RADIO WORLD

REG. U.S. PAT. OFF.

The First National Radio Weekly
641st Consecutive Issue *Thirteenth Year*

JULY 7
1934

NRA

15¢
Per Copy

One-Tube DX Sets

Padding Supers
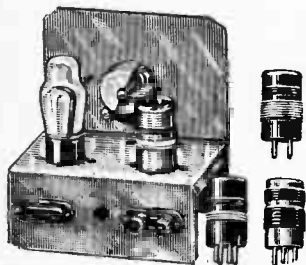
The RGH-4, A.C. & D.C.

SCOUT UNIVERSAL PORTABLE

The Scout Universal Portable, for Broadcasts and Short Waves. See pages 15 and 16.

Two Oscillators
For Generating Very High Frequencies
By J. E. Anderson and Herman Bernard

FIG. VIII-13
A high frequency oscillator circuit (left) in which the tuned coil consists of a single turn of wire and the tickler consists of one and a half turns.
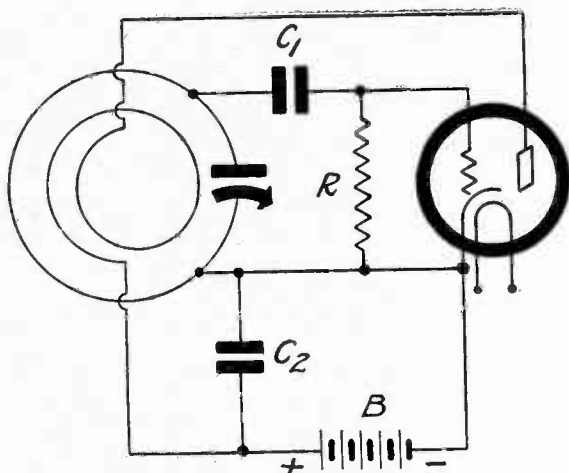
FIG. VIII-14
This circuit (right) is an ultraudion in which the inductance consists of a single turn.
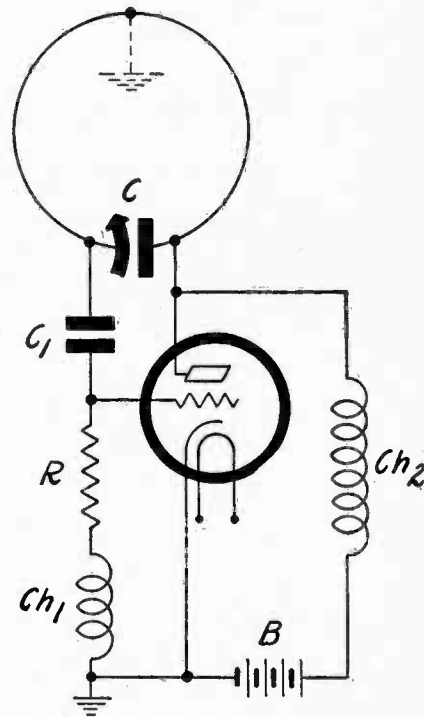
IF THE frequency of oscillation is to be 30 megacycles or higher the coils become simple. Sometimes the entire inductance system consists of a single turn of heavy wire, sometimes of two turns, one for the tuned winding and the other for the tickler. Two such simple circuits are indicated in Figs. VIII-13 and 14. The first of these is of the tuned-grid type in which the tuned winding consists of a single turn of heavy wire closed by the tuning condenser and the tickler consists of one turn and a half. The tickler is larger than the tuned winding because, as a rule, this must be the case if oscillation is to be maintained at the higher frequencies. This follows from the fact that the tickler is partly shunted by the plate-cathode capacity, as has already been discussed. While the grid and cathode connections to the tuned turn are not shown to be near the condenser, they should be as close to it as possible, because to connect them physically as indicated in the drawing would make the coupling to the grid very loose. Chances are there oscillation could not be induced with any tickler.

One-Turn Ultraudion

The second circuit, Fig. VIII-14, is an ultraudion but it may be converted to a Hartley, in appearance at least, by grounding a point of the single-turn inductance near the middle of the turn. This is indicated by a dotted ground symbol. When the circuit is so connected it is customary to call it a Hartley, but it may in fact be a doubly periodic circuit, or tuned plate tuned grid. It is best to avoid this circuit, for the ultraudion is a better oscillator at the higher frequencies.

While the plate of the ultraudion is fed through a choke, Ch2, connected directly to the plate, this coil may also be connected to the center of the coil. Doing this does not convert the circuit to a

Hartley, but it remains the same type as when the choke is connected as in the drawing.

In the ultraudion there is a radio frequency choke, Ch1, in series with the grid leak R. In high-frequency oscillators, especially those to be used in transmitters, it is customary to arrange the grid leak this way. Avoidance of blocking of the grid necessitates the use of a very low impedance in the grid circuit; but as such a low resistance partly shorts the grid, the choke is inserted to maintain a very high impedance. This choke is not needed in an oscillator that is to be used in a receiver or short-wave converter, for in these applications the intensity of oscillation should be low for best results. It does not matter, then, whether the leak is low and the oscillation weak, provided that the circuit actually does oscillate. A resistance of 10,000 ohms is all right in a receiving circuit oscillator, but such a low value should not be used unless blocking of the grid forces it.

A Crystal Oscillator

In many short-wave receivers crystal oscillators are used for the purpose of supplying a steady oscillation of the intermediate frequency. There are many circuits which can be used for this purpose, but the one shown in Fig. VIII-15 is about as simple and satisfactory as any other. X is the quartz crystal which must be ground to a particular frequency. G.L. is a grid leak of comparatively low value, and RFC is a radio frequency choke. This circuit, therefore, is an illustration of the choke-resistance grid leak discussed in the preceding paragraph.

It will be noticed that there is a resonator in the plate circuit of the tube. The plate of the tube is connected to a tap on the

Padding of Supers
Using Three Tie-down Points
600, 1,000 and 1,450 kc.

WHEN two alternating voltages of different frequencies are impressed simultaneously on the same detector, one of the components of the output of the tube is a current having a frequency equal to the difference between the frequencies of the impressed voltages. The two original waves are said to beat, or to heterodyne, and to produce a beat, or a heterodyne current. The frequency of this heterodyne current may have any value whatsoever, for the two beating frequencies are entirely unrestricted.

The value of the frequency of the beat current can be varied at will by varying the frequency of either of the voltages producing it. If one of the voltages is a radio-frequency signal arriving from some distant transmitter, no means is at hand, at the receiver, for varying its frequency; but if the other voltage is generated in the receiver, we can vary its frequency to suit our purpose, and by this variation we can also vary the beat frequency. If the incoming radio-frequency voltage is modulated, and if the locally-generated auxiliary frequency is not, the modulation will appear on the beat frequency current in the same form as it appeared on the original carrier. The first detector tube, or mixer as it is also called, has only effected a change in the carrier frequency, the amount of the change being determined by the auxiliary frequency. The beat frequency carrier may be selected by appropriate resonators and then amplified to any desired extent. If it is then detected in the usual way, the modulation frequencies will appear in the output of the receiver just as they would have done had the carrier frequency not been changed.

The Principle of the Superheterodyne

The superheterodyne type of receiver is based on the amplification and selection of the heterodyne carrier produced by the beating of a modulated radio carrier with a locally-generated frequency. Tuning this type of circuit is done primarily by varying the auxiliary frequency for different station carriers, and in that manner maintaining the heterodyne frequency between the locally-generated source and some given signal carrier frequency constant. When tuning is done in this manner, the resonators that select the heterodyne frequency component are invariable. That is to say, they are left tuned to a fixed frequency, which had previously been determined, and they are not at all changed during the process of tuning. The fixed frequency is usually called the intermediate frequency in a superheterodyne. The constancy of the frequency, however, is not essential to the superheterodyne principle; neither is the method of tuning just explained, for the superheterodyne may have a variable intermediate frequency and the tuning may be done by adjusting the frequency of resonance of the heterodyne selectors. The fixed-frequency superheterodyne is the more practical and is the one usually employed.

Image Interference

As was just explained, the tuning of a superheterodyne is done primarily by varying the frequency of the auxiliary oscillator, which is accomplished in most instances by varying the capacity of a condenser. This tuning, however, is not enough for if there is only a frequency change to a lower level, the auxiliary frequency will bring in two different signals. This follows from the fact that the same difference frequency will be generated whether the local oscillator frequency is greater or less than a signal frequency by a fixed amount. The two signals will be brought in simultaneously if the local oscillator frequency is half way between the two signal frequencies and if their difference is equal to twice the value of the fixed frequency of the intermediate resonators. Intolerable interference will result if this condition is permitted to obtain.

There is only one way of eliminating this image interference, as it has been called, and that is by suppressing one of the radio-frequency carriers capable of producing the intermediate frequency. This may be done either by trapping out the undesired signal or by building up the desired carrier by means of resonance. The second method is almost universally adopted because of its greater simplicity. Naturally, both methods may be combined, that is to say, a rejector circuit may be used for suppressing the undesired carrier and an acceptor circuit for intensifying the desired signal.

Radio Frequency Tuning

The simplest arrangement consists of two or three radio-frequency tuners through which the signal must go before it will reach the mixer tube. These will be tuned to the signal desired. If there is no stray coupling between the antenna and the mixer tube, which would permit the radio frequency signals to reach the mixer without going through the selector, and if the tuned circuits are reason-

High-Frequency Oscillator Circuits
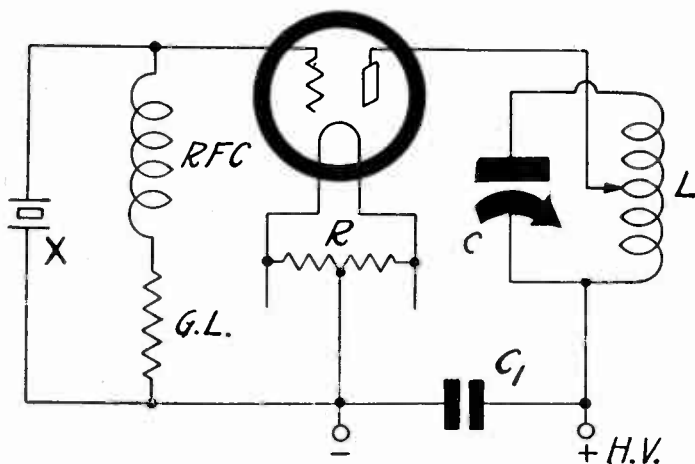
FIG. VIII-15

One of the simpler crystal oscillator circuits. The crystal is put in the grid circuit and the plate is tuned nearly to the same frequency as the crystal.

FIG. VIII-16

Cross section of a simple quartz crystal mounting. The crystal rests on one brass plate and another and lighter brass plate rests on the crystal.

