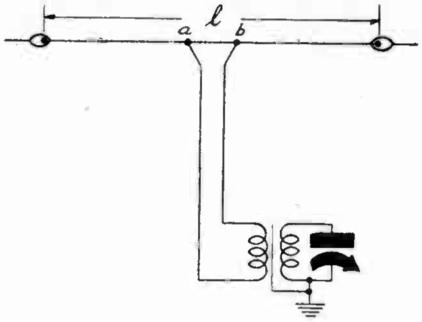


FIG. IV-10
A horizontal doublet fed by an untuned transmission line. The length of the line is immaterial provided the line is attached correctly to the aerial and line pickup is avoided.

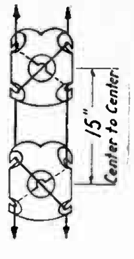


FIG. IV-11
Two transposition blocks with a short section of a transposed parallel wire.

parallel circuit, LC in the figure, is equivalent to one-half wave, so that the total effective length of the conductor in the line is three half-waves. The horizontal, or radiating, portion is also one half wave long but it may be any number of whole half-waves. The dotted lines show the current distribution in the vertical as well as in the horizontal portions of the circuit.

An aerial such as is illustrated in Figs. IV-7 and 8 is known as a Zeppelin, so named because it was first used on an airship of this type. The characteristic features of the Zeppelin aerial is that it is voltage-fed and that only one of the transmission line conductors is connected to the radiating wire.

The Hertz aerial can also be fed at the center with a transmission line. Suppose we have an arrangement such as that in Fig. IV-6 except that the line is three quarter wavelength long. In other words, it is supposed to be half a wavelength longer than it is. There will be a current loop at the bottom and a current node at the top. Between these extremes there will be one current loop, a quarter wave from the top, and a voltage loop, a quarter wave from the bottom. Now suppose that the line be changed as in Fig. IV-9. That is, a quarter-wave length of one conductor is bent to the left and another quarter-wave length is bent to the right, leaving a vertical transmission line one-half wavelength. In bending it will be necessary to change the horizontal lengths a little but we assume that Fig. IV-9 represents the true condition after the changes have been made.

The current and voltage distributions are the same as they were before the bending, the current distribution being indicated by the dotted lines. The line is current-fed from the transmitter tank circuit and the radiating portion of the aerial is current-fed from the line. While the vertical portion of the system in Fig. IV-9 is only one-half wave long, it could just as well be any number of half wavelengths long. The horizontal portions are both quarter wave long. One half wavelength could be added to either or to each without changing the conditions. Indeed, any number of half wavelengths could be added to either.

It is clear that in Fig. IV-8 another half-wave wire can be connected to the free vertical wire and run in the opposite direction to the horizontal wire shown. The power would be supplied at a high potential point on a radiator one wavelength long, and that point would be the center.

The Untuned Line

The transmission lines so far discussed are tuned, which means that they have been adjusted in length so that a system of standing waves exist on the line and the aerial. A tuned system requires close adjustment, yet in one sense it is less critical than an untuned system, because of the fact that the tuners permit making adjustments for discrepancies in the line and the antenna. Moreover, the adjustments can be made from the transmitter room.

A transmission line can also be untuned, and such a line has many advantages. We have already spoken of the characteristic impedance, or surge impedance, as it is also called. We have defined, or rather expressed, the surge impedance as the square root of the ratio of the inductance and capacitance per unit of line length. This does not clarify its physical significance. Suppose we have a uniform transmission line infinitely long. We measure the impedance of the line at the end, and find it to be Zo, the surge impedance. Next we cut off any length of the line and again we measure the impedance at the end. It is still Z, for the line is still infinite regardless of how much we cut off. The impedance at any point on an infinite line is the surge impedance.

Now suppose that we measure the impedance of the line at the end before we cut off a length. It is Z, of course. Now let us choose any point whatsoever and remove the portion of the line from there to infinity and in place of that portion let us substitute an impedance equal to Z. Since we have substituted an impedance equal to what we removed, we made no change in the circuit in so far as we can tell at the original point of measurement. There we found the impedance to be Z and it remains so.

Let us once more consider the infinite line. At the end let us connect a high-frequency generator. A current-voltage wave starts down the line. Since the line is infinitely long, the front of this current-voltage wave will never reach the remote end. Hence it cannot be reflected. As long as the generator is going, energy will go into the line and there is no return. In other words, the line is a bottomless sink.

Termination of Line

We just found that, if we cut the infinite line at any point and substitute an impedance Z for the infinite remainder, there would be no change at the input end. As far as the generator is concerned no change has taken place in the line. The end of the line continues to be a bottomless sink. From this we conclude that if we terminate a transmission line with its surge impedance, energy will be absorbed by that impedance just as fast as it comes up, and that no reflection can take place. Since reflection is impossible, standing waves are also impossible, for standing waves are the result of two equal traveling waves moving in opposite directions.

We have already called attention to the fact that the characteristic, or surge, impedance is a pure resistance in most practical cases. Thus we may terminate the line with a pure resistance with the assurance that there will be no reflection. We have two ways of getting such a resistance, one by the use of a non-reactive resistor and the other by tuning. Both methods are useful in radio transmission and reception.

A transmission line is seldom terminated by a non-reactive resistor, for all the energy coming in would be wasted in that resistor. There is one case, however, where such termination might be used to advantage. Suppose we wish to amplify the signal coming in by means of a vacuum tube. The line could then be terminated by a pure resistor and the voltage developed across this resistor could be used as input signal on the amplifier. While the power would be wasted in the terminal resistance, the amplified signal would still be available.

Usually, the transmission line is terminated by a pure resistance obtained by tuning, for then the power that arrives is available for radiation. Practically all the resistance offered to the line is radiation resistance.

The Doublet

An application of an untuned feeder to a horizontal aerial is illustrated in Fig. IV-10. The length, *l*, of the horizontal wire is slightly less than one-half wave. The height of the feeder is of little importance provided that the termination at (*a*, *b*) is correct. The line should be attached to the aerial so that *a* and *b* are at equal distances from the center point of the horizontal wire. The actual distance between two points at which the feeder wires are connected depends on the surge impedance of the line and on the height of the aerial above the ground. The proper points of attachments are those for which no standing waves appear on the transmission line. If no such waves appear, the current will be the same at any point of the line where a current meter may be inserted.

It will be noticed that there is a flare in the feeder line just before it is attached to the aerial. The object of this separation of the wires is to match the impedance of the line to that of the radiating wire. The impedance of the line gradually increases as the distance between the two conductors increases.

The distance (*a*, *b*) as well as the height of the flare in the feeder depends on the surge impedance of the line and on the height. Supposing that the surge impedance is 600 ohms, the distance between the points where the line is attached should be one-

(Continued on next page)

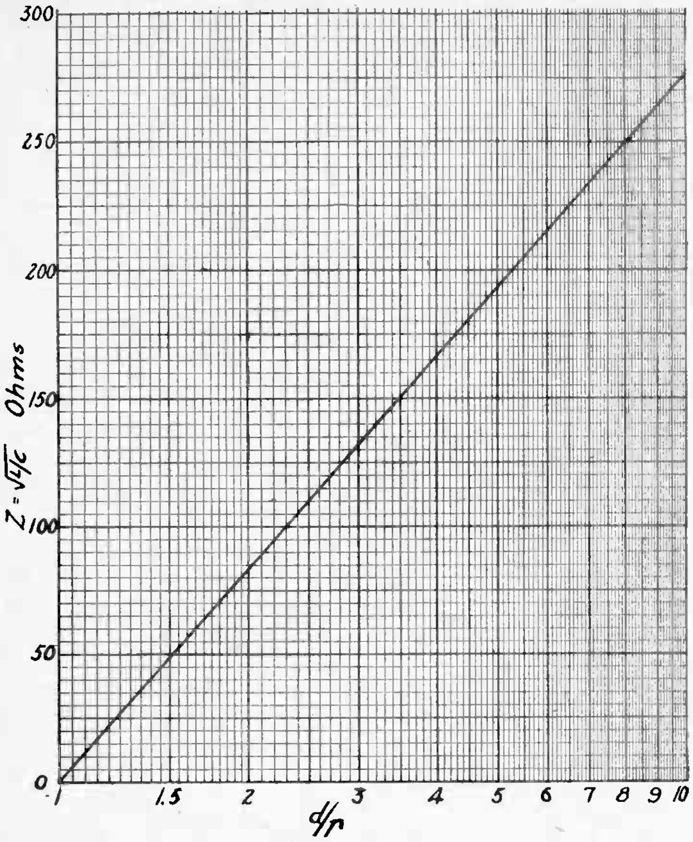


FIG. IV-12

A graph relating the surge impedance of a parallel wire line with the dimensions of the line, *d* being distance between centers of wires and *r* the radius of either wire. For each time 10 occurs as a factor in d/r add 276 ohms.

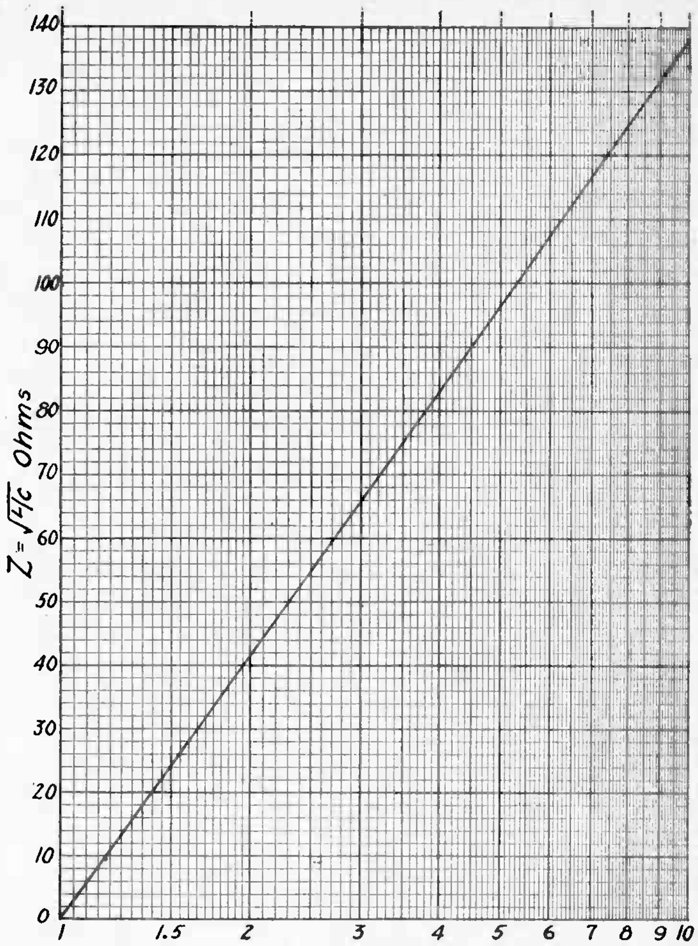


FIG. IV-13

A graph relating the surge impedance of a concentric tube line with the dimensions of the line, r_2 being inner radius of outer tube and r_1 the outer radius of inner tube. For each time 10 occurs as a factor in r_2/r_1 add 138 ohms.

(Continued from preceding page)

eighth wavelength if the height above ground of the horizontal wire is more than one-half wavelength and one-tenth wavelength if the height is less than one-half wavelength. The height of the flare, that is, the distance between the horizontal aerial and the top of the uniform line, can be determined by h = 45/F, where h is in meters and F in megacycles.

The aerial illustrated in Fig. IV-10 is sometimes called a "doublet."

Receiving Antennas

If only one frequency is to be received with an antenna, it would be desirable to construct it on the same principles as the transmitting aerials just discussed, but this is not feasible when a large number of different frequencies are to be received. Neither is it of first importance that the receiving antenna be highly efficient because modern receivers are very sensitive and they can easily compensate for lack of efficiency in the antenna. Still, this is no excuse why the best antenna possible under a given set of circumstances should not be used.

It is not practical to tune the receiving antenna for the reason given, namely, that any one of a large number of different frequencies is to be received. Hence it should be aperiodic, in general, but it may be tuned for certain frequency bands.

Transmission lines are just as useful for reception as for transmission. In many receiving locations the antenna must be placed at a considerable distance from the receiving set. In such cases the loss and attenuation in the lead-in will be very large so that even with the most sensitive receiver available the signals will be less than mediocre. Instead of putting the antenna in an exposed position and using a long lead-in, a small indoor antenna might be erected near the set. This will eliminate the attenuation and loss in the lead-in, but the antenna itself will be shielded from the arriving waves and once more an extremely sensitive receiver is required. If a transmission line is used as a connecting link between the antenna and the receiver, the separation between the two may be considerable without appreciable attenuation or loss. The antenna can be erected "in the clear" and the receiver can be placed wherever it is most convenient. Then with the proper line between them the signals can be conducted effectively.

Perhaps the simplest transmission line for this purpose is the so-called transposed lead-in. This consists of a line of two parallel low-resistance conductors in which the relative positions of the two wires are transposed at regular intervals. How the transposition is effected is illustrated in Fig. IV-11. There are two "transposition blocks" at each of which the two wires change places. The two wires cross at right angles to each other and on opposite sides of the block. Hence the capacity between the wires is small and the transposed line does not differ greatly from a uniform line in which the two conductors have the separation determined by the blocks. It is customary to place these blocks every 15 inches.

Aside from providing a low-attenuation lead-in between the antenna on the roof and the receiver below, the transposed lead-in has a marked advantage in connection with noise pick-up. Most of the noise originating in electrical devices appears to be vertically polarized. Only a vertical antenna will pick up this noise. The lead-in is effectively a vertical antenna but due to the fact that the two wires are transposed at regular intervals, the net pick-up of the vertically polarized noise is practically zero. One section will pick up a little of the noise in one phase; the next section will pick up an equal amount of noise in the opposite phase. Since the voltages picked up by the various sections add, the pick-up in one section is canceled out by that in the next.

The very fact that the two conductors are close together also prevents a certain amount of pick-up of the noise. Just as the transmitting line to a transmitting aerial does not radiate, so does the transmission line from a receiving antenna not collect. The transposition aids in preventing pick-up.

A very simple transmission line, which is also transposed, is one made of twisted pair. The wires in this case are close together and for that reason the surge impedance is low. This fact, however, is not material if the proper matching is done. Since the twisting is done uniformly, without any sudden bends, the line is uniform and its surge impedance can be computed on the supposition that the two conductors are parallel and straight. Unfortunately, the dielectric constant of the insulator is not unity nor definitely known. Hence accurate computation cannot be done.

Concentric Conductors

The best of all transmission lines is one made of two concentric conductors. If the inner conductor is mounted so that the insulation between the conductors is virtually all air, the loss in the line will be negligible. There can be no radiation loss since the inner conductor is wholly inclosed by the outer.

The optimum ratio of the inner radius of the outer tube to the outer radius of the inner tube is 3.6. For lower values of this ratio than 3, the attenuation increases very rapidly, but above the optimum value the increase is slow. Any value of the ratio between

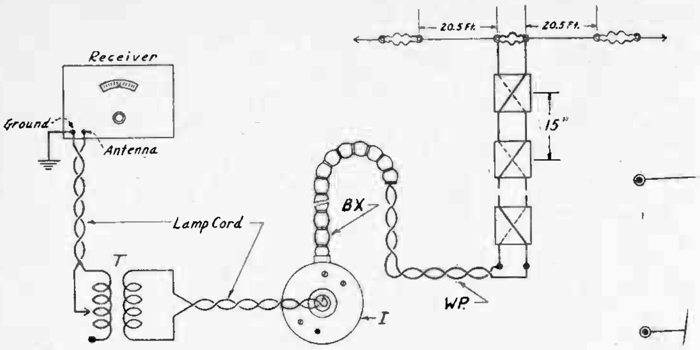


FIG. IV-14

Schematic showing the essentials of an antenna installation with a transposed lead-in.

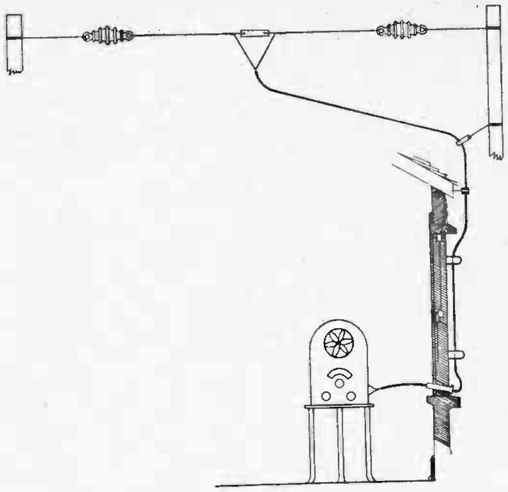


FIG. IV-15.

A simplified antenna installation in which the line consists of two closely placed conductors.

3 and 5 will give a low attenuation. When the ratio has the optimum value, the surge impedance is 76.8 ohms. While this impedance depends only on the ratio of the radii of the two conductors, the attenuation depends on their absolute values as well. If the conductors are of copper and the inner diameter of the outer tube is 3 inches, the attenuation is 1.41 db/km at 25 megacycles. For other values of the outer radius, keeping the ratio and frequency constant, the attenuation is inversely proportional. Thus if the diameter of the outer tube is 1.5 inches instead of 3 inches, the attenuation is doubled.

For two parallel wires the optimum separation is such that the distance between the centers of the two wires is 2.72 times the radius of either. At this separation the surge impedance is nearly 120 ohms. Such small separation is not practical if the insulation between the wires is to be air, for it requires that the thickness of the insulation be only 0.72 of the radius.

A common separation between two parallel wires is 2.5 inches, or 6.35 cm. If the wires are No. 12 gauge, the diameter is 0.0808 inches. Hence the ratio of the separation to the radius of the wire is 61.9. This makes the surge impedance 495 ohms. The attenuation is 9 db/km at 25 megacycles, if the wires are of copper and the insulation is air.

Surge Impedance Graphs

While simple formulas for the calculation of surge impedances from the dimensions of transmission lines are available, it is more convenient to use graphs for the determination. Such graphs are given in Fig. IV-12 for the parallel wire line and in Fig. IV-13 for the concentric tube line. In each case the vertical scale gives the surge impedance in ohms and the horizontal scale the ratio of the pertinent dimensions. In Fig. IV-12 d is the distance between the centers of the two equal parallel wires and r is the radius of either of them. In Fig. IV-13 r_2 is the inner radius of the outer tube and r_1 is the outer radius of the inner tube. In each case it is the ratio of the larger dimension to the smaller that counts.

The graphs are straight lines if the impedances are plotted on a linear scale and the ratios of the dimensions are plotted on a logarithmic scale. These facts are very convenient because they obviate the necessity of plotting the graphs over more than one cycle for each curve, that is, from 1 to 10. The impedances for values of ratios higher than ten are easily obtained by a method to be explained below.

It will be noticed that the graph for the parallel wire line indicates an impedance of 276 ohms at the end of the first cycle, that is, when the ratio $d/r = 10$. In the next cycle it will rise by the same amount, so that at 100 the impedance would be 276 plus 276. At 1,000 it would be three times 276 ohms. For ratio values other than these the impedance can be obtained by the same method of addition. Suppose, for example, we wish to find the impedance when the ratio is 120. This lies in the third cycles for it is greater than 100 and less than 1,000. If we divide the number by 100 the quotient lies in the first quadrant. The impedance for 1.2 we find from the graph to be 22.5 ohms. By adding 276 we get the impedance for 12 and by adding 276 once more we get the impedance for 120. Therefore the surge impedance of this line is 575 ohms. Let us take another example. Suppose that $d/r = 80$. This is in the second quadrant. Hence the impedance is 276 plus what the curve shows at 8, which is exactly 250 ohms. Therefore $Z = 525$ ohms.

The graphs can be used to answer such questions as: "What should the ratio d/r be to give an impedance of 600 ohms?" First let us subtract 276 from 600. We have left 324. Let us repeat the subtraction. We have left 48. The graph shows that the value of d/r when the impedance is 48 is very nearly equal to 1.5. Since we subtracted 276 twice to get 48, we have to multiply 1.5 by 10 twice to get the required ratio. That is, our result is 150.

Let us carry this one step further. We know only the ratio of the distance between the wires to the radius of either wire. Suppose now that we use No. 12 gauge wire, the radius of which is 0.0404 inches. How far apart should these wires be placed to give a surge impedance of 600 ohms, assuming that the wires are placed in air? We just found that the ratio d/r should be 150. Therefore the wires should be spaced $d = 150\ r$, or 6.06 inches.

Concentric Tube Line

The graph for the concentric tube line in Fig. IV-13 is similar to that for the parallel wire line. In this case, however, the impedance rise per cycle is 138 ohms instead of 276 ohms. Suppose, then, that the ratio r_2/r_1 is 25. What is the surge impedance of the line? Since 25 lies in the second cycle, the surge impedance is 138 plus what we find at 2.5. Here we find 55 ohms and therefore the surge impedance of the line in question is 193 ohms.

Suppose we wish to construct a concentric tube line having a surge impedance of 200 ohms. What should the ratio of the radii be? If we subtract 138 from 200 we get 62 left. A line has a 62-ohm surge impedance when the ratio of the radii is 2.8. Since we subtracted 138 only once, we multiply 2.8 only once by 10. Therefore the required ratio is 28.

If the radius of the inner tube is 0.375 inches, what should the inner radius of the outer tube be to make the surge impedance 200 ohms, assuming that the insulation is air? We just found that the ratio of radii should be 28. Therefore the inner radius of the outer tube should be 0.375x28, or 10.5 inches. That would make the diameter 21 inches. Apparently, it is not practical to go to such high values of surge impedance when the line is of the concentric tube type. We stated previously that the most suitable range was between 3 and 5. Fig. IV-13 shows that between these values of the ratio of the radii the surge impedance varies from 66 to 96 ohms.

It is, of course, possible to make smaller concentric tube lines than the example considered above. The inside conductor might be a solid wire, say No. 14, and the outside a tube which will give approximately the best ratio, namely, 3.6. A number 14 bare copper wire has a diameter of 0.06408 inch. If we multiply this by 3.6 we get 0.23 inch, which would be the inside diameter of the outside tube. Of course, such a small-gauge transmission line would have a greater attenuation than a line in which the dimension were ten to twenty times greater. But the attenuation is small in any case, and by means of the small-gauge line we could conduct the signal through almost any obstruction.

Matching Impedances

Our chief interest in the surge impedance lies in the information it supplies regarding the design of apparatus for matching. Of course, in most cases the actual matching is done experimentally, but a knowledge of the value of the impedance that must be matched will help as a starting point. Matching means the joining of two lines or other electrical devices of different impedances in such a manner that there is no reflection at the junction. It is done by the insertion of a transformer having the same impedance ratio as the two impedances between which it is inserted.