(Continued from preceding page)

coil L, rather than to the top of the resonant circuit. The correct position of the tap on the coil is that which makes the circuit oscillate most satisfactorily. This is the point at which the impedance of the crystal is equal to the impedance of the output circuit of the tube. It may be that when there is a match the crystal will oscillate too violently, which will manifest itself by excessive heating of the crystal or actual breakage. To prevent this occurrence the voltage applied to the plate of the oscillating tube should be low. There is no reason whatsoever why the oscillation should be intense when the only purpose of the oscillator is to provide a local signal of

high constancy for beating or heterodyning against the incoming signal. A method of mounting the crystal is illustrated in Fig. VIII-16, a drawing that is self-explanatory in so far as the construction is concerned. The crystal is resting on one brass plate and another brass plate is in turn resting on the crystal. The top plate is so light that it causes slight damping or change of frequency of the crystal. The large brass plate should be connected to the low potential side of the circuit, that is, to the center of the balancing resistance R on the filament. It will be noticed that the structure of the crystal mounting is such that it forms a condenser. For that reason no other grid stopping condenser is necessary in the circuit.

ably selective, two acceptor circuits in tandem are enough to suppress the image interference adequately, provided that the intermediate frequency is not lower than about 150 kc. Of course, the two circuits would have to be tuned accurately to the same frequency if any great gain is to be secured by radio frequency tuning. The radio-frequency circuits must track with each other and also with the oscillator by the difference required by the intermediate frequency.

Tracking

While it is essential that the radio-frequency tuners be selective and that they track well, this is not sufficient for the elimination of the image interference, nor for the making of a sensitive superheterodyne. It is necessary that the oscillator track with the radio-frequency tuner because the oscillator frequency determines when a given signal comes in, that is, when the heterodyne frequency between the given signal and the oscillator frequency is equal to the fixed intermediate frequency. In order that the circuit as a whole be sensitive and selective, it is necessary that the radio-frequency tuner be exactly in tune with the desired carrier when the heterodyne frequency is exactly equal to the fixed intermediate frequency. This condition must be fulfilled at every setting of the oscillator control, whence it follows that there must be close tracking between the oscillator and the radio-frequency tuners. The preciseness of this tracking determines, in a large measure, the excellence of the receiver as to sensitivity and selectivity.

The tracking problem is complicated by the fact that the difference frequency is constant whereas the beating frequencies are both variable. Theoretically, a simple solution of the problem would be to have tuners, both for the oscillator and the radio-frequency circuits, in which the frequency of resonance would be strictly proportional to the angular displacement of the tuning condensers. But such condensers are extremely difficult to produce. Therefore, the tracking must be accomplished in some other manner.

One way in which the problem has been solved is by special design of the condensers. The condensers used in the radio-frequency tuners are alike and are of no special design. The oscillator condenser, however, is designed to have a different rate of change of capacity. This means that the rotor plates, and sometimes also the stators, are shaped differently from the corresponding plates of the radio-frequency condensers. If the design is right, close tracking is attained.

This method of tracking seems to be the ideal arrangement, yet it has its drawbacks. For example, a condenser that has been designed for an intermediate frequency of 175 kc is not good for any other frequency, for the relative difference between the condenser plates is a function of the intermediate frequency. Also, it is necessary to hold the inductances in the circuits within close limits.

Padding

There is another method of making the oscillator track with the radio-frequency circuits, and that is by padding the oscillator circuit. This means that the oscillation circuit is treated to make the rate of change of frequency such that the difference between the oscillator frequency and the natural frequency of the radio circuits is always constant. This requires a special choice of inductance, a fixed condenser in series with the variable oscillator condenser, and a small fixed condenser in shunt with the variable or with the variable and the series condenser. This arrangement is applicable to the case when the oscillator frequency is greater by a constant amount than the signal frequency, the usual practice.

There are three different cases of padding, and these are illustrated in Fig. IX-1. In each of the three cases the simple circuit on the left represents the radio-frequency tuner, or one of several identical radio-frequency tuners, L being the inductance and C the capacity in that circuit at any given setting. In each case the circuit marked Osc. is the padded oscillator circuit. Lo is the inductance, C is the variable portion of the capacity, assumed always to be equal to C in the radio-frequency circuit, Cs is the series capacity, and Cm is the minimum capacity in the oscillator circuit, not counting the minimum of C itself.

Case 1 differs from the other two only in the treatment of the minimum, and this difference will be brought out later. Cases 2 and 3 differ from each other only in the disposition of the minimum capacity, in Case 2 it being connected only across C and in Case 3 being connected across C and Cs in series. The mathematical analyses of Cases 2 and 3 are quite different, but the results are so nearly alike that they are interchangeable.

Case I.

It is assumed that C in the oscillator is exactly the same as C in each of the radio-frequency circuits. Further, it is assumed that when C is set at its minimum value, that is, when the circuits are tuned to the highest frequency, Cs has no effect. Cm may then be regarded as an integral part of C. With these assumptions we can obtain the value of Lo, in terms of L, as soon as we know the intermediate frequency and the frequency of the signal. Let us suppose for the sake of illustration that the signal frequency is 1,500 kc and that the intermediate frequency is 450 kc. The oscillator frequency should then be the sum of these two, or 1,950 kc. Since the capacities in the two circuits are the same, the frequencies differ only because the inductances are different. We are to find Lo in terms of L and the two frequencies. Applying the frequency formula to each circuit and dividing one equation by the other, we obtain $Lo=L(1,500/1,950)^2$. That is, the required inductance in the oscillator circuit is equal to the inductance in the radio frequency circuit multiplied by the square of the ratio of the signal frequency and the oscillator frequency. For the case when the intermediate frequency is 450 kc and the signal frequency is 1,500 kc, the formula becomes $Lo=0.5915L$.

Case I

Case II

Case III
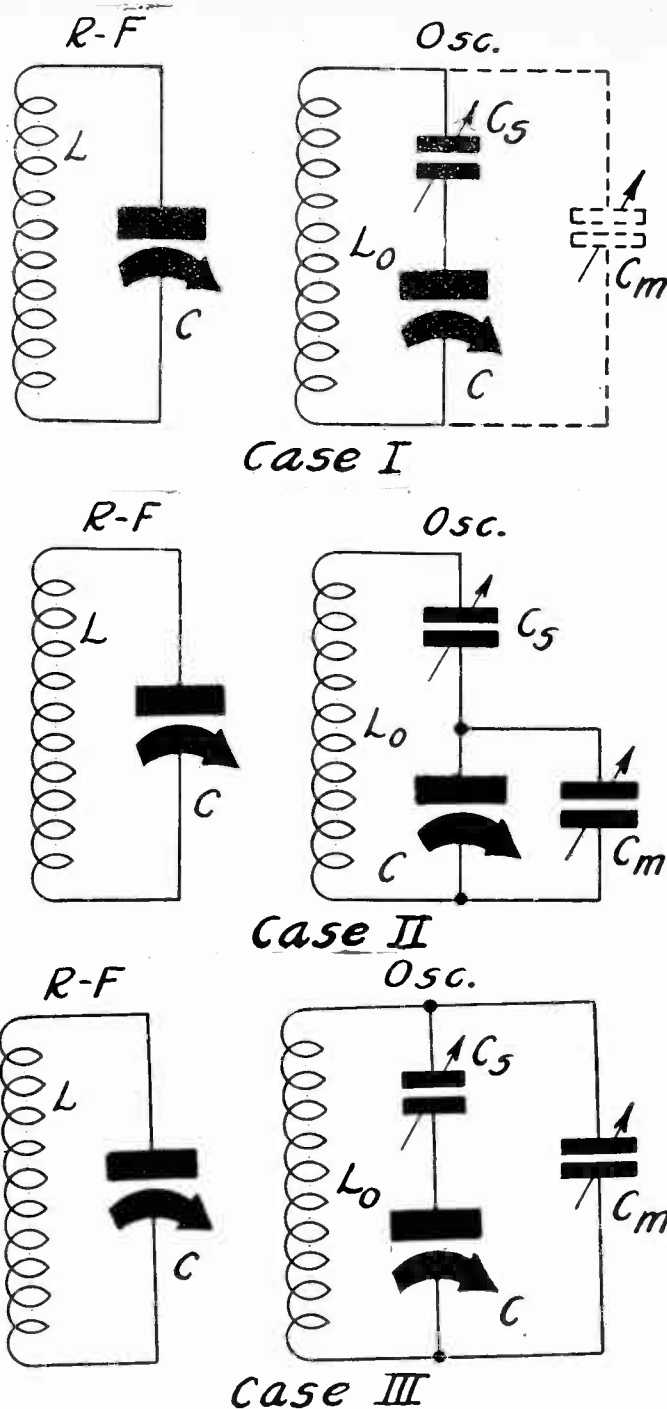
FIG. IX-1

Three different examples of padding.

We have yet to determine the value of Cs, and to do this we still ignore Cm. Cs will have the greatest effect at the lowest frequency, that is when C has the largest value. Suppose the circuit tunes to 550 kc. Then the capacity of the condenser C is $83,700/L$, where C is in micromicrofarads and L is in microhenries. But what should the capacity across Lo be in order that the oscillator circuit should tune to 550 plus 450 kc. that is, 1,000 kc? Making use of this frequency and the fact previously found that $Lo=0.5915L$, we obtain $K=42,750/L$, where K is the capacity required across the coil. But this is made up of Cs and C in series. Therefore, $Cs=CK/(C—K)$, whence Cs equals $87,500/L$ mmfd., L being expressed in microhenries. A common value of L in a broadcast set is 245 microhenries. With this inductance, Cs is 357 mmfd.

Fig. IX-2 shows the closeness with which the tracking can be adjusted by this method. The abscissas show the signal frequencies between ordinates show the deviation from perfect tracking. If the curve had coincided with the zero line, the tracking would have been perfect. The maximum deviation is not great, being only about 8,500 cycles out of 400,000 cycles; yet it is larger than it should be, for it can be held to about one per cent of the intermediate frequency, or to 4,000 cycles in the case illustrated. For any intermediate frequency the deviation need not be greater than about 4,500 cycles.

It is clear from Fig. IX-2 that the tracking can be improved without making any changes in the padded circuit. Suppose that the intermediate frequency is lowered, by retuning the intermediate circuits, by about 4.1 kc. The tracking will then be much improved at all frequencies except those close to 550 kc.

The reason the tracking curve dips so deeply at 800 kc is that the inductance in the oscillator circuit is slightly too large. This
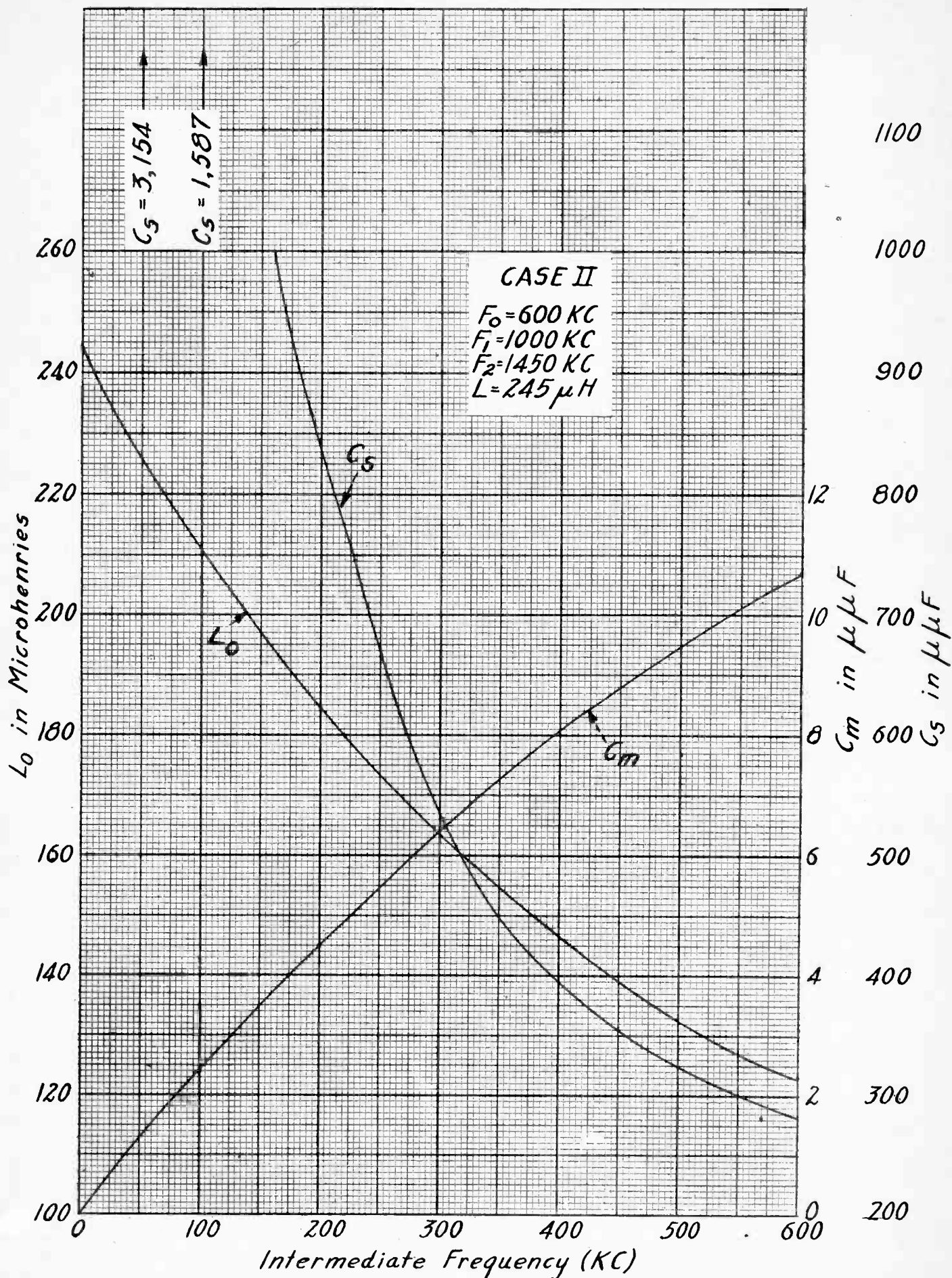
FIG. IX-4

Graphical representation of the formulas of Fig. IX-3 under the conditions stated. The three padding condensers can be found for any intermediate frequency from 0 to 600 kc.
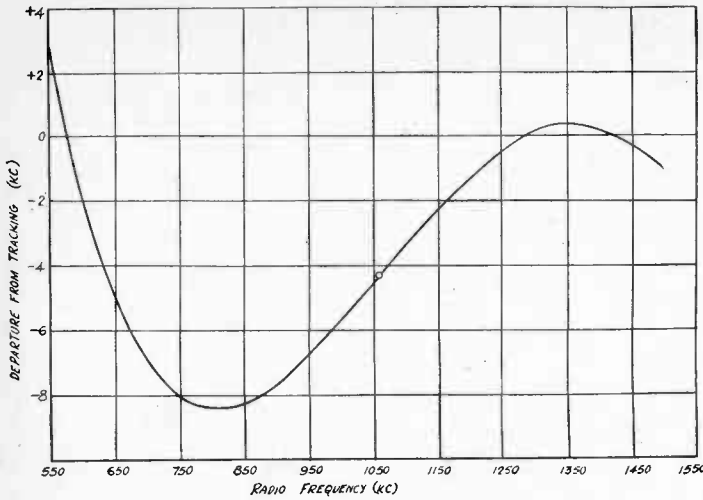
FIG. IX-2

The result of padding by Case 1. Poor tracking at low frequencies is due to excessive inductance.

$$C_m = \frac{2 C_0 f F_0^2}{(F_0+F_1)(F_0+F_2)(F_1+F_2)+2f(F_0F_1+F_0F_2+F_1F_2)}$$

$$C_s = \frac{(F_0+F_1+2f)(C_0+C_m)(C_0F_0^2+F_1^2C_m)}{fC_0[2F_0F_1+f(F_0+F_1)]-F_1^2C_m(F_0+F_1+2f)}$$

$$L_0 = \frac{L(C_0+C_m+C_s)C_0F_0^2}{(C_0+C_m)C_s(F_0+f)^2}$$

FIG. IX-3

Formulas for use in computing the padding values when the parts of the oscillator are arranged as in Case II, Fig. IX-1.

can be prevented by computing the inductance at a lower signal frequency, say at 1,450 kc instead of 1,500 kc.

Case II.

Case II allows a more precise adjustment of the padding, for in this case the tracking is made exact at three different points in the frequency scale. If these points are judiciously placed the maximum deviation will be small. It has been found that the best frequencies for tying down the tracking are close to 600, 1,000, and 1,450 kc, and these are also convenient for computation.

The padding problem is completely solved, theoretically, as soon as Lo, Cm, and Cs have been obtained in terms of the inductance, L, of the radio frequency circuit. It is sometimes more convenient, however, to express these quantities in terms of the capacity in the radio frequency circuit at the lowest of the three tie-down frequencies, which may be done when L is known. The mathematical work is complicated. The resulting three formulas are reproduced in Fig. IX-3.

In these formulas Fo is the lowest, F1 the middle, and F2 the highest of the tie-down frequencies, while Co is the value of C when the circuit is tuned to Fo and f is the intermediate frequency.

The value of Cm is first obtained by the first formula. Then Cs is obtained from the second formula, using in this the value of Cm just obtained. Finally, Lo is obtained from the third formula, using the values of Cm and Cs obtained by the preceding formulas.

As an illustration of the application of these formulas let us take the parts are arranged as in Fig. IX-1, Case II, and therefore, they henries. It follows from the assumed values of L and Fo that Co=287 mmfd. Substitution in the formula for Cm yields Cm=8.72 mmfd. Similarly, the second formula yields Cs=362 mmfd. and the third Lo=141 microhenries.

The formulas in Fig. IX-3 are applicable to any case in which the parts are arranged as in Fig. IX-1, Case II, and therefore, they can be used for working out the padding of short wave circuits as well as for broadcast circuits. The work in any particular case is rather tedious, however, if exact values are to be obtained, because the arithmetical work must be carried out to at least five places. To avoid this work for broadcast frequencies the curves in Fig. IX-4 have been prepared. As indicated in the inserted legend, the tie-down frequencies are 600, 1,000, and 1,450 kc while the inductance in the radio frequency circuit is 245 microhenries. From these curves the three padding values can be read off directly for any intermediate frequency from 150 to 600 kc. The minimum capacity and the oscillator inductance can, in addition, be read for intermediate frequencies down to zero. For the low intermediate frequencies the series capacity becomes very large, as is indicated by the two isolated values when f is 50 and 100 kc. When the series pad becomes large
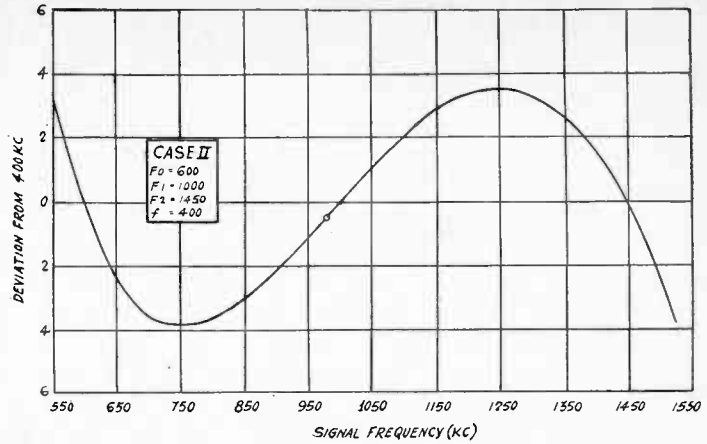
FIG. IX-5

A tracking curve in the broadcast band when the intermediate frequency is 400 kc. It represents, approximately, the best adjustment that can be effected.

$$C_s = \frac{C_1 B - C_2}{1 - B}$$

$$B = \left(\frac{F_1}{F_2}\right)^2 \left(\frac{F_0+F_2}{F_0+F_1}\right)\left(\frac{F_0+F_1+2f}{F_0+F_2+2f}\right)\left(\frac{F_2+f}{F_1+f}\right)^2$$

$$K_0 = \frac{C_0 C_s^2 (F_1+f)^2 (F_0+F_1)}{(C_0+C_s)(C_1+C_s)F_1^2(F_0+F_1+2f)}$$

$$L_0 = \frac{C_0 F_0^2 L}{K_0 (F_0+f)^2}$$

FIG. IX-6

Formulas for the computation of the padding constants when the circuit is arranged as in Case III.

the need for it becomes less. As suggested by the curves, the lower the intermediate frequency the less need there is for the series condenser. It is not the absolute value of the frequency that counts, however, but the relative values of the intermediate and the signal frequency. Therefore, if we keep the intermediate frequency at a fairly high value, say 465 kc, and increase the signal frequency, the need for the series condenser soon vanishes. It is for this reason that in short-wave superheterodynes no series padding condenser is used for the higher signal frequencies, although it is usually employed for the band of frequencies just above the broadcast band.