Suppose, for example, that we have two transmission lines, one having a 25-ohm surge impedance and the other having a 625-ohm surge impedance. If these two lines are connected together directly there will be much reflection at the junction because there is such a large difference between the two impedances. If a transformer with very closely coupled turns is connected between the two lines, reflection can be prevented if the inductances of the windings are proportional to the impedances of the line. This is virtually the same as to say that the ratio of turns should be equal to the square root of the ratio of the impedances. In the assumed case that would make the ratio of turns five-to-one.

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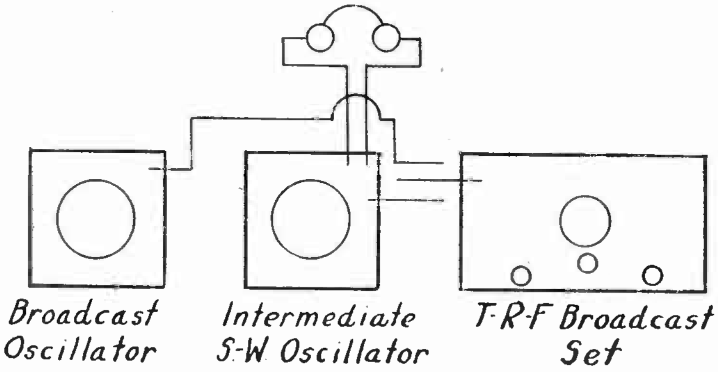
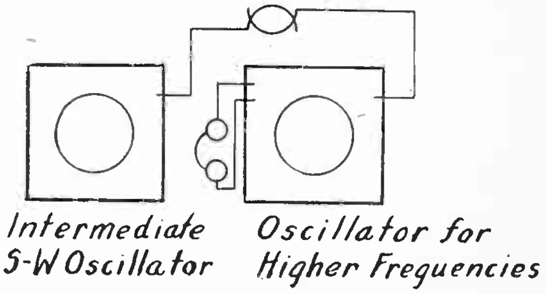
A Precision Cal

For Intermediate, Broadcast and First Sho

By Herma



Sometimes when parts of an intended curve are "open" and one desires to fill in with new points, these may be ascertained with the aid of a broadcast oscillator and a broadcast receiver, to calibrate short-wave oscillators.



Any oscillator may be used for its harmonics. The figure illustrates an intermediate short-wave oscillator for calibrating an oscillator that covers higher frequencies. This is known as "beating up."

USING broadcasting stations as standards, for their degree of accuracy is high, it is possible to calibrate receivers and oscillators. It is preferable to calibrate oscillators and then use them in addition to a calibrated receiver, because due to two oscillations, one from the station, and the other obtained locally, the accuracy is improved at the recording end by use of zero beats.

When two waves are mixed they are said to beat, and if the two frequencies are nearly enough alike the beat is a note, that is, can be heard. It is in the audio spectrum. Since the frequency of the local oscillator, which is really a test oscillator for the purposes of the present discussion, or a signal generator, to give it the fancier name, is to be determined, the highest accuracy obtains when there is no difference in frequency between the two waves. Then there is no note. This is called zero beat. It means no difference in frequency, both frequencies identical, and it provides a close means of calibrating resonance.

Strong Locals

The broadcast receiver should be of the tuned-radio-frequency type to avoid too numerous spurious or confusing responses that might result from use of a superheterodyne receiver. Preferably the broadcast set should have three or four tuned circuits, four being advisable if any strong reliance is to be placed on the frequencies in the higher brackets of the broadcast band. The circuit tends to lose selectivity anyway, at these higher frequencies, and the extra tuned stage, or fourth one, helps to preserve a high enough selectivity. Nevertheless, where strong local stations are present, it is always a possible source of confusion that a person can cause a beat with a wave to which the receiver is not directly tuned, as well as with the wave to which it is tuned, because enough of the detuned frequency gets through to the detector of the set to enable registration of the beat. This fact always must be borne in mind, to avoid any confusion.

One of the first requirements is the construction of a broadcast-band oscillator. Numerous circuits for the purpose have been printed in these columns. In general, a standard broadcast condenser and coil of any type may be used, with coil primary as the feedback winding, secondary tuned. Since for the purposes of calibration it is not vital to have modulation, it may be omitted.

A battery-operated device, or an a-c device that has a good filter circuit, may be used as the oscillator, and since numerous bands are to be covered, plug-in coils are acceptable. The universal type oscillators should not be used on a.c. for this wide-range calibration, because then the oscillator can not be used as a listening post. A circuit suitable for oscillator for the present purpose is the "receiver" printed on page 12.

What Equipment We Have

Remember we are already provided with a broadcast-band oscillator, and have made a calibration curve for it, and if there is adjustable output, called attenuation, then the calibration should be made for a particular setting of this control, e.g., maximum output, and

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Matching Antenna Circuit Consist

(Continued from preceding page)

This "matching" does not take into account the facts that the line impedances are pure resistances and that the transformer windings are inductive, except that it was stipulated that the windings should be closely coupled. The more compactly the transformer is made, the more nearly the conclusions arrived at above hold.

There does not seem to be any occasion for changing the characteristic impedance of a line run between an antenna and a receiver. The question of matching, then, is mainly one of selecting the proper impedances for the terminals. There might be one transformer between the antenna and the line, a step-down transformer, and another transformer at the receiver end, which would be a step-up transformer if it is to feed into the grid circuit of an amplifier. It is not very convenient, however, to put a transformer near the antenna. Hence the transmission line impedance should be about that of the antenna and a suitable transformer should be used at the receiver end.

Transposed Lead-in Connection

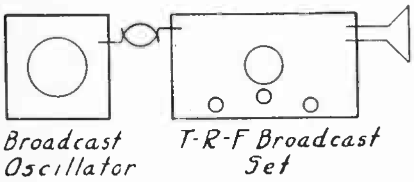
Fig. IV-14 shows how a transposed lead-in is used for connecting the antenna to the receiver. At the top, somewhere over the roof or out in the back yard, a 41-foot double antenna is erected on poles, preferably wooden provided they are not living trees. The antenna is broken up into two 20.5-foot lengths held together at the middle by means of an insulator. The transposed lead-in is connected to this insulator. It is desirable to make the horizontal and vertical portions continuous wires so that there are no breaks at the insulator. From the insulator down to the level of the roof or to the window where the line is brought into the house the line is transposed about every 15 inches. At the bottom it is firmly attached to insulators so that the lead-in as a whole cannot twist. From these points of attachment a waterproofed twisted pair conductor is run to a short length of BX cable, which is bent into a bow with the convex side upward and constrained to remain in this shape. The object is to prevent water from running into the line. As an aid in this the end of the BX cable that is exposed to the weather should be sealed with wax or pitch. The twisted pair from the line to the BX cable and the cable should be no longer than is absolutely necessary.

The BX cable terminates with an insulator, I, inside the house but the line continues as a short length of twisted pair to a match-

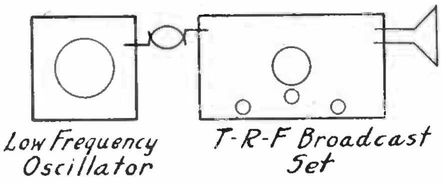
ibration Process

t-Wave Band, Using Broadcasting Stations

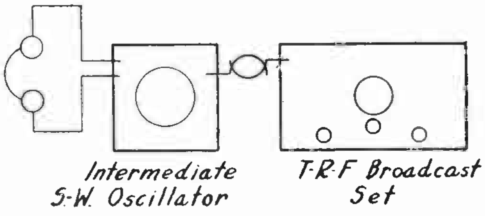
n Bernard



A broadcast-band oscillator is calibrated by using a t-r-f set, and zero beating the oscillator with the station carriers, noting the points on the oscillator dial at which the frequencies come in. Then on graph paper a curve is run, frequencies on one dimension, dial settings on the other.



It is easy to calibrate a low-frequency oscillator, as all that one need do is to couple the oscillator to a broadcast set, and either use the same station and tune the oscillator. If one leaves the oscillator put and tunes the set he can find what one frequency on the oscillator is.



Although not generally known, it is possible to calibrate short-wave oscillators against broadcast receivers directly, due to the presence in the broadcast set of second harmonics. For very strong stations a response will be heard in the broadcast set. Otherwise the oscillator itself is the preferable listening post.

used that way always for close accuracy. Attenuation may change the frequency slightly.

Having stations, and a broadcast-band oscillator and the broadcast receiver we have calibrated, we have our starting equipment. The receiver is never used for final measurements, only to register beats.

The broadcast or other oscillator may be coupled to the broadcast receiver by twisting together two wires, one going from receiver antenna post, the other from oscillator output post. The ends of the wires are left loose. Principally the capacity between the two wires is used for coupling.

Suppose the first problem is to calibrate a low-frequency oscillator, one intended for intermediate frequencies, or at least frequencies lower than the lowest in the broadcast band. The test oscillator will generate harmonics, and, incidentally, must have grid leak and condenser for the aid these render to stability of frequency.

When Responses "Grow"

It is obvious any frequency of oscillation lower than the lowest in the broadcast band will yield at least one harmonic somewhere in the broadcast band that will beat with a station in that band. Therefore, the only problem is to ascertain the harmonic order. You desire to know which harmonic of the test oscillator is beating with some known fundamental.

Since the receiver is calibrated in frequencies, there being at least a chart relating the frequencies to arbitrary numerical dial settings, if you turn on the low-frequency test oscillator, and pick up a beat with a station, it will be due partly to a particular oscillator harmonic. Let us call this harmonic n. Now if the test oscillator is not disturbed, and the receiver is tuned to some other frequency in either direction (higher or lower frequencies) another response would be heard if the test oscillator were modulated, or if there happened to be a station at this other point. But if there is no modulation, and no station, the broadcast-band oscillator may be turned on also, and used as listening post, to pick up the second response.

Suppose the second response is a higher frequency. Then the harmonic order is one higher than formerly, or n + 1. The consecutive responses are always related to the oscillator fundamental, since they represent nothing but different harmonic orders of the low-frequency test oscillator. Therefore by measuring the frequency difference on the broadcast set, or broadcast oscillator, the frequency of the fundamental at any setting of the low-frequency test oscillator is obtained. Let us take a practical case.

Getting Started Right

A low-frequency oscillator is used. It is identified as such because the coil is a honeycomb and seems to have a large inductance. It is confirmed as such an oscillator because it yields several or numerous responses at different points on the broadcast set, or

(*Continued on next page*)

s of Selecting Proper Impedances

ing transformer, T, the secondary of which is connected to the receiver with another length of twisted pair. The total length of the twisted pair should be as short as possible. The secondary of the radio-frequency transformer should be tapped at a number of points so that the most effective ratio of turns can be selected.

A Simplified Line

The transmission line in Fig. IV-14 is of the parallel wire type but it is not uniform for there are changes in the surge impedances at several points. But it is quite feasible to make the line uniform all the way, if we select the proper parallel wire transmission line. In Fig. IV-15 is illustrated a simple case in which the same conductor is used from the receiver to the center of the Hertz antenna. The two conductors constituting the parallel wire line may be surrounded by a metal shield, which then may be grounded, provided the construction is such that each of the two conductors is disposed the same way toward the sheath. If the two conductors are not shielded, they must be insulated thoroughly at every point of support. It is clear that whatever the line may be, the insulation must be such that it will not absorb moisture.

The running of the parallel wire line is important. It must not bend immediately it leaves the horizontal portion of the antenna, as is indicated in the diagram, but should run at right angles as long as possible, and not less than about one-third wavelength. When it bends the curvature should be gentle and not abrupt, for sharp change in direction will change the surge impedance. Note carefully the way the line is run just outside the window where the line enters the house. There is a downward bow and at the same time the porcelain insulator through the window sill slopes downward from the inside. The arrangement is to prevent water from entering the house, for water that runs down the line while it is raining will drip off outside.

A line of this type need not be twisted or transposed because the two conductors are so close together that there will be no pick-up. Yet uniform twisting will do no harm. It will be realized that the surge impedance of a line like this will be very low, since the two conductors are so close together. But low surge impedance is no detrimental if a suitable transformer is used between the line and the set. The most convenient place to put this transformer is in the receiver.

(*Continued from preceding page*)

broadcast oscillator, when the low-frequency oscillator is left at one setting, and either of the others is varied, or if the setting of the receiver or broadcast oscillator is left in one position and the test oscillator is varied. However, we are taking up first the question of what's what when the receiver is tuned to different frequencies of response, as that is somewhat simpler.

Take 1,000 kc as the broadcast station frequency that beats with the unknown test oscillator. Suppose that we leave the t.o. as it is and tune the receiver to higher frequencies and get a response at 1,100 kc, or to lower frequencies, and get a response at 900 kc. The fundamental generated by the low-frequency test oscillator is the difference in either example, or 100 kc. By this method at least we get a fairly close idea of the region in which we are working, especially if we get a few well-distributed responses, using other test oscillator settings, and other station frequencies.

The curve can be confirmed closely by leaving the receiver at one particular frequency, for a station as low as possible in frequency, and then getting numerous points by turning the test oscillator dial.

By this method the process is different, as always a different test oscillator frequency is generated fundamentally, and the same station used on the broadcast set, or quite the opposite to the previously-described procedure.

Extending the Calibration

As stated, we know to a close approximation the region in which we are working. We are aided by the fact that condensers of 0.00035 mfd. or so will yield a frequency ratio, maximum to minimum, of 3 or a little less, those of 0.00014 mfd. around 2. Realizing the approximate ratios narrows the possibilities of errors.

Suppose now that we beat with 600 kc station frequency, leave the receiver thus, and start at the maximum-capacity setting of the test oscillator we desire to calibrate. We tune slowly and pick up the first response. The harmonic order is known, because the closely-approximate curve previously established gives us the clue. The harmonic is the fourth, and the fundamental of the test oscillator is 600/7 or 85.7 kc. By the previous method, of variably tuning the receiver, we subtracted two frequencies revealed by the set to get the answer. Now we divide.

The advantage of the second method, of leaving the receiver at one position and tuning the oscillator, is that we get a real calibration of the oscillator itself. The harmonics we may expect to use in the 600 kc station instance, when 85.7 kc was the lowest fundamental yielding harmonic response, would include for 0.00035 mfd. or so, the sixth, fifth, fourth, third and possibly second, though the second would be unlikely, as the oscillator starts at around 80 kc and can not be expected to go higher than 240 kc. This we know from the frequency-ratio information. But if the capacity is 0.0005 mfd. we could get a ratio of 4.

"Regular" Curve Should Result

By using another station, of higher frequency, and tuning the oscillator variably, we can get more points. Some will produce odd values, and even ones are usually preferred for actual plotting, the odd ones being used as confirmation. The resultant curve will be, or should be, fairly regular, otherwise there have been mistakes made. If a few points fall notoriously off the curve they may be classed as experimental errors and disregarded.

By the foregoing rules it is possible to calibrate accurately any low-frequency oscillator. If modulation is used, it should be used always and at the same quantity, for instance maximum, when using the oscillator for frequency measurements later, as modulation changes the frequency a little.

For higher frequencies on the set the responses will be more numerous, because the low frequency of the test oscillator is divisible into a higher frequency a greater number of times. Thus for 600 kc there might be five responses. For 1,200 kc there then would be ten responses, for the fundamental is 100 kc, and 100 is divisible into 1,200 twice as many times as into 600.

The warning has been given, and will be repeated, that if the receiver is not highly selective, or if strong local stations exist, the beats resulting from mixing of test oscillator harmonics with the strong station may be heard no matter to what frequency the set is tuned. There will be audible responses like this, even though no interference is actually heard from the local station in the normal tuning process and during regular listening. The reason is that the response is equal to the product of the two frequencies, and even if the stray one is weak, if the test oscillator is strong, the beat will be strong.

If the broadcast set is purposely so made that it has a detector that is easily overloadable, the receiver detector will generate harmonics, particularly the second harmonic.

Now if the intermediate short waves are to be covered by a test oscillator, if we use the oscillator as the listening post, which means no modulation should be used in it for this purpose, we can hear a squeal due to that second harmonic existing in the broadcast set. If the station is strong enough, the test oscillator to be calibrated is coupled to the antenna, the beat will be heard in the receiver's speaker. This fact is not well known. Consideration of the presence of second harmonic content in all the r-f and tubes, however, will give all the theoretical proof one needs. Actual practice will confirm the statement, but the station must be very strong.

A high frequency in the broadcast band may be used, say, 1,250 kc. Then if the intermediate short-wave oscillator is coupled to the set, the squeal will be plainly heard when this oscillator is set at 2,500 kc. Hence one point is indicated, though there is danger the frequency is 2,500, 3,750 kc or 5,000 kc. However, all response points, say, three, would be noted. The placing of the squeals in their proper chart position will be done later.

Further Verification

We still have a broadcast-band oscillator, remember. Using that, beating it with some particular station on the broadcast receiver every time we want accuracy, we establish some frequency, say, 600 kc.

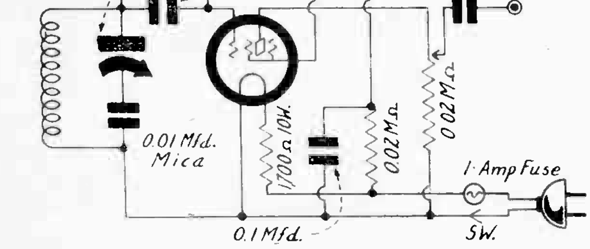
Now, 1,800 kc may be expected, also 2,400 kc and possibly 3,000 kc. If we can get responses near the extremes we can determine approximately the frequency coverage of the test oscillator. Suppose we did get a response from 600 kc five times, with a bit of overlap. Estimate say 500 kc for overlap. The span is (4x600) + 500 or 2,900 kc. The frequency ratio, previously obtained experimentally by dividing the lowest into the highest frequency for the broadcast-band coil (assuming same condenser), the low-frequency extreme is 2. The low-frequency extreme is 2900/2 or 1,450 kc. We can confirm by resort to the broadcast set, as some of the oscillator tuning will produce beats with stations (1,450 to 1,600 kc).

We may use a low frequency of the broadcast-band oscillator, and get numerous harmonic responses by listening in the intermediate short-wave oscillator.

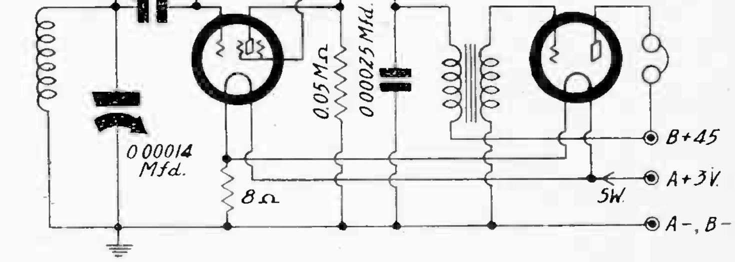
We can spot points this way, by harmonics of the broadcast band oscillator, first zero beating that oscillator with a station in the broadcast set, and then turning off the set. We get points but don't know what they are. Also we get points we don't expect, but after we have found a few points on the curve that "stand up" well, we can ignore all off-curve points, and use only responses that fall on or close to the curve. These responses create the new and real curve.

[*Next week, calibration to 40 megacycles*].

Circuits Used for Calibration Charts on Page 2, 13, 14 and 15



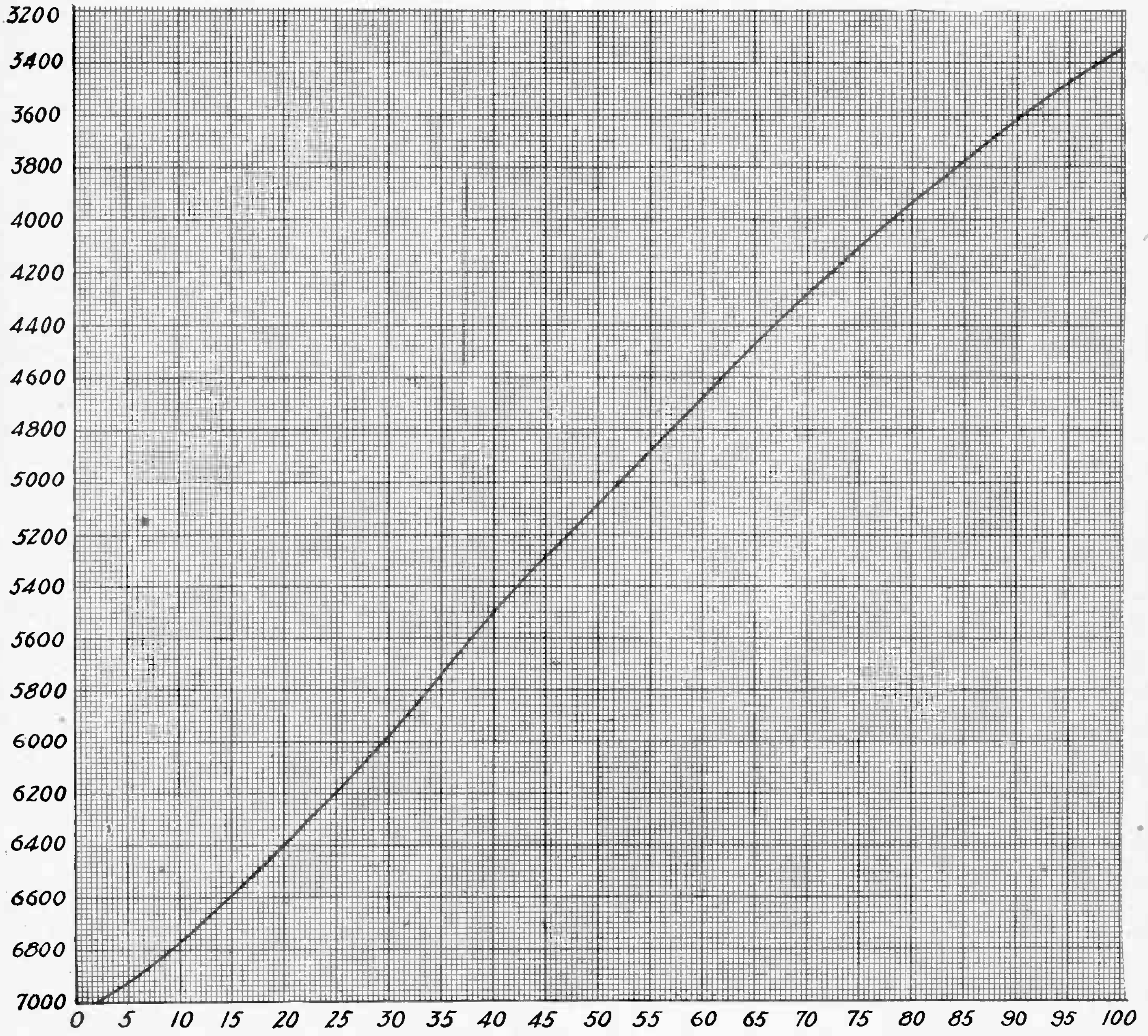
The receiver used for calibrating the tuning for the charts on pages 2, 13, 14 and 15 was built according to this diagram. No regeneration control was used, because of detuning.