Closeness of Padding

The closeness with which oscillator and radio-frequency circuits can be tracked by padding as in Case 2 is illustrated in Fig. IX-5. The intermediate frequency in this case was 400 kc and the frequency coverage is supposed to be from 550 to 1,500 kc. It will be noticed that at no point within the band covered is the deviation as much as 4 kc, which means that the tracking is better than one per cent. of the intermediate frequency. There are two points at which the deviation is maximum, namely, 750 and 1,250 kc. At three points, namely, 600, 1,000, and 1,450 kc, the deviation is zero because these were chosen as the tie-down frequencies. Below the lower tie-down frequency and above the higher, the deviation increases very rapidly, and for this reason it is important that the two extreme tie-down frequencies be not chosen too far inside the band limits.

The curve in Fig. IX-5 has been plotted from computed values of deviation, the computation having been based on padding constants obtained by the formulas in Fig. IX-3. By using great care in getting the correct value for Lo by computation, and then still more care in getting a coil of this value, it is quite possible to attain a padding as close as that indicated in Fig. IX-5.

When the circuit is arranged as in Case III, Fig. IX-1, the formulas in Fig. IX-6 may be used for computing the value of the series condenser and that of the inductance in the oscillating circuit. Just what the value of Cm is does not make much difference for it is always adjusted experimentally. To some extent this is also true of the series condenser, for that is adjusted experimentally, but its exact value is necessary for the computation of the oscillator inductance.

The value of Cs is given by the first formula, where C1 is the value of C at the middle tie-down frequency, C2 is the value of it at the highest, and B is the ratio given by the second formula. C1 and

Oscillator

By Observation of Plate C

By Herma
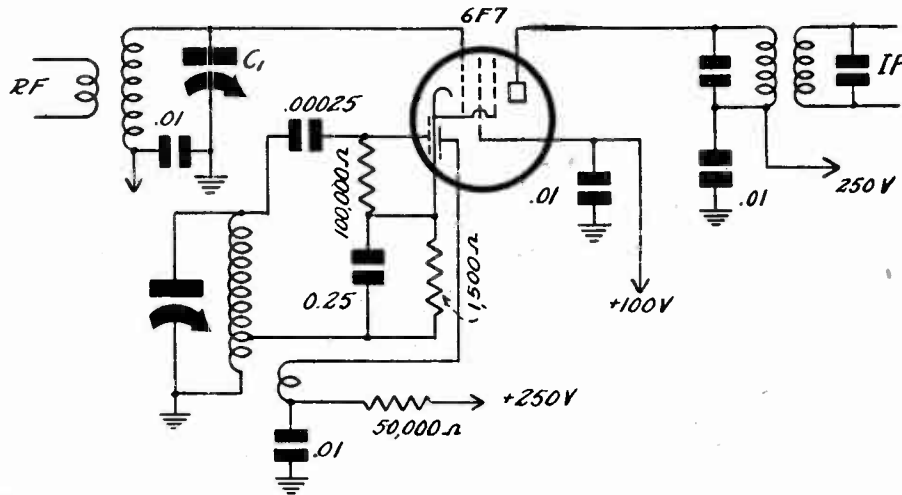
In the circuit at left the grid condenser is 0.00025 mfd. and the leak, 100,000 ohms, shunts the complete grid circuit.

THE test oscillator is a requisite for servicing and construction of superheterodynes and is helpful in connection with peaking and building any receiver.

A test oscillator is a generator of alternating-current frequencies used for adjusting the tuning mechanisms of sets. Commercially a vacuum tube always is used, with feedback or negative resistance introduced for production of the oscillation. The most common form of feedback is to couple inductively to the tuned grid circuit a winding through which plate current is passed. Negative resistance may be introduced directly into certain tubes, e.g., the 22, 24 and 32, by tuning the plate circuit and applying to the plate a d-c voltage that is critically lower than the screen voltage. A typical negative resistance oscillator is the dynatron. The grid of the dynatron tube need not be used. The mercury vapor rectifier tubes, 82 and 83, could be arranged in dynatron circuits, because their resistance is negative. This is true also of some vapor-glow tubes, such as neon and argon tubes.

What Negative Resistance Is

A tube has a negative resistance characteristic when the current increases with decrease of voltage.

In the negative resistance oscillator the behavior of the direct current in this manner determines the condition favorable to oscillation, but the plate circuit must be tuned.

In all oscillators the alternating-current resistance of the circuit is negative. In the dynatron the d-c resistance of the plate and screen circuits is negative as well.

If a radio-frequency oscillator has audio frequency introduced into it, then a receiver will eliminate the radio-frequency at the detector, but the audio frequency will carry through to the speaker, like any other signal. The introduction of audio is called modulation and the modulated oscillator is called a signal generator.

All oscillators generate harmonics, that is, frequencies that are whole-number multiples. The original frequency generated is called the fundamental or first harmonic. If this is 100 kc then the second harmonic is 200 kc, the third harmonic 300 kc, etc. Oscillators intended especially to receive a fundamental and multiply it thus are called frequency doublers, though they treble, quadruple, etc., as much as they double. All oscillators in which grid current flows are particularly rich in harmonics, which are predominantly in the plate circuit.

Stability of Oscillators

Oscillators are stable or unstable. In general, instability prevails. To achieve stability certain precautions must be taken.

Instability amounts to unsteadiness of the generated frequency. The dynatron is inherently unstable, the worst known example of instability, though just the opposite is stated in some articles in the technical radio press. For ordinary purpose, at broadcast and lower radio frequencies, instability is not so serious a consideration, and there are practically no commercial broadcast superheterodynes with really frequency-stabilized local oscillators. The generated wave does not change its frequency more than an audio-frequency value,

say, 10,000 cycles, for carriers of 1,600 kc and lower, not deemed serious. At high frequencies, particularly ultra frequencies, stability of frequency is important, because the absolute change becomes large, perhaps several hundred kilocycles, so that a form of fading is produced because the wobbly oscillator is in effect causing the signal to be tuned in and out.

At usual lower frequencies good enough stability is not hard to achieve. Grid-leak type oscillators are stable over at least a part of the tuning range. By careful proportioning of leak and grid condenser values the stability can be further improved. Screen grid tubes are inherently more stable than triodes, but any tube can be stabilized. That is achieved when all the voltages, loads and other constants are so selected and circuited that the tube is made to behave like a pure resistance, which is a resistance having no inductance or capacity. Methods of stabilization include series or parallel or series-parallel inductances, resistors and capacities, or combinations.

Since all the effects of tube behavior show up in the plate circuit, the oscillator may be tested by tuning it over its entire span for any band and watching the needle of a low-resistance plate-circuit milliammeter. If the needle stands still (continued presence of oscillation assumed) the oscillator is stable.

In a leak-condenser type oscillator, when the plate current decreases the oscillation current or voltage or amplitude increases. Higher voltage, less current, it will be recalled, suggests also a negative resistance characteristic.

So if at higher frequencies of tuning, in any band, the current reads less, compared to lower frequencies of that band, decrease the value of grid condenser until the plate-current reading is about what it was for the low-frequency tuning. If the grid condenser is made too small in comparison to the resistance of the leak the circuit will not oscillate. For a typical 30 tube oscillator, with tuned grid, and with the plate feedback inductive, experimental values for good stability were leak, 200,000 ohms; grid condenser, 0.000125 mfd.

High Series Resistance

One of the best and easiest methods to improve frequency stability is to put a bypassed high resistance in the plate return circuit, between the end of the tickler and the B voltage source. The resistance should be about ten times the d-c resistance of the tube's plates, or

Padding Superhet

C2 can be obtained from the tie-down frequencies and the inductance, L, in the radio frequency circuit. When Cs has been obtained it may be substituted in the third formula to give Ko. Finally the fourth formula may be applied to yield Lo. In order to get an accurate value of Cs it is necessary to compute the components accurately, especially B.
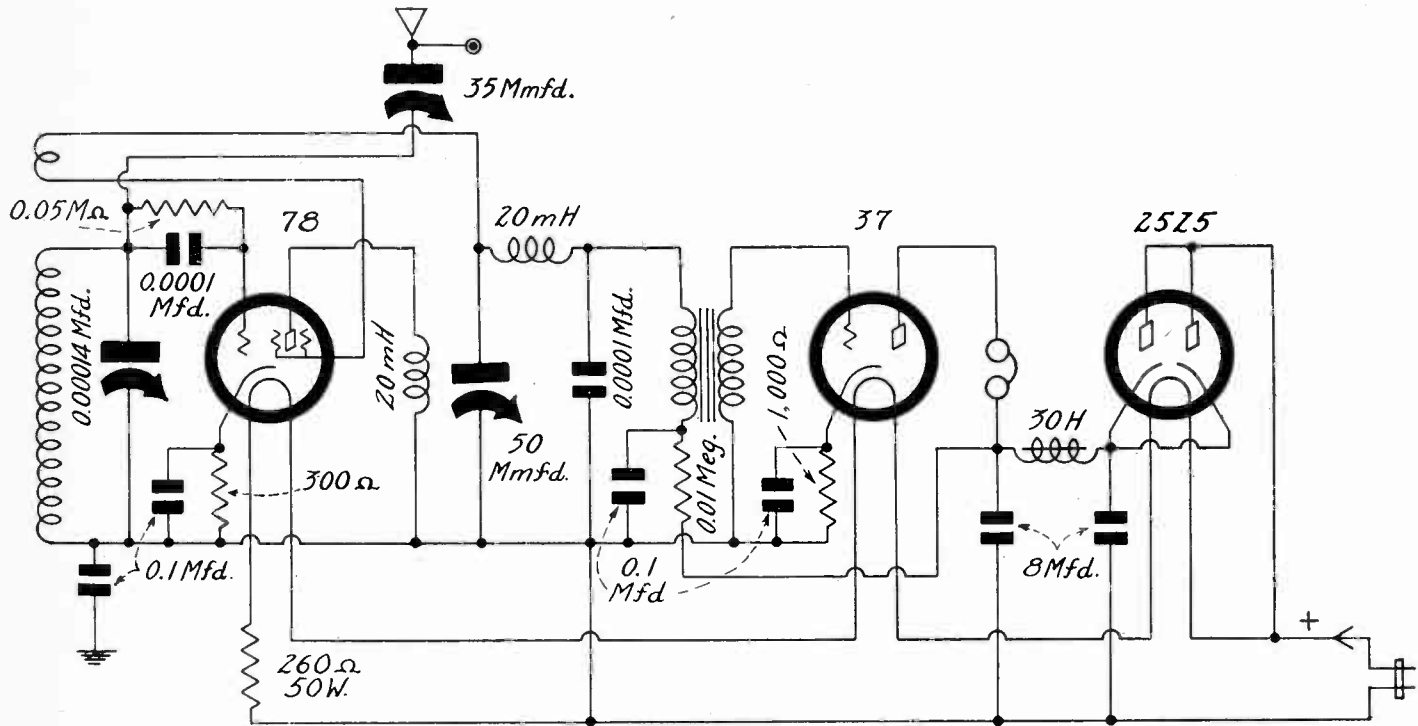
Let us apply these formulas for the computation of the padding constant for the broadcast band and an intermediate frequency of 175 kc. Let us assume a radio frequency inductance of 245 microhenries

s Checked

Current as Stability Gauge

n Bernard

The Date meter could go between the low end of the 0.01 meg. resistor and the B plus lead in this circuit.