The signal generator used was as shown above. It is a universal type, but was used on a.c. for hum modulation. No attenuation was used, to avoid detuning.

THE capacity values for the operating conditions of the receiver or signal generator, applicable to all four bands, are: Bud condenser, minimum, 15 mmfd.; maximum, 140 mmfd. Circuit capacity (tube, coil, wiring, etc.), 22.7 mmfd. The total minimum is therefore 37.7 mmfd. The total maximum is 166.7. Thus the capacity ratio is 166.7/37.7 = 4.45. The frequency ratio is $\sqrt{4.45}$ or 2.11, very closely confirmed, for instance, the 1,730-3,660 kc range equals 2.115, lowest frequency coil (page 2), with effective secondary inductance of 52 microhenries. In the next highest frequency coil (below) the inductance is 20 microhenries.

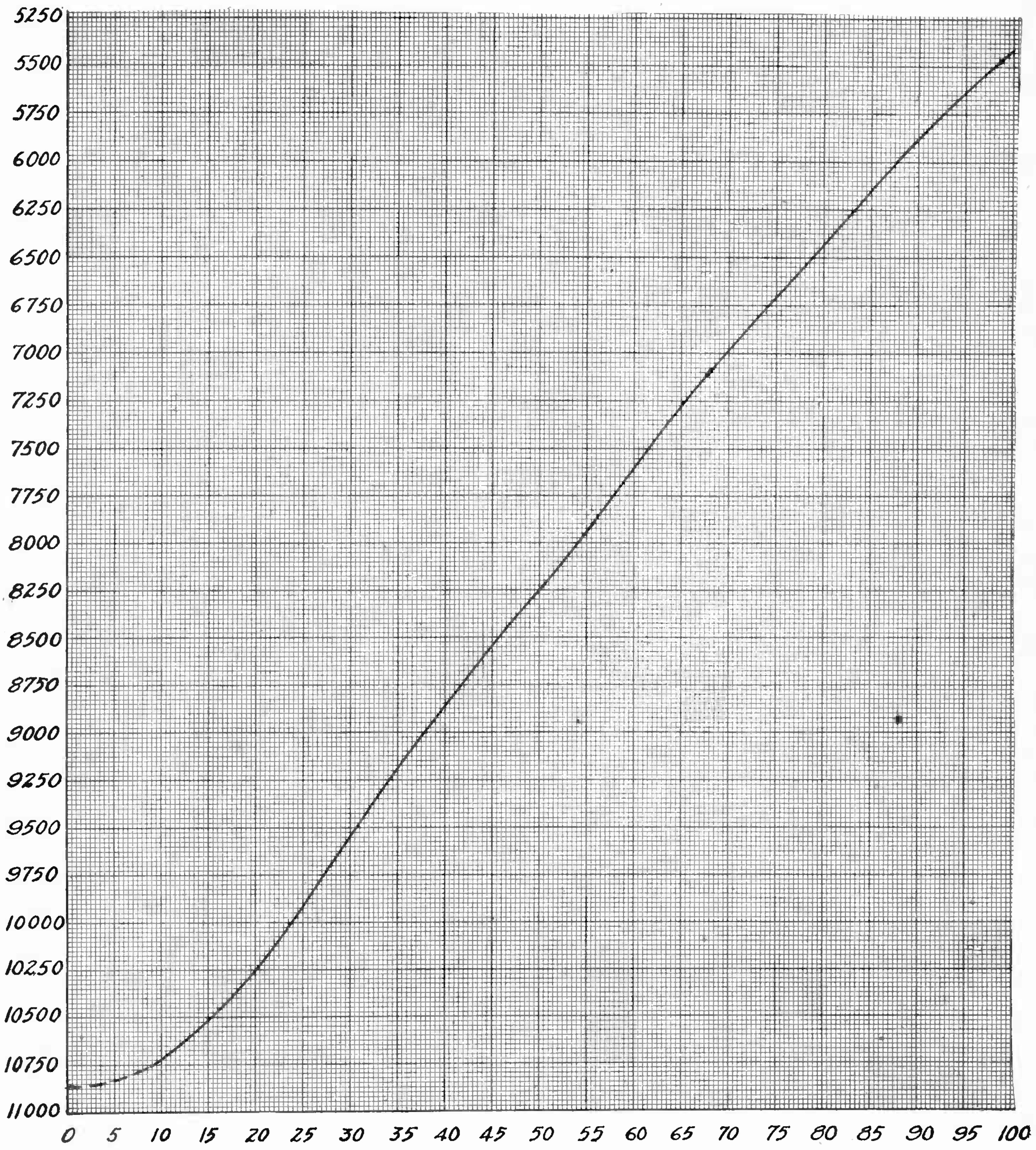
3,340-7,000 kc Chart for Bud 0.00014 mfd. and Black Insuline Plug-in Coil



This is the second of the four charts for the Bud-Insuline combination. The color identifying the coil is that of the whole form itself.

[The circuit diagrams of the generator and receiver used in calibrating are shown on the opposite page. The "receiver" of course may be used as an unmodulated generator, hence as a station finder by the beat method. The four curves apply to condenser with trimmer removed.]

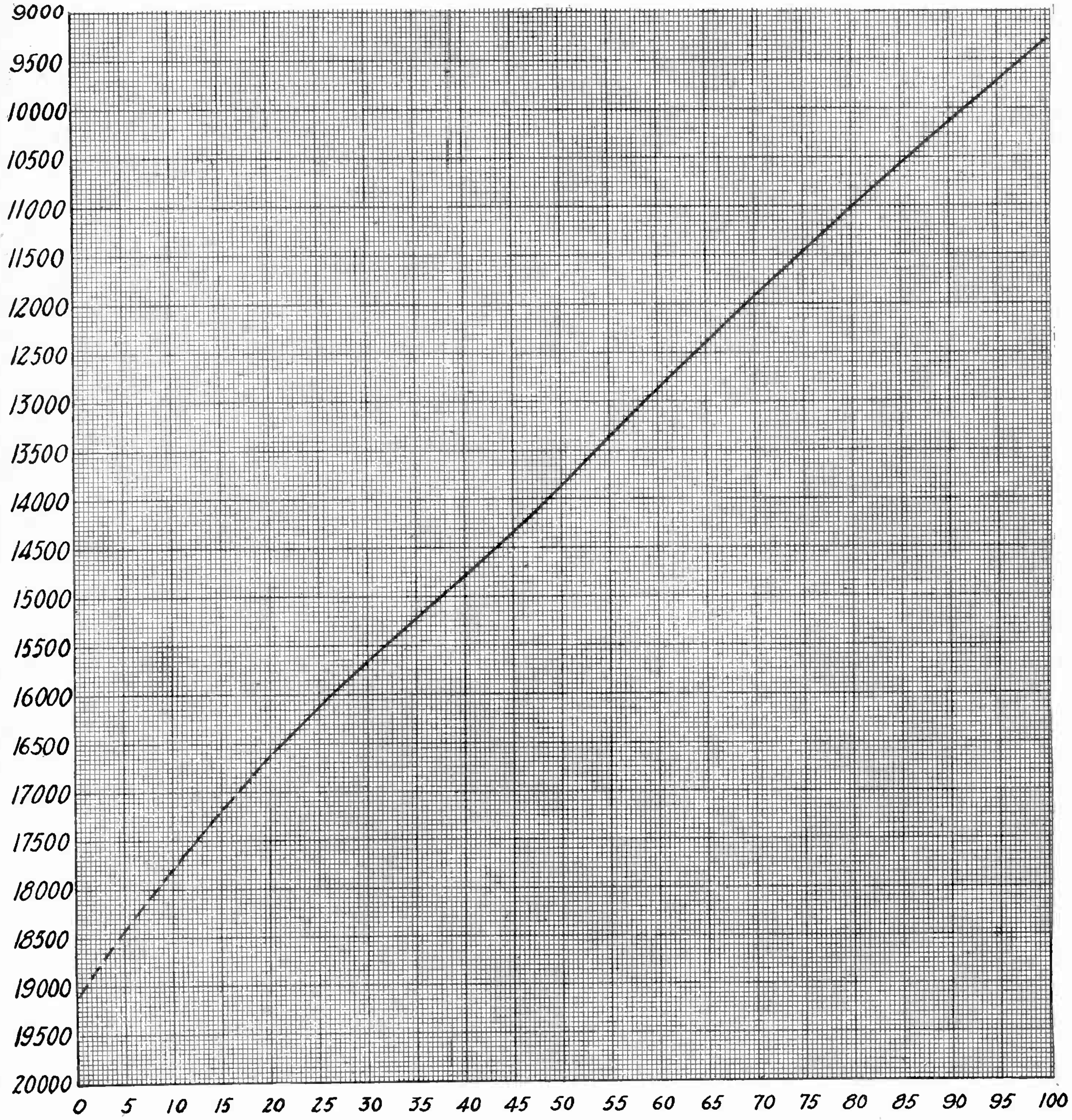
5,400-11,750 kc Chart for Bud 0.00014 mfd. and Brown Insuline Plug-in Coil



The frequencies are given in kilocycles for this series of curves for purposes of consistency. To express values of frequencies in megacycles, divide by 1,000. Thus this range in megacycles would be 5.4 to 11.75.

[*The curves as shown are literal, and no attempt has been made to smooth out any portion, as slight irregularity may be ascribed to the changing impedance effect of the tickler winding. The dashed portion is theoretical.*]

8,700-19,000 kc Chart for Bud 0.00014 mfd. and Green Insuline Plug-in Coil



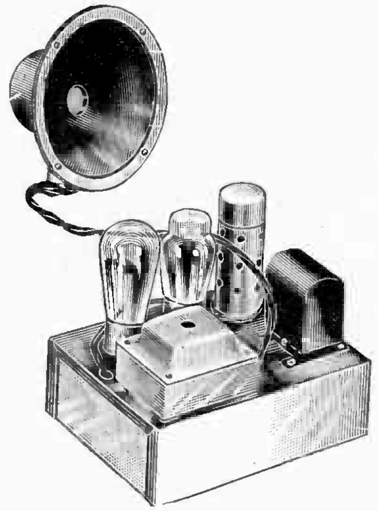
This covers the last band. The dashed portion of the curve, lower left, represents extrapolation. It can be seen, this curve, like the others, is straight frequency line, except for about 20 to 0 on the dial.

Most of the readers who have short-wave sets use plug-in coils of commercial manufacture, and nationally-known condensers, therefore will find their sets calibrated in frequencies by reference to the proper combination of coil and condenser in this series of charts. Possessors of non-calibrated receivers of other kinds, including factory-made all-wave sets, and sets using coils wound by the set constructor himself, will prefer to build an oscillator from any combination and use the oscillator as a station finder. The oscillator should be tuned from the highest frequency limit to the lower-frequency values until the first beat note is established. This beat will disclose the frequency without harmonic complications, otherwise confusing.