100,000 ohms for the 30 tube, 200,000 ohms for the 22, 24, 32 and 34. The condenser may be 0.05 to 0.1 mfd.

A pure resistance is now 0.9 of the total plate-circuit resistance. The plate meter needle will be substantially still. Reduction of needle movement can be accomplished by leak or grid condenser adjustment. Finally the needle can be made to stand absolutely still. But if a very sensitive meter is used, a microammeter, since it will have a substantial d-c resistance, put a bypass condenser across the meter. This should be done anyway, to prevent a.c. from burning out the sensitive meter. The a.c. must flow through the meter though the meter does not register it.

2 or 3% Just Passable

An incidental advantage of a stabilized oscillator is that when beating with a carrier the beat is "clean" and easily identified. It is possible to get "clean" beats from a stabilized oscillator even though a.c. is applied to the plate, instead of d.c.

All service oscillators should have at least a measure of frequency stability. It is possible to achieve a stability comparable to that of crystal control without temperature oven, say, of one part in 100,000. This is much more than is necessary due to impossibility of reading dials that closely, but the greater the stability the better, especially as instability, when present, may reach such heights as to cause output meter readings to be wobbly.

The "accuracy" of an oscillator or signal generator means the percentage of error within which any calibration is kept. Thus, 2% accuracy means that the oscillator, when set for 100 kc for instance,

will never generate a frequency more than 2% off, that is, 98 and 102 kc are the error limits. An accuracy of 2 or 3% is just passable for most purposes, but an accuracy of 1% is attainable by more careful design, especially in instruments with frequency-calibrated dials. If charts must be consulted the accuracy factor becomes more difficult, because charts can not be read as closely as dials, except very large charts, measured in feet.

Frequency stability has no particular relationship to the accuracy just discussed, except at very high frequencies, say, above 20 megacycles.

Signal generators of the better grades have frequency-calibrated dials, that is, are direct-reading. Some rely on harmonics for fundamental range extension, hence there is no switching. Others do not rely on harmonics, but switch in different coils. Both methods work well. If the harmonic order to encompass the broadcast band is not above the fourth there is little likelihood of confusion.

Harmonic Counter

Besides, a new method of computation, due to Edward M. Shiepe, permits harmonic counting, almost without limit. Read any frequency of the signal generator, an harmonic of which frequency causes a response in the set. Turn the generator dial either way until the next response is heard, the receiver being unmolested. Call the higher frequency A, the other B. Then the harmonic order of

$$A = \frac{B}{A-B} \text{ and that of } B = \frac{A}{A-B}, \text{ always a whole number.}$$

Here are two examples:

Suppose the set is tuned to frequency Fx, unknown. The generator yields responses at 380 and 370 kc. The difference is 10, divided into 380 gives the 38th harmonic of 370, or, divided into 370, gives the 37th harmonic of 380. Both 38x370 and 37x380 equal 14,060 kc, which is Fx.

Suppose the two frequencies are 250 and 300 kc. The difference is 50 kc, which, divided into 250 is 5 (hence fifth harmonic of 300), or divided into 300 is 6 (sixth harmonic of 250), both 1,500 kc. Note that the difference divided into one gives the harmonic order of *other*.

Knowledge of the above simple but brilliant mathematics gets rid of much possible confusion due to use of harmonics.

rodynes Accurately

and let the three tie-down frequencies be 600, 1,000, and 1,450 kc. Then Co = 287 mmfd., C1 = 103.2 mmfd., and C2 = 49.1 mmfd. By substituting the frequencies in the formula for B we get B = 0.9474. Therefore Cs = 922 mmfd. It follows that Ko = 223 mmfd. On substitution in the formula for Lo we obtain Lo = 189 microhenries. The curves in Fig. IX-7 gives 190 microhenries.

Fig. IX-8 gives a sample tracking curve based on Case III. It will be noticed that it is closely like the corresponding curve for Case II.

Great DX on One Tube
Literally Coast-to-Coast, and Often Much More
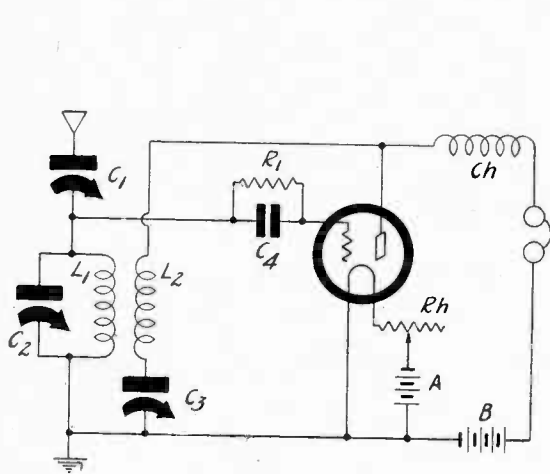### By Roger Gunfold

FIG. 1

A simple one-tube regenerative receiver for earphone reception of broadcast programs, yielding excellent results.
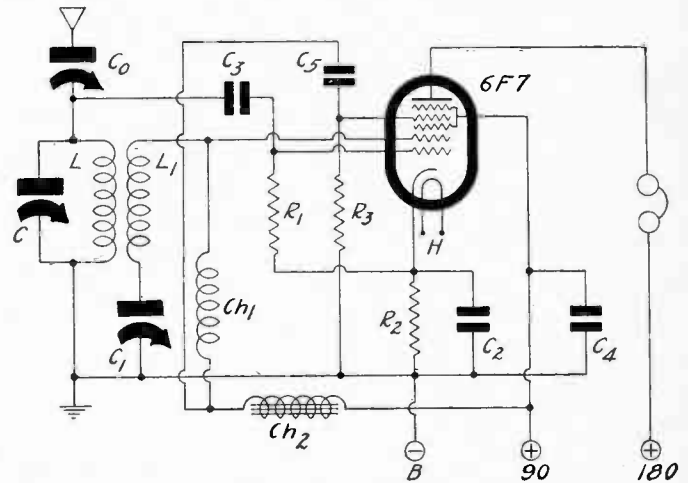

FIG. 2

Although a single tube is used in this circuit, it contains a regenerative detector and a pentode audio amplifier.

"IS it possible to go from coast to coast with a one-tube regenerative receiver? If so what kind should the receiver be? Will you kindly describe simple receivers utilizing one tube only?"

Literally, it is possible to go from coast to coast with a one-tube receiver, or with any other receiver. And we need not stop at the coast for we may either continue in the same direction or turn around and retrace our steps, all the while carrying the one-tube set with us. The set may also be dispatched by mail, express, or freight.

We confess that the first question in the first paragraph was purposely misunderstood because there was an opportunity to do it. Spoofing aside, there is a small chance of receiving signals originating near one coast of North America with a one-tube receiver set up at the other. Still, however small the chance

may be, there is a real chance. And what the chance may be, mathematically, depends on very many factors. Let us name a few. The power of the transmitting station, the time of day, the time of year, the relative latitudes of the two coastal points, the particular epoch of the solar cycle, the weather distribution between the two points in question, the design of the one-tube set, all these factors affect the reception. And they are only a few.

A One-Tube Receiver

The chance that all these factors will be favorable is small, very small indeed, but that fact is a weak argument against a one-tube set. Over ninety-nine per cent. of the time any receiver is tuned in on a local station. This is true of the 16-tube superheterodyne as well as the more practical 5-tube receivers, and it ought to hold for the single-tube receiver. Perhaps for this type of receiver it will be true by necessity, whereas for the multitube superheterodyne it will be true by choice. No one will be seriously discommoded by the failure of the small receiver to pick up far away stations, for attempts will rarely be made to receive any but the local stations.

We shall present a few simple circuits, not because of what they might do on exceptional days, or under exceptional circumstances, but because there are many who want one-tube receivers with which they can reasonably expect to receive stations within a radius of 100 miles with comfortable headphone volume. By comfortable we mean here that the signals are loud enough to overwhelm the background noise, yet not so loud that they will paralyze the auditory nerves after a moment of listening.

The Tickler Connection

In Fig. 1 we have about the simplest one-tube receiver that can be constructed, that is, if it is to be built for sensitivity. It utilizes a filament type tube in which the filament current is only 60 milliamperes. The coupling between the antenna and the tuned circuit is direct, with a small, adjustable condenser, C1, in the antenna lead to increase the selectivity. A condenser of 110 mmfd. capacity is all

right if the circuit is designed for broadcast waves, but if it is designed for short waves the condenser might better be of about 50 mmfd. capacity.

The tickler coil L2 is connected in shunt with the plate feed and the stopping condenser, C3, is used as one of the regeneration controls. Since the condenser is put on the ground side of the tickler, its rotor can be grounded and body capacity effects will be eliminated. The choke, Ch, in series with the headphones should have an inductance of the order of 50 millihenries, but its value is not at all critical.

The grid leak and the grid stopping

LIST OF PARTS (Fig. 1)
Coils
L1, L2—One radio frequency transformer as described
Ch—One radio frequency choke, any inductance from 10 to 125 millihenries
Condensers
C1—One 100 mmfd. variable air condenser
C2—One 350 mmfd. tuning condenser
C3—One 350 mmfd. tuning condenser, or a 250 mmfd. condenser
C4—One 250 mmfd. grid condenser, mica dielectric
Resistors
R1—One one-megohm grid leak
Rh—One 25-ohm fixed resistor, and one 25-ohm rheostat, in series
Other Requirements
One high impedance headset
Three knobs, for C1, C3 and Rh
One dial for C2
One four-contact socket
One 45-volt B battery
Two No. 6 dry cells
One small subpanel, wood or metal
One small panel
One type 30 tube

LIST OF PARTS (Fig. 2)
Coils
L, L1—One radio frequency tuning coil as described in connection with Fig. 1
Ch1—One radio frequency choke coil (10 to 125 millihenries)
Ch2—One audio frequency choke (100 henries or audio transformer)
Condensers
Co—One 100 mmfd. variable air condenser
C—One 350 mmfd. tuning condenser
C1—One 350 or 250 mmfd. variable condenser
C2—One 25 mfd. electrolytic condenser, low voltage
C3—One 250 mmfd. fixed mica dielectric condenser
C4—One 0.25 mfd. by-pass condenser
C5—One 0.01 mfd. mica dielectric condenser
Resistors
R1—One one-megohm grid leak
R2—One 300-ohm bias resistor
R3—One 0.5-megohm grid leak
Other Requirements
Two knobs (For Co and C1)
One dial (for C)
One small 7-spring socket
One high impedance headset
One grid clip
Heater supply, 6.3 volts, 0.3 ampere
Plate voltage supply, 180 volts
One small sub-panel, wood or metal
One small panel

condenser should have their usual values, namely, one megohm for the resistance, R1, and 250 mmfd. for the capacity, C4.

Perhaps the main regeneration control is the filament rheostat Rh. Normally the filament current should be 60 milli-amperes, but often better results will be obtained when the current is lower, and sometimes it is necessary to make it lower in order to stop oscillation. For the higher frequencies the regeneration control condenser, C3, cannot be made small again, and then the rheostat comes into play.

The tube requires a filament voltage of 2 volts. The nearest voltage supplied by dry cells is 3 volts, obtained by connecting two cells in series. There is a normal excess of one volt, and sometimes an excess of as much as 1.5 volts. If we assume that the voltage at maximum is 3 volts and that the smallest current on which the tube will function is 40 milli-amperes, we should need a rheostat having a resistance of 42 ohms. Let us therefore say that the external resistance is 50 ohms. This might well be broken up into one fixed resistance of 25 ohms and a variable resistance, that is, a rheostat, of 25 ohms. This will allow close control of the current, and hence of the regeneration. The closest adjustment of the regeneration is, of course, effected by the condenser C3.

Coils Required

It is assumed that the antenna condenser used is so small that very little of the antenna-ground capacity is added to C2. Then we can select a coil L1 on the basis that C2 alone is across it. Then if C2 has a maximum value of 350 mmfd., L1 should have an inductance of 240 microhenries.

Coils of this inductance can be obtained in the shielded midget types, in which the coil form is about one inch in diameter and the shield form is about 2.5 inches in diameter. These coils are not recommended because of their inefficiency. They are all right for the receivers for which they have been designed but not for one-tube sets. A good coil for the present set should be wound on a form 2.5 inches in diameter, or larger, and it should not be shielded. On this diameter, using No. 24 enameled wire,

sixty-two turns will be required to make the inductance 240 microhenries. This tickler winding should have approximately two-thirds as many turns, and these turns may be of much finer wire. Of course, the same size wire may be used for the tickler as for the tuned coil, but it is better to use fine wire for the tickler for it will make a more compact winding and it will introduce less loss into the tuned winding.

Use of Multiple Element Tubes

Fig. 2 looks a good deal more complex than Fig. 1, and it is more complex. Still it is only a one-tube receiver. But saying that is not the same as saying that it is only a one-stage receiver. Indeed not. This one has a regenerative detector almost identical with that in Fig. 1, and in addition it has a stage of audio frequency amplification, choke-resistance-capacity coupled to the detector. Moreover, this stage contains a pentode tube. It is, therefore, not unreasonable to suppose that the sensitivity of this circuit is vastly greater than that of the preceding receiver.

This receiver, Fig. 2, would be the ideal vest pocket model collector of ether-diffused entertainment were it not for one somewhat serious drawback, namely, the difficulty of supplying the filament power. The tube, the 6F7, requires a heater voltage of 6.3 volts and a heater current of 0.3 ampere which, according to our slide rule, represents a power of 1.89 watts. The preceding circuit got along with a power of only one-eighth of a watt. That is a rather large difference and it rules out certain applications for the circuit.

Where to Use Set

While many applications are ruled out for practical reasons, there are many left. We can use the circuit in an automobile, for example, for there we can draw the necessary 0.3 ampere from the car battery and we can easily tuck away a 180-volt plate battery where it will not be felt on the bumps. But in this application we must not expect too much because there will be very little pick-up in the car and the regeneration cannot be driven close to the limit, for jars will upset any close adjustment.

The most likely place for a receiver like this is where there is electric power available. The heater current can be supplied by a transformer which steps the voltage down to 6.3 volts. The plate voltage could then be obtained either from a 180-volt battery, or higher voltage, or from the line through the medium of a rectifier and filter. If the line voltage is uni-directional both the plate and the heater voltage can be obtained very easily from the line. A 360-ohm, 50-watt ballast resistor should be connected in series with the heater and the line and a large electrolytic condenser should be connected across the line. The side of the circuit marked ground should then be connected to the negative side of the line and the 180-volt tap to the positive. A 5,000-ohm resistor may be used between the high voltage side and the 90-volt tap. When batteries are used to supply the power the voltages indicated should be used.

Note particularly how the grid returns are made to secure the correct bias voltages. C3, a 250 mmfd. grid condenser, serves the regenerative part of the circuit, and the grid of this part of the tube is connected to the cathode through a grid leak R1 of one megohm. The amplifier section of the circuit requires a negative bias for best operation. Therefore, a resistor R2 of 300 ohms is connected in the cathode circuit before the grid leak, R3, is connected to it. This grid leak should have a value of 0.5 megohm. C5 is the stopping condenser between the anode of the triode and the grid of the pentode. The capacity of this condenser should be about 0.01 mfd.

The audio choke Ch2 is necessary in the anode circuit of the detector as a coupling means between the two stages. Of course, this audio choke could be replaced by a resistor of about 100,000 ohms, but then the applied voltage should be greater than 90 volts. This audio choke may well be an inexpensive audio transformer, the secondary of which may be used alone or with the primary connected in series aiding with the secondary.

The parts pertaining primarily to the regenerative detector are the same as the corresponding parts in Fig. 1, as is brought out in the list of parts.

A NEW NBC program is the "Tintype Tenor." Jack Parker, well known to NBC audiences, will warble the daring, romantic and lachrymose ditties that were all the rage in the gay Nineties; each Tuesday, at 7:15 p. m. over an NBC-WJZ network. . . . Vic and Sade, those popular "true-to-life" characters, heard from Chicago daily except Sunday over WJZ and network, celebrated their second anniversary over the air last week; still as well-liked as when they first started. . . . Clyde Doerr, who helped to introduce the saxophone to New York a decade ago and a former member of many NBC groups in Manhattan, is now a musical director for the NBC in San Francisco. . . . The theme song which Grace Hayes uses to identify her NBC broadcasts, "One In Love," was written especially for her by Newell Chase, pianist and composer, who accompanies Miss Hayes on the air. . . .

Victor Young, the dapper little maestro of the Chevrolet and Schlitz beer programs, is one orchestra leader who can be proud of his ability as a composer. Mr. Young has written many lovely melodies; his latest, "Love Me," is a very appealing ballad, heard frequently over the air. . . . Joseph White, NBC tenor, formerly known as the "Silver Masked Tenor," sang the hymn, "Bless This House," at the dedication of the new Bronx County Court House in New York. White took part in the program at the invitation of Borough President James Lyons. . . . Guy Lombardo and his Royal

Station Sparks
By Alice Remsen

Canadians, will take the air for their first commercially sponsored series over NBC facilities on Wednesday, July 11th, and each Wednesday thereafter, at 10:00 p. m. over an NBC-WEAF network, under the sponsorship of Plough, Inc. . . .

"Accordiana," the program of lilting melodies, featuring Abe Lyman and his orchestra, with Vivienne Segal, soprano, and Oliver Smith, tenor, will continue throughout the summer, under a contract renewal; broadcasting time as usual, 8:30 p. m. EDST, each Tuesday. . . . Sterling Products, Inc., is featuring a beautiful series of programs, called "Lavender and Old Lace," and starring Frank Munn, and Muriel Wilson, in the interests of Bayer's Aspirin; each Tuesday at 8:00 p. m. EDST. . . . "Ex-Lax" has a new series over WABC and network, featuring Lud Gluskin and his Continental Orchestra, with Henrietta Schumann, famous Russian pianist; each Monday at 9:30 p. m. The Three Marshalls, mixed harmony team from the South, will add their singing as a vocal complement to the flavor of Guskin's music. . . . Fats Waller, well-known negro composer and pianist, has inaugurated a new series over WABC called "Fats Waller's Rhythm Club"—a program with which he became

identified over WLW, Cincinnati, a couple of years ago; with Waller on the program will be the Beale Street Boys, and Johnny Augustine's orchestra; each Tuesday at 7:00 p. m. EDST. . . . George Givot, "Greek Ambassador of Good Will," has been signed for a summer series over the Columbia network, with Freddie Rich's 45-piece orchestra, and Edith Murray, blues singer; each Tuesday at 9:00 p. m. EDST. . . .

Kate Smith lost forty pounds during her recent vaudeville tour; dancing did it. Vaughn De Leath has lost plenty of pounds, this not due to dancing, however, but a special treatment by the "Miracle Man"—of whom you will hear more in the near future. This man is truly marvelous; he takes weight off or puts it on without medication or starvation. . . . George B. Storer, president of Station WMCA, New York, recently announced the formation of a new network, known as the American Broadcasting System. It is now in operation, and consists at present of seven stations; others will be added from time to time. Karl Knipe, former sales manager of CBS, is now acting in that capacity for the American Broadcasting System; Egon Putz, organist and concert pianist, has joined the musical department of the WMCA-ABC studios, replacing William Bartley. Putz will accompany Vaughan de Leath on her series of morning programs and will also have a program of his own each Monday and Thursday at 1:00 p. m. EDST.

The RGH-4 Universal

Two Tuned Circuits in Regenerative Short Wave Receiver

By Robert G. Herzog, E. E.
Thor Radio Company

FIG. 1

The circuit diagram of the RGH-4 all-wave regenerative receiver with which stations throughout the world have been received. The plug-in method of changing coils is used.

FIG. 2

Top and rear view of the chassis of the RGH-4 all-wave receiver showing the arrangement of the parts. The square box at the left rear is a coil shield.

FIG. 3

Bottom view of the chassis showing the wiring and the location of the controls. Note small antenna trimmer near bottom and center of the chassis.

THE RGH-4 is a very simple, inexpensive, all-wave, regenerative circuit designed to suit the beginner in the short-wave field. Its widespread popularity is undoubtedly due to its exceptional performance on all bands.

If the set is purchased in kit form the parts supplied fit readily into the holes in the drilled chassis. If the parts do not fit the holes provided it is advisable to drill the additional holes before mounting any of the parts on the chassis.