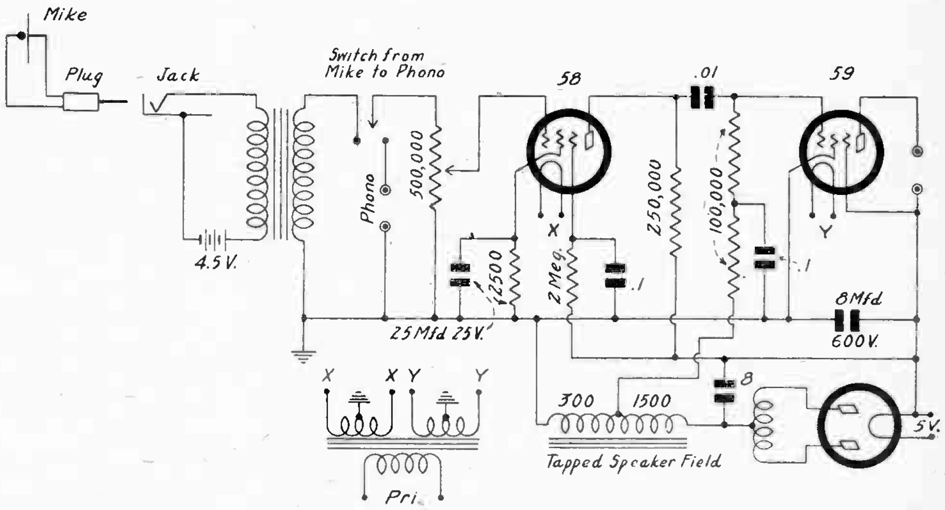
A Portable P-A System

It Weighs Only 23 Lbs. and Has 3½-Watt Output

By Herman Cosman and Sydney Bass
Try-Mo Radio Corporation



The neat arrangement of parts on top of the sub-panel of the portable power amplifier.



The circuit diagram.

THE spring and summer months are most appropriate to devote to public address systems and their possible sales. Every radio man can readily build this portable system at small cost

There are any number of possible markets for a complete portable system. To mention just a few, users of public address systems are swimming pools, dance halls, baseball parks, beauty parlors, picnic excursions, outdoor orators, political functions, seashore entertainments, restaurants, business advertising, office intercommunication, home recording, parks, circuses, fairs, traveling bands and orchestras.

Uses Hand Microphone

There is a wonderful opportunity in this field, and now is the time to start. The Portable P. A. system described is fully self-contained, including a dynamic speaker, the chassis and an R.C.A. hand microphone.

Of the varied selections of tubes manufactured, the types 58, 59 and 80 were the most logical ones to incorporate when space was limited.

All frills are eliminated, cutting down the cost in construction, yet there is high gain.

LIST OF PARTS

One drilled chassis.
One double button mike transformer.
One 500,000-ohm potentiometer.
One 58-socket.
One 59-socket.
One 80-socket.
One 4½-volt C battery.
One power transformer.
One 8-inch dynamic speaker with 1,800-ohm field.
Two 8 mfd. 600-volt filter condensers.
Two 0.1 mfd. 400-volt condenser.
One 2,500-ohm, 1-watt resistor.
One 2-meg., 1-watt resistor.
Two 100,000-ohm, 1-watt resistor.
One ¼-ohm, 1-watt resistor.
One phono tip jack.
One SPDT switch.
One mike jack.
One RCA handmike.
One plug.
One a-c cable.
One 58-tube.
One 59-tube.
One 80-tube.
Assorted hardware.

In checking the circuit, the radioist can readily see how simple it is. All the parts are mounted on a steel metal chassis, including a 4½-volt C battery for the microphone current.

The 58 tube is coupled to the 59 which delivers an output of approximately 3½ watts. The 80 tube is used to supply the plate current. The outfit can be used in conjunction with either a single- or double-button mike, or with a phonograph pickup.

May Be Used on Auto

The power output is sufficient to operate three or four dynamic speakers besides the self-contained speaker, all supplying their own field.

A switch located in the rear enables one to control operations of either microphone or phonograph pickup.

A 6-volt rotary converter, supplying 110 volts A.C., enables one to use this amplifier for automobile or truck advertising installations.

The front cover shows one of the authors alking into the All-Purpose Public Address Outfit. Note the professional appearance of the cabinet. Its graceful lines and compactness will appeal to the constructor and the potential buyer.

Literature Wanted

Readers desiring radio literature from manufacturers and jobbers should send a request for publication of their name and address. Address Literature Editor, RADIO WORLD, 145 *West 45th Street, New York, N. Y.*

Anthony Yeouze (short wave receivers and transmitters), 32 Mulberry St., Buffalo, N. Y.
Master Radio Service, Staples, Minn.
Henry Bauer, 2226 W. Superior St., Chicago, Ill.
Carroll Anderson, 1666 Malasia Road, Akron, Ohio.
Grover E. Kruecke, E.T.S.E., Radio Service, 3011 No. 40th St., Milwaukee, Wisc.
Walter Glardon, Tampashores, Fla.
W. La Marche, Mgr., Radios Repaired, 6224 So. Park Ave., Chicago, Ill.
Al Hayden, 14475 Faircrest, Detroit, Mich.
Tatter's Repair Service, 1510 Columbus Ave., N. S., Pittsburgh, Pa.
Henry E. Jacob. Radio Service, 1708 Mabert Rd., Portsmouth, Ohio.
John Stephens, 425 South Eighth Street, Escanaba, Mich.
Emil Swenson, Room 120, 346 Jackson St., St. Paul, Minn.
R. V. Dodge, Jr., 406 West Ash St., San Diego, Calif.
J. F. Seidel, 906 5th Ave., Altoona, Penna.
R. Del Valle Sarraga, P. O. Box 935, San Juan, Puerto Rico. W. I.
J. B. Reilley, 5 Forest Park, Jamestown, N. Y.
M. Crowe, 130 East Market St., Louisville, Ky.
George Lambert, 1117 Fullerton Ave., Chicago, Ill.

A THOUGHT FOR THE WEEK

WHEN "SINGIN' SAM" announced he was going on the air for a beer concern we made up our mind that we didn't care what program he was on so long as he sang. This human chap, who made so many friends when he was on the Barbasol program, is one of those cheerful singers who make new friends every time he sings a number. He has a fine voice—natural, rich and appealing, and it hasn't been trained down to the point where it has lost any of its native depth and feeling. If radio had more singers like Harry Frankel there would be fewer unturned knobs these pleasant evenings.

Converter Results

How to Achieve Tuning Success for Short-Wave Reception—Connections Detailed

By Steve Erdel

Chief Engineer, Experimental Radio Laboratory

I HEARD persons say, "I wouldn't give a cent for all the short-wave converters," but I also heard persons say they wouldn't trade their converter for any short-wave set.

Analyzing the reasons why some do and others don't get any good results with a short-wave converter, we find three:

First, the set is not suitable to be used in conjunction with a short wave converter.

Second, the converter is not connected properly, or not operated properly.

Third, the converter is not designed properly.

The Principle

Let's start off with the first point, the suitability of the set. To understand this part, we have to know how a short-wave converter works. Since we know that in a superheterodyne we have the first detector, oscillator, intermediate frequency and power amplifier, we find that the short-wave converters incorporate the first detector and the oscillator, the set being used as the intermediate frequency and audio amplifier. Thus, one has really a short-wave superheterodyne receiver.

But not all the sets are suitable to be used as intermediate-frequency amplifier. The only requirement is that the set should be fairly sensitive. Any superheterodyne will undoubtedly do. That does not mean that a t-r-f set isn't just as good! There are a lot of old-time sets, some of them are better for short waves than a lot of today's products. If your set is fairly sensitive on the highwave, that is, if you can tune in a few out-of-town stations, your set will be o.k. for short-wave.

Through my previous experiments I found that many times the converter was all right, the set all right, and still the report was adverse. These cases are due to the converter not being connected or tuned properly. A converter usually has three wires, one you connect to the ground post on your set and leave the ground wire on the set also. You disconnect the outside antenna from your set and connect it instead on the converter wire marked "Ant." The third wire on the converter is marked "Ant. Post." Connect it to the vacated antenna post of your set.

Some very cheap converters have no power supply. They take power from your set. That's the fourth wire.

The first thing to do to tune a converter properly is to see that the converter is equipped with a fine high-ratio dial, not just an ordinary common dial, or mere knob. Tune slowly. Imagine that for every division on the dial there are at least ten stations operating.

The other important factor is you shouldn't leave the broadcast set tuned to a broadcast station.

The Receiver Frequency

Usually the best results are obtained when the set is tuned around 570 kc. Leave your set on a stationless spot, and only then start to tune in short waves on your converter. Using the converter over and over again, have your set tuned always on the same spot in order to receive the short-wave stations on the same dial reading or number.

One of the biggest factors for good short-wave reception is the converter itself. It's got to be designed right. The coils should be calibrated for the right frequency, and the best parts should be used for best results.

If any information is desired on short-wave converters, you may write to the author in care of RADIO WORLD, 145 West Forty-fifth Street, New York, N. Y.

The Radio University

Static's Strange Behavior

WHEN I TUNE my short-wave set I sometimes run into fierce flashes of static. It sounds like cannons going off. However, I am at loss to understand this, because if I shift the band I don't hear this interference. What is the cause?—K. C. S.

The cause of the interference is static. While this may be considered as present in the common medium through which radio waves travel, it is one of the mysteries of short waves that the static is not heard in some bands at all, though fierce in others.

* * *

Ratios Change

IN CONSTRUCTING a short-wave set that uses a regenerative detector, I desire to build my own coils, and also calibrate the set. Can you tell me whether, if I strike the frequency ratio for one band, it will hold for the other bands?—K. L. C.

No, it will not hold. The rule is that as the band of frequencies increases, so does the frequency ratio. Assume that for the intermediate short-wave band the ratio is 2. Thus, if you start at 1,600 kc you strike 3,000 kc at the other end. But for the next band the ratio might be 2.05 and for the next 2.1. The principal reason is the reduced distributed capacity, due to fewer turns on coils, and to smaller capacity effect of fewer-turn ticklers on secondaries of smaller coils.

* * *

Hears Upper Frequencies

WHEN I TUNE my short-wave set and hear a station on a much higher frequency than the one that the set is supposed to be tuned to, what is the reason?—J. C.

If the set is of the t-r-f type, including regenerative sets, then if the weak response is from a station of twice the frequency to which the set is tuned, the cause is the presence of second harmonic content in the r-f amplifier and detector tubes. This is a rare occurrence, from an audibility viewpoint, since the harmonic content is present, but usually too weak to actuate the earphones. However, if the regeneration is made extremely strong, the possibility of response at the higher frequency becomes more pronounced, because regeneration is more effective on weak signals than on strong ones. Bearing in mind, though, that regeneration is set for the fundamental, it is strange to hear of response at the second harmonic. If the detector is turned into a regular oscillator, and generates its own frequencies that way, the possibility of second harmonic response is greatly increased, but also the likelihood of being able to hear the program is small. If your set is a superheterodyne a higher frequency of response might be due to insufficient r-f selection ahead of the modulator, whereby a frequency equal to the oscillator frequency plus a station frequency gets by the intermediate amplier. For instance, if you are tuned to 5,000 kc, the oscillator for a 465 kc superheterodyne is at 5,465 kc, but 5.465 kc also serves for 5,000+465 kc, or 9,465 kc. This is called the image.