Shifting from one band to another is accomplished in the RGH-4 by changing the two plug-in coils. Two of one color

LIST OF PARTS
Coils

Two sets of plug-in coils (8 coils).
Two radio frequency choke coils.
One audio frequency choke, 300 henries
One power transformer, 600 volts, 40 ma.
One speaker with 1,800-ohm field coil

Condensers

One 140 mmfd., two-gang condenser
One 50 mmfd. midget condenser
Two 8 mfd., 450-volt electrolytic condensers
Six 0.25 mfd. by-pass condensers
One 0.5 mfd. 400-volt by-pass condenser
One 0.02 mfd. condenser
One 0.01 mfd. condenser
One 0.002 mfd. condenser
One 0.00025 mfd. condenser
One 0.0001 mfd. condenser

Resistors

One 50,000-ohm potentiometer with switch attached
One 15,000-ohm variable control
One 100,000-ohm, one-watt resistor.
One 25,000-ohm, one-watt
One 4-megohm, one-half-watt
One one-half-megohm, one-half-watt
One one-quarter megohm, one-half-watt
One 150,000-ohm, one-half-watt
One 15,000-ohm, one-half-watt
One 350-ohm, one-half-watt bias resistor

Other Requirements

One RGH-4 chassis
One coil shield
Two 58 tube shields
Five wafer sockets
Two 4-prong coil sockets
One dial pilot lite bracket and escutcheon plate
Four knobs
Three binding posts
Phone posts
Resistor racks
Line cord and plug
No. 18 hookup wire
Solder and hardware

---

are used for each band. The antenna coil is shielded to prevent stray feedback from the detector stage.

Wiring the Set

The detector plate is impedance coupled—necessarily so since the high plate impedance of the 58 detector eliminates the possibility of transformer coupling and the high value of the required load resistor is a theoretical resistance stage would not allow the proper effective voltage on the plate. The choke used in this circuit must have at least 300 henries and it must be capable of standing at least 3 milliamperes without saturation. A reversed audio transformer could not be used.

In wiring the RGH-4 run all the filament, screen, and B plus leads around the edges of the chassis so as to leave the center clear for the small parts and the more important wires. The radio frequency and detector plate and grid leads are wired from point to point with heavy bus bar. The leads to the detector and the radio frequency grids should be as short as possible with No. 18 stranded wire.

Tuning Learned by Experience

When the set is completely wired, check the wiring carefully, making sure all connections are soldered solidly and that no splashes of solder have lodged where they may do harm. After having checked the wiring, plug in the tubes and coils, connect the antenna and ground, and the a-c line. The set is now ready for tuning. No complicated alignment is

Radio University

Radio-Optical Limitations

ARE THE RADIO-OPTICAL waves easily generated and influenced by an optical system? How does tube limitation affect the result?—K. J.

The radio-optical waves, meaning usually waves of less than 1 meter, and called optical or quasi-optical because their behavior is akin to that of light waves, in that they are subject to reflection and are seriously obstructed by objects in their path, are difficult to generate. The higher the frequency the greater this difficulty. As to the optical aspects, however, including directional transmission, the higher the frequency the easier the problem. Special tubes are used in present experimental work, and these are not commercially manufactured. In fact, a great part of the experimental work consists of developing the proper tubes. At present much work is being done with tubes that are controlled by an electromagnetic field instead of by an electric field. Both transmitters and receivers present large problems in this sphere of activity, and although there is much progress in developmental work, and the future wide use of these waves seems assured, as yet there is considerable groping.

* * *

Static on Ultra Waves

HOW IS IT possible that there is absence of static at the ultra frequencies, and yet some scientists report presence of static on 73 centimeters? What is the accustomed range of reception of such frequencies or wavelengths?—I. H.

Some workers in the field have reported static, but the reputation for absence of static is no doubt based on the practical absence, compared to reception on lower frequencies, when at these lower frequencies there is static of considerable magnitude. For instance, on 73 meters there may be deafening disturbance, due to static, and yet on 73 centimeters this particular static is totally absent, although some other and much milder form of static may be experienced, and even of a type that endures after the static disturbance on the low frequency or higher wave disappears. The behavior of the centimeter waves is so different than that of the higher waves that the field has to be explored very carefully, and progress is necessarily slow. The normal distance of penetration is approximately equal to the distance of the horizon, and naturally this depends in part on the elevation of the transmitting aerial above earth. The higher the aerial, the farther away geographically is the horizon. Normally the horizon is 25 miles away. However, reception of micro waves has been reported by several workers, including Marconi,

over considerably greater distances, between 150 and 175 miles. Methods of pushing these waves over the horizon, so to speak, may be expected as the technique is more fully developed. Now the technique is entirely in the embryonic state.

* * *

Varying Transconductance

IS THE MUTUAL conductance of a tube, used for short waves, a constant, or is there an impedance factor to consider? —I. J. D.

The transconductance, to use the preferred term, is a variable factor, affected by frequency, hence is reactive. This fact is confirmed by the experience of many, using familiar short-wave circuits of the regenerative type, with throttle condenser to control feedback. In general, and for three of the four common bands of short-wave tuning, the higher the capacity setting of the throttle condenser, the stronger the feedback. However, on the last or highest-frequency band, usually rated at 30 to 15 mgc., or 10 to 20 meters, it will be noticed that the throttle condenser is worked in reverse to accomplish the desired result. This confirms the phase shift. The ascribed cause is the approach of the velocity of the electrons in the space stream of the tube to the frequency of resonance. This factor of time of transit of electrons is also a limiting factor in oscillators in general, using regular tubes, because contributing to the critical frequency at which the tube will stop oscillating, and also the transit time affects the input resistance to the tube. At high frequencies, not far removed from the critical frequency of oscillation stoppage, the input resistance is decidedly low, which would account also for feebleness of oscillation and for reduced selectivity. Even at frequencies as low as 15 mgc the effect is noticeable. The tube engineers have a lot of work ahead to cope with the requirements below 10 meters, and most particularly below 1 meter.

* * *

Light-Circuit Line Used

CAN SHORT WAVES be transmitted on the lighting circuit? If so, could not a short-wave set somewhere in the house be plugged into the line to pick up what is thus transmitted?—H. J.

Yes, short waves may be so transmitted, but the lighting-circuit line is not suitable for any but medium short waves, due to the bypassing effect of the distributed capacity in particular. In sound engineering sometimes the lighting-line-transmission method is used, by borowing from radio, to avoid installing a special line to cover a considerable indoor dis-

---

necessary, for when wired correctly, the RGH-4 will play immediately.

Tuning is a matter which can only be learned by experience and patience. However, some advice can be given here. When the tubes are fully heated with the bias control of the radio frequency stage turned clockwise as far as it will go, turn the regeneration control clockwise slowly until a hissing sound is heard in the speaker. Rotate the tuning knob very slowly until a slight squeal is heard in the speaker. Concentrate on this squeal, rotating very slightly backwards and forwards until some signal is distinguishable, reducing somewhat if necessary on the regeneration and bias controls. When a signal is heard it can be brought out

clearly by means of the antenna compensating condenser.

The Antenna

Although the doublet antenna is almost a necessity for short-wave reception, good results are obtainable on an ordinary antenna. In this case the lower end of the antenna winding is grounded and a small (30-70 mmfd.) variable trimmer is connected in series with the antenna.

Results depend only upon the skill with which the novice wires and tunes the receiver. Verifications have been received already by fans from all parts of the world, including New Zealand and Australia—all on the loudspeaker.

A test oscillator, without modulation, for battery operation. Switching is used for coverage from 125 kc to 16,000 kc. The detector or second detector plate current in a set may be read for indication purposes, in the absence of modulation which would actuate an output meter.
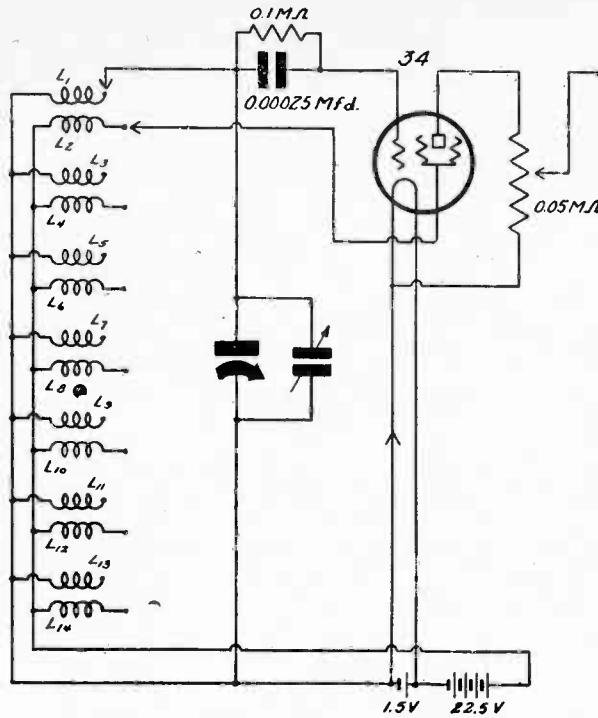
(Continued from preceding page)

tance. For instance, an orchestra is located in a pit at a night club, and a public address system is used, necessitating some reproducers at a considerable distance. The choice lies between sending the audio frequencies over the line, or sending a radio frequency, assuming the line is to be used at all. If audio is sent, as there is a 60-cycle hum present, or 120-cycle hum, on a-c lines, and even on d-c lines there is a commutator frequency around 800 cycles, and other noises, and since by audio transmission all frequencies below the highest of such interference would have to be wiped out to get rid of them assuredly, radio-frequency transmission is used. A small oscillator has the orchestra's audio frequencies impressed on it, and this r-f voltage is fed to the line through small condensers, around 0.01 mfd., and picked off at a remote point by a receiver tuned to that frequency, and perhaps feeding another power amplifier. In general, a low frequency is used, somewhere around the intermediate frequencies now popular in superheterodynes. Random experiments have been made at higher frequencies, but strong attenuation is noted as the frequency of the carrier is increased. A point to consider is whether one is entitled to use the lines that are the property of the power company without its permission, so it is well to consult the power companies before any such use is attempted, and also to consider that any possibility of creating interference with the sending or reception or authorized carriers raises the problem of getting a transmitting license, besides.

* * *

Test Oscillator Values

PLEASE LET ME KNOW what the inductance values have to be for a test oscillator to cover the intermediate and higher frequencies (you assign the limits), and give the value of tuning capacity Switching is desired.—T. L.

For an oscillator such as the type illustrated, which is for battery operation, and has no modulation, by the way, if the tuning condenser is to have a trimmer, which must be of the air-dielectric type, the capacity of the main condenser may be 140 mmfd. maximum, that of the trimmer 36 mmfd., and the inductance to reach a frequency as low as 125 kc would have to be 6 millihenries. The succeeding inductances would be reduced by one-fourth to complete the seven needed to go from 125 to 16,000 kc. This range would be sufficient. If the trimmer is to be omitted, a condenser of 0.0001 mfd. will be satisfactory, the low-frequency inductance 10.5 millihenries, and the same scale of reduction for succeeding stages, that is, prior coil reduced in inductance until it is one-fourth that of its predecessor. The frequency ratio slightly exceeds 2 to 1. The tuned windings are meant. The ticklers would have to be selected large enough to insure oscillation.