* * *

Separate Volume Control

IS IT NECESSARY on a short-wave regenerative set to have a volume control in addition to the regeneration control? I find regeneration is a volume control, too.—I. D.

It is advisable to have the separate volume control, because then to reduce the volume you do not have to reduce the selectivity at the same time. Suppose you wanted to cut down volume and keep selectivity high? How would you do this if the regeneration control were the sole volume variant?

* * *

Tickler Turns

IS THE NUMBER of tickler turns the same for all types of tubes in short-wave detectors, or, if the number is different, what rule shall I follow?—J. S. C.

Number of tickler turns depends on how close the tickler is to the secondary and also on the type of tube. Assuming some given number of turns and a certain coupling, using a low-mu tube, the number of turns has to be increased materially if a high-mu tube is used as regenerative detector. For instance, when 1-inch diameter has 47 turns of No. 26 enamel for the intermediate short-wave band, using a 30-tube, the tickler consisted on 18 turns of No. 32 enamel wound over the secondary, 0.02-inch insulation between, but when the 19 tube was used the tickler had to have 27 turns.

* * *

Wants Compulsion

IS THERE ANY WAY we can get foreign stations to announce every fifteen minutes what their call letters and frequency are?—K. D.

No, there is not. While listeners often want just that information, rather than merely to listen to the program, nevertheless the stations are on the air for the purpose of having persons listen to their programs, and not particularly to their call letters and frequency announcement, which do not constitute entertainment of any particular value. However, we sympathize with you, and sometimes feel the need of some such compulsion, but there is no sanction behind it.

A Voltage Supply
for Cathode-Ray Tubes 905 and 906

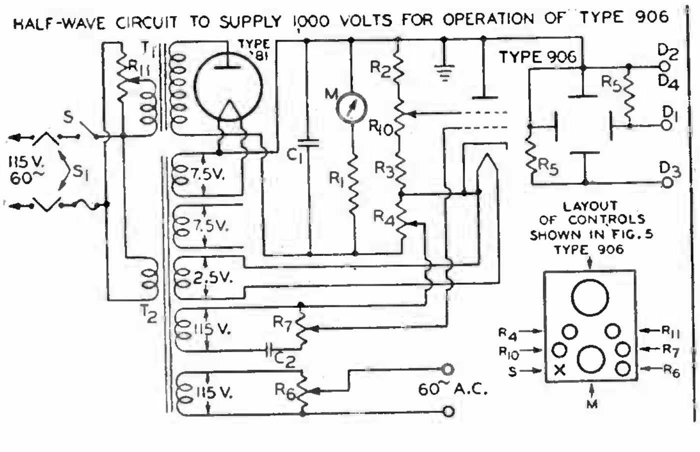


FIG. 1

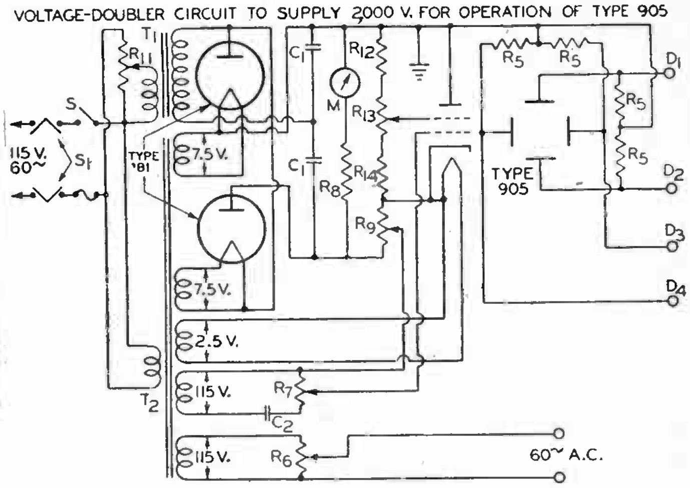


FIG. 2

Circuits of the power supply and cathode-ray tubes, 1,000 volts at left, 2,000 volts at right.

THE cathode-ray oscillograph is becoming increasingly popular as new applications in the laboratory and in the radio industry are found for it. This popularity is chiefly due to the simplicity of construction, convenience of operation, portability and low cost of modern oscillographic equipment employing cathode-ray tubes.

Our experience with various oscillographic applications has shown that the equipment required for all usual purposes can be constructed at low cost, can be made portable enough to be carried about by hand and is simpler to construct than the power supply for an a-c operated radio receiver.

In this Application Note we will show circuits and design information for voltage supplies for the 905* and 906 (3-inch and 5-inch cathode-ray tubes) and will give illustrations of a small portable oscillograph which has been found very convenient for laboratory use and admirably suited to many industrial applications. This oscillograph, shown in Figs. 5 and 6, is constructed in a case whose outside dimensions are 17 inches in length, 8 inches in height and 6 inches in width.

Voltage Supply

The d-c voltages required are 1,000 volts maximum for the 906 and 2,000 volts maximum for the 905. The transformer specified is designed to supply 1,000 volts in a half-wave rectifier circuit and is also used for the 2,000-volt supply by employing two half-wave rectifier tubes in a voltage-doubling circuit. The design specifications for this high-voltage transformer are included in this Note under our identification number S-122. Specifications are also given for the filament and timing-voltage transformer, identified as S-124. Both of these transformers have been designed to have small physical dimensions. Design data are obtainable from RCA Radiotron Co.

If it is inconvenient to obtain a transformer such as the S-122, any transformer capable of supplying to the rectifier a peak voltage of 1,000 volts at 5 miliamperes may be used. The desired rectified d-c potential is assumed to be equal to the peak voltage provided the charging of the condenser C_1 (Figs. 1 and 2) takes place during a small part of the a-c cycle and provided the direct current taken from the condenser is so small that the condenser voltage is practically constant throughout the cycle. This assumption is justified when a low value of ripple is a design requirement.

The value of condenser C_1 depends upon the amount of ripple that can be tolerated and the permissible ripple in turn depends upon the application of the cathode-ray tube. When too much ripple is present, it varies the potential on the control grid of the cathode-ray tube and produces flicker, or an intermittent trace, and also some defocussing of the beam. Also, if the ripple is too great, hum may become troublesome in the anode circuit and manifest itself in distortion of the image. In general, the ripple voltage for good filtering should not exceed one per cent.

The curves of Fig. 3 show per cent. ripple voltage vs. effective load in megohms for the various values of filter capacity C_1. To illustrate the use of these curves, let us take an example. In Fig. 1 the parallel resistance of the voltage divider and the voltmeter is 1.4 megohms. From Fig. 3 the corresponding capacity for one per cent ripple voltage is read as approximately 0.3 mfd. The voltage supplies of Figs. 1 and 2 employ a capacity C_1 of 2 mfd. and have a ripple of only 0.2 per cent.

Fig. 4 shows the voltage regulation for the 1,000-volt and 2,000-volt supplies. These curves indicate that the desired maximum voltages of 1,050 volts for the half-wave circuit and 2,050 volts for the voltage-doubler circuit are obtained when the load current is adjusted to 0.5 miliampere and 1.5 milliamperes, respectively. In each case, these voltages include an allowance of 50 volts to provide for control-grid bias of the 905 or 906 tube. This bias is taken from the potentiometers R_4 and R_9 (Figs. 1 and 2).

VALUES OF COMPONENT PARTS FOR FIGS. 1 AND 2.

C_1 = 2 mfd. (1,000 V.)
C_2 = 0.015 mfd. (200 V.)
R_1 = 5 Meg.
R_2 = 1.0 Meg.
R_3 = 0.4 Meg.
R_4 = 0.1 Meg.
R_5 = 1 to 10 Meg.
R_6 = 50,000 Ohms.
R_7 = 50,000 Ohms.
R_8 = 10 Meg.
R_9 = 30,000 Ohms.
R_{10} = 0.5 Meg.
R_{11} = 1,000 Ohms.
R_{12} = 0.75 Meg.
R_{13} = 0.4 Meg.
R_{14} = 0.25 Meg.
M = Microammeter (0-200).
S = Switch.
S_1 = Interlock Safety Switch.
T_1 = Transformer, Design Identification No. S-122.
T_2 = Transformer, Design Identification No. S-124.

Small Anode Current

The anode current of either the 905 or the 906 is very small and normally does not exceed 200 microamperes. Care should be taken that the combined bleeder and anode current is not so high as to reduce the anode voltage below the desired value. The resistance values shown for the voltage dividers of Figs. 1 and 2 were selected to provide as large a bleeder current as is consistent with voltage requirements in order that the anode current might be a minimum percentage of the total divider current. This was done to insure optimum voltage regulation from the divider when adjustment either of anode No. 1 voltage or of the control-grid voltage is made. The regulation curves and divider values are based on an input supply of 115 volts to the primary of transformers S-122 and S-124.

If a voltage divider of lower resistance is used so that the anode current becomes a sufficiently small percentage of the bleeder current, defocussing due to adjustment of the control-grid voltage will be minimized and readjustment of the anode voltage made unnecessary.

In case a high-voltage transformer other than the S-122 is used, and its regulation permits operation with higher bleeder currents than those discussed above, the voltage divider should be designed to supply to anode No. 2 a voltage approximately one-fifth of that (the maximum) applied to anode No. 1 and to supply a negative bias of from 45 to 50 volts to the control grid.

There are two 115-volt secondaries on the filament and timing-voltage transformer. One of these is used to supply the control grid with a voltage of the same frequency as that of the spreader voltage, in this instance, 60 cycles, but 90° out of phase. This procedure causes a brightening of the front wave and a darkening or elimination of the back wave of the screen trace and thus simplifies the pattern for purposes of frequency determination or wave study. The other 115-volt winding provides the 60-cycle timing voltage for one pair of deflection plates. These plates are connected to terminals on the case

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* The same voltage supply can also be used to provide 2,000-volt operation of the 903 and 904 cathode-ray tubes.

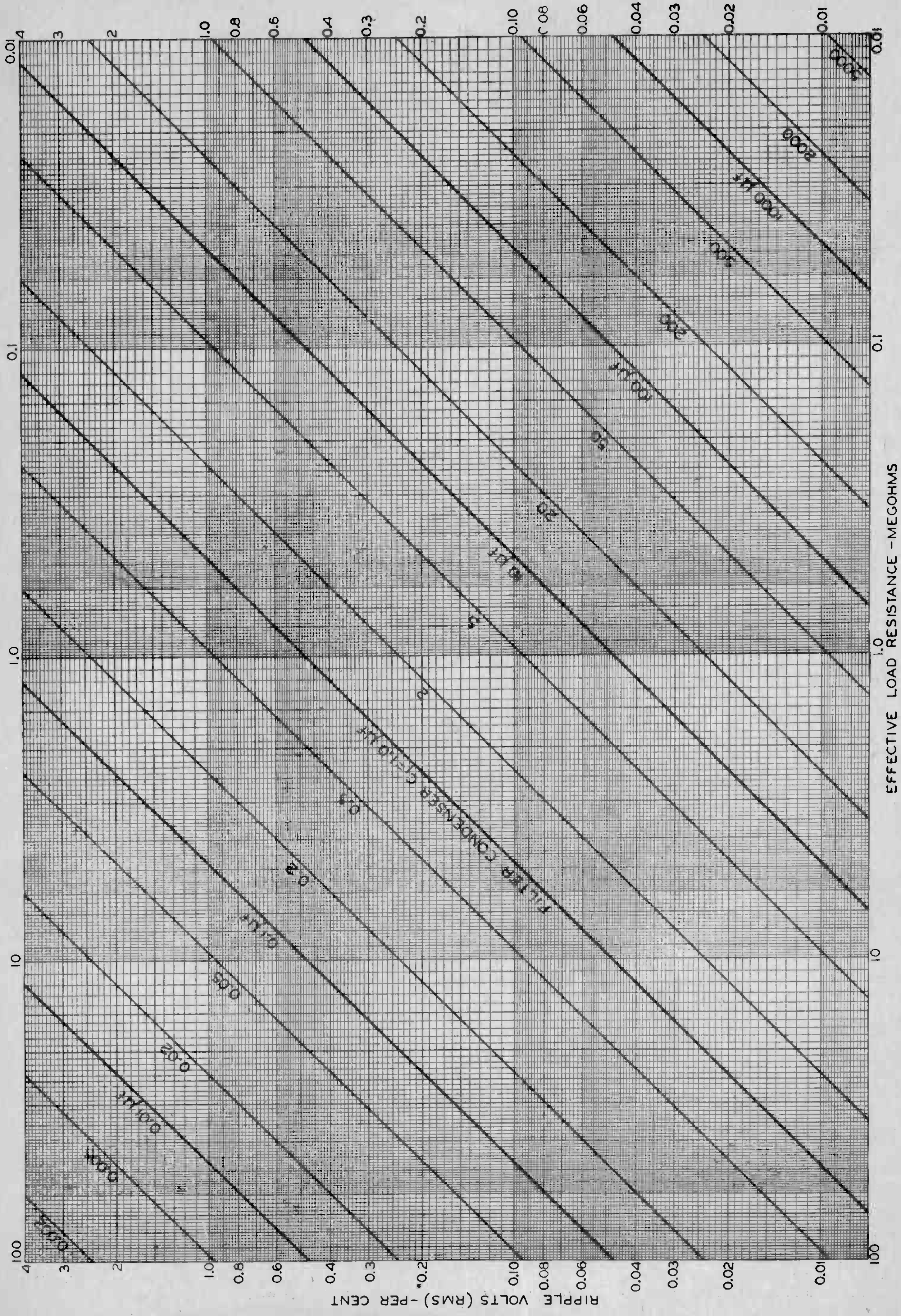

FIG. 3

Filter design considerations for the power supply of cathode-ray tubes.

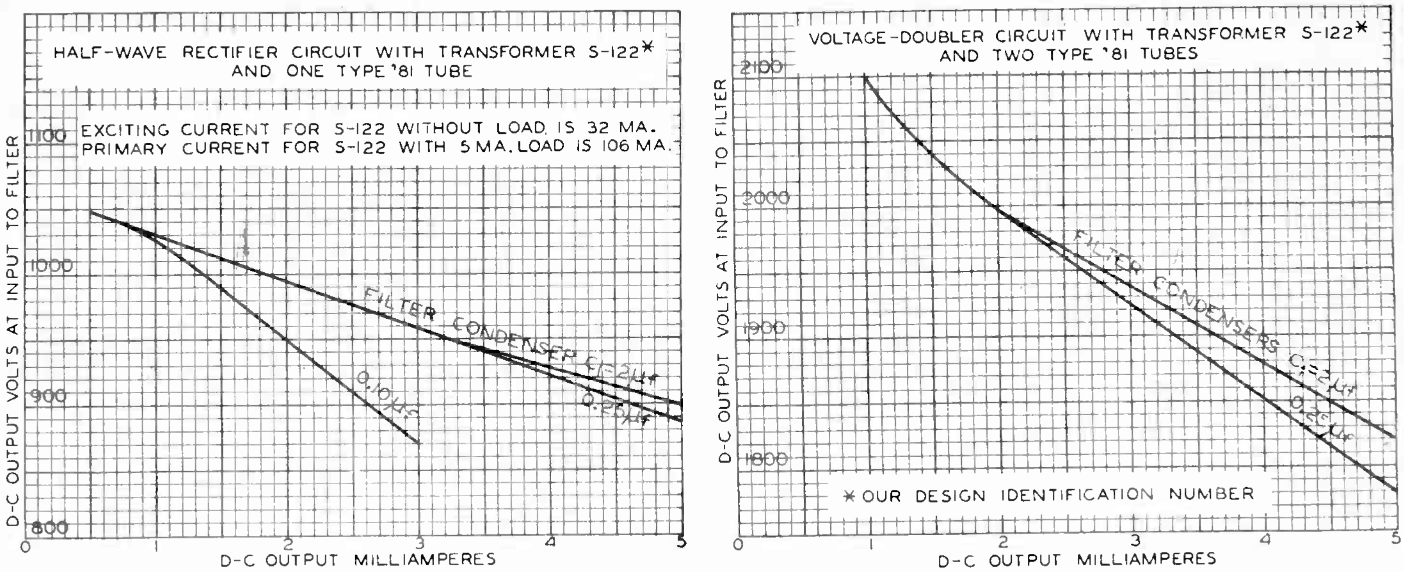

FIG. 4
Regulation characteristics of Figs. 1 and 2. At left, for a single 81 tube, at right for two 81 tubes.

(Continued from preceding page)
of the instrument in order that a voltage for any other timing-axis frequency may be conveniently utilized. The 905 may require at times a timing voltage of 220 volts.

It is important that precautions be taken to prevent the user from coming in contact with any high voltage. These precautions should include grounding the case of the instrument during operation, discharging the condenser before the case is opened and completely enclosing all parts carrying the high voltage. An interlock switch should be used to break the power-supply circuit when the case is opened.

As previously stated, this compact cathode-ray oscillograph has been found very useful in our laboratory. It has provided a ready means of making frequency determinations, examining wave forms, checking percentage modulation and observing voltages of high or low frequency. It can also be used as an indicator for h-f bridge measurements.

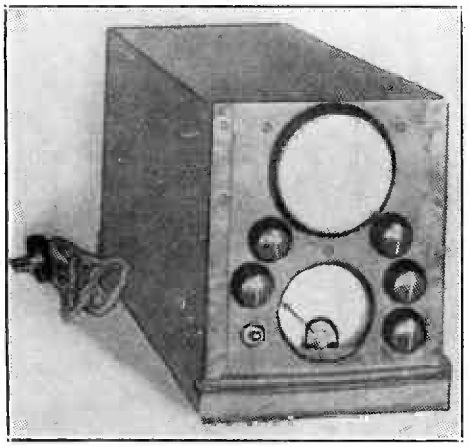

FIG. 5

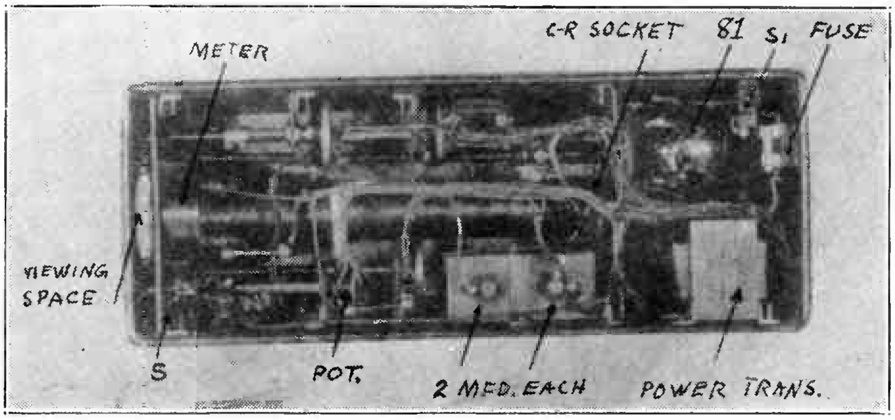

FIG. 6
Underneath view of the c-r outfit.

STATION SPARKS

By ALICE REMSEN

AS I WRITE THIS a most terrible disaster is happening in Chicago. The first inkling that came to us of the Chicago fire was via radio. I can hear the crackling of the flames, jangling fire-bells, and the rush of water, as thousands of volunteer and regular firemen endeavor to overcome the awful blaze. The radio men deserve a lot of credit for sticking to their posts under such conditions. One more instance of the power of radio in time of disaster. . . . Jessica Dragonette is to make a film for Paramount. She will not go to Hollywood, as the filming will be done in Astoria, Long Island. . . . Ralph Kirbery will begin a new series of programs over WJZ on June 3rd, Sundays at 11:30 a.m. EDST. . . . Painting or a musical career. This was the decision which the young basso, Alden Elkins, had to make a few years ago in Somerville, Mass. Music won and New England lost a promising young artist. Some of Elkin's oils and charcoals are now hanging in Bay State galleries. Elkins got his first chance in radio with Station WBZ, the NBC affiliate in Boston. He still continued his art studies, however, at that time, and if he had not won first prize in the Atwater Kent Auditions of 1931, he might have turned permanently to painting; as it is, he is now heard over NBC networks from Radio City each Sunday at 9:45 a.m., EDST on his own program over WEAF, and on other broadcasts. . . .

When Jack Benny first met Mary Livingstone he didn't like her. Jack, who felt himself quite grown-up, went to visit her older sister, and Mary, who was then a maddeningly mischievous child of twelve years, was rather contemptuous of Jack's dignity. But he married Mary instead of the sister—and he's not sorry, either! . . . Joe Cook, Broadway's latest contribution to the air-waves, has come to the microphone to stay. The popular comedian has been so successful as the host of the Colgate House Party broadcasts over a nation-wide NBC-WEAF network, that an option has been taken on his services until the end of 1935. . . . Ed Lowry, former vaudevillian and master of ceremonies, now heard over NBC networks, twice a week, was destined to be a lawyer, according to his parents and teachers, but Fate and Ed ordained otherwise, and Gus Edwards, that perennial picker of talent, started him on his way in "School Days," and Ed has been going ever since. . . . Johnny Marvin, the singer from the plains, is back on the air, after taking his first vacation in eleven years. Johnny is heard four days a week over WEAF and network at 12:15 p.m. . . .

Well, for goodness sake! So Phil Davis, of WLW, you have lost thirty pounds in the last sixty days, that's half a pound a day; keep it up, Phil, and you'll be as sylph-like as Bill Stoess! . . . There is a new quartet on the Columbia air-waves—the Beale Street Boys—from way down south, a discovery of Morton Downey. They are heard each Wednesday and Friday at 6:45 p.m. . . . And speaking of Downey, he is now in Chicago at the Chez Paree Supper Club; his network programs are relayed from there. . . . Nick Lucas is proud of the title "crooner"; but then Nick was one of the first of those soft-voiced boys to raid radio. . . . And Colonel Stoopnagle insists that what this country needs is a good five-cent cigar without the scent. . . . "Maxne" is a new songstress to be heard via the Columbia air-waves and WABC, with Phil Spitalny's Orchestra and Ernest Chappel as master of ceremonies, under the sponsorship of Cheramay, Inc., each Friday at 10:30 p.m. EDST. . . . Another Southerner has made the grade at Columbia; he's Jerry Cooper, baritone from New Orleans, who plays trombone and guitar, and sings rather well; has been given a series of programs each Tuesday and Thursday at 4:30 p.m. Take a listen; he is pleasing.