* * *

Permanence of Calibration

FOR SHORT-WAVE WORK, how can anything be calibrated and stay put, if there are variable factors that are not even taken into consideration? Practically everything changes.—T. G.

Yes, it is very difficult to have a permanently accurate calibration of any receiver, but one way of going about the problem is to construct a very good oscillator, calibrate it carefully, after having introduced safeguards for maintenance of the frequency. These might include a temperature oven. This oscillator's harmonics, and for a small bit of the tuning its fundamentals could be used as a precision check against the changing errors that time works in the set. The oscillator could have resistors that were of known fixed inductance and would remain constant in both respects, would have coils free of meteorological effects, and capacities of the air-dielectric type, and otherwise safeguarded against changes due to expansion, contraction, vibration, temperature, moisture, etc. As a further check some crystal-controlled low-frequency source of constant frequency could be used for its harmonics to check the oscillator, which in turn is used to check the set, but this would be a rather elaborate set-up. The frequencies will change from what they were when the set was calibrated due to many causes. Precision type calibration is meant, however, as for general receiver use a calibration of sufficient permanence can be put right on the dial scale, and be relied on for station-finding, even including short waves to 15 meters.

* * *

Resistor to Replace Choke

IS IT PRACTICAL to use a resistor instead of a choke in a small universal type short-wave set, using plug-in coils? —H. H. D.

Assuming that the filter choke in the B leg is meant, a resistor may replace it, with reliance being placed mainly on the high capacities of the filter condensers.

The Scout Portable

Short-Wave Set Has Broadcast Coil and Works on Either A.C. or D.C.
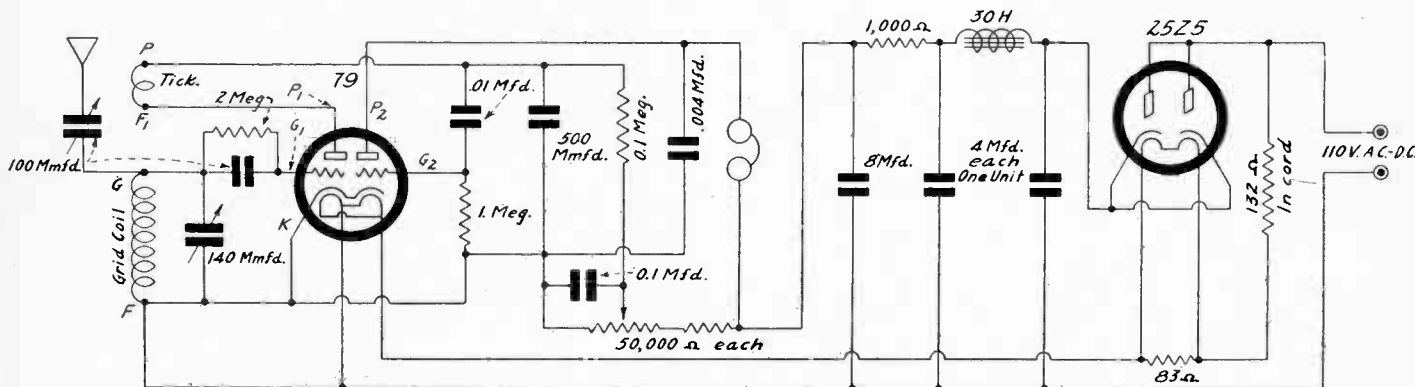
By Herman Cosman

Try-Mo Radio Corporation

FIG. 1

The circuit diagram of the universal short-wave receiver. The use of a 79 tube and a 25Z5 rectifier makes the receiver the equivalent of a three-tube regenerative circuit.

THE advantages of a portable radio receiver at vacation time are so well known and appreciated that it is unnecessary to adduce any reasons why such a set should be taken along on summer trips. The main objections to so-called portable receivers are that they are too heavy and that they add excess baggage to the traveling equipment. These objections are no longer valid, for now a portable receiver is as easy to carry around as an overnight bag, and it bulks even less. The erstwhile portable receiver, which was merely transportable with the aid of truck and husky porter, exist only in history.

By portable receiver is not always meant that it can be carried everywhere and that it can be set up for operation anywhere. Sometimes, as in the present use of the term, it means a receiver that can be carried about without effort, but one that can be set up for operation only where there is electric power available, either a.c. or d.c.

At first it would seem that a receiver that is restricted in this manner would not be suitable for portable use, it would seem that it would be necessary to carry a power plant along as well as the little box containing the receiver. On second thought we conclude that the first thought is all wrong. There are few places, indeed, where a camper can go, especially a motor camper, where there is no electric power. One of the first things that the camp management provides is light, and that usually means electric light. Hence electric power is available in most places.

Rugged Individualism

If the camp management provides electric light and power, does it not also provide a radio receiver for the use of the customers? Yes, as a rule there is a receiver for use by the public, just as there is a pen in every post office for use by the people. And the quality of that public receiver is of the same order as the quality of the post office pen. Just as every one who has a fountain pen uses it in the post office, so does every one who has his own set in camp use it in preference to the receiver provided. And every camper who has had previous experience is sure to bring along his own

---

LIST OF PARTS
Coils

One set of Bruno four-pin plug-in coils (15 to 500 meters).
One 30-henry Midget filter choke.
Condensers

One 0.0001 mfd. mica condenser.
One 0.0005 mfd. mica condenser.
One 0.01 mfd. by-pass condenser.
One 0.1 mfd. by-pass condenser.
One 0.004 mfd. mica condenser.
One 8 mfd., 175-volt electrolytic condenser.
One 2-section, 4 mfd. each, 175-volt electrolytic condensers.
One 0.00014 mfd. tuning condenser.
One 0.0001 mfd. antenna trimming condenser.
Resistors

One 2-megohm, ½-watt grid leak.
One 1-megohm, ½-watt grid leak.
One 100,000-ohm, ½-watt resistor.
One 50,000-ohm, 1-watt resistor.
One 1,000-ohm, 1-watt resistor.
One 50,000-ohm potentiometer.
One 83-ohm, 255-watt resistor (wire-wound).
One line cord, 132 ohms.
Other Requirements

One aluminum chassis (as described).
One carrying case (as described).
One four-prong Isolantite coil socket (Hammarlund).
Two six-prong wafer sockets.
One three-inch vernier dial.
One tube shield.
One 79 tube.
One 25Z5 tube.
One pair featherweight phones (Acme).

---

receiver. The post office pen and the public radio receiver have one thing in common, both scratch and sputter.

There is still another reason why each camper or motor traveler should have his own receiver along, and that is that he need not defer to anyone as to choice of program or time of listening. The idea of having what one likes when one likes it is just as strong in the country as in the city, in the camp as in the home. The freedom of choice of time and program is the main reason for having a receiver along, for a person's individualism is not left behind on the vacation trip.

Why Set is Light

What reason can be assigned for the extreme lightness of the portable under discussion at the present time? First of all, it is the leaving of the power plant at home and the utilizing of the plant that is available where the receiver happens to be set up. Batteries are not weightless, however small they may be; and if they are large enough to be sufficient, they immediately put the receiver into the transportable class.

The second reason is that a dual function tube is used in the circuit, as will be seen from Fig. 1. The 79 tube is first used as a regenerative detector and then as a resistance coupled audio amplifier. Right here we have two facts that contribute to lightness, or rather, that detract from weight. One is regeneration, which is weightless; the other is resistance coupling, the parts for which are featherweight. The other essential parts of the circuit are light and compact, too, so that weight everywhere has been minimized.

A glance at the diagrams will disclose that the receiver is provided with a pair of headphones. These clearly indicate that the receiver is for individual entertainment. Let the public receiver bleat anything it likes, or that the camp proprietor likes, but the possessor of this portable receiver will hear what he likes, and nothing else. And what will he like?
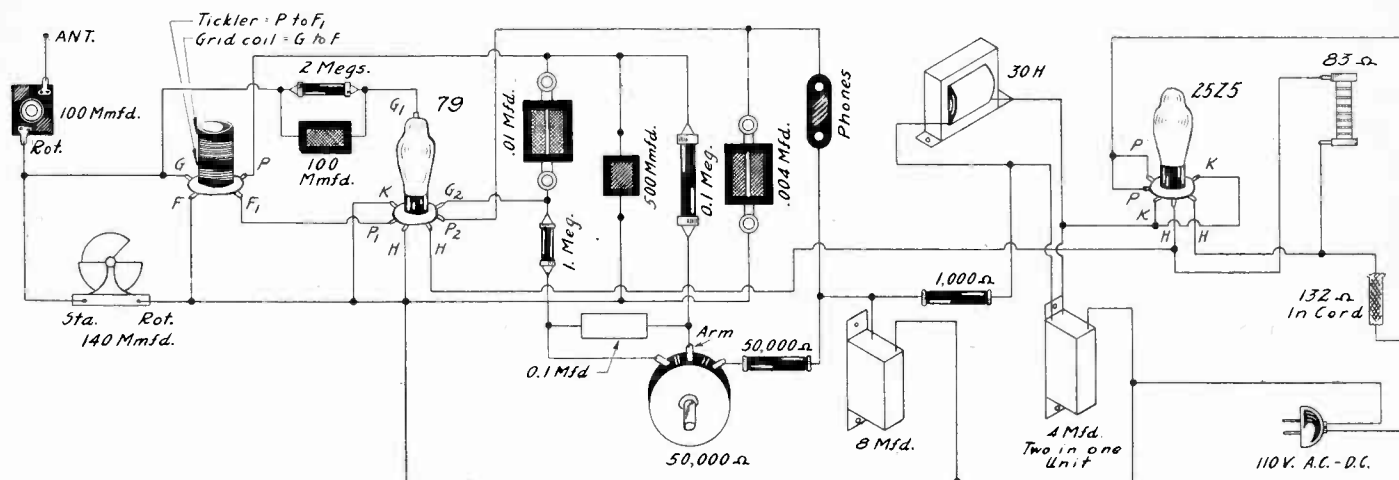
FIG. 2

This is the wiring diagram of the same circuit as that given in Fig 1. The pictorial layout facilitates wiring the circuit. The ballast resistor is concealed in the line cord.

(*Continued from preceding page*)
Most likely he will be listening to foreign stations, or at any rate, stations far removed.

Foreign stations! Is it possible with a receiver as simple and as light in weight as this to bring in foreign stations on broadcast waves? Yes, some, but not many. The fact is that this is not primarily a broadcast set. It is primarily a short-wave set and secondarily a broadcast set. On the short waves, say the waves of 20 and 40 meters, it will bring in stations from across the oceans, either east or west. Many samples of this receiver have done it, and there is no reason why any other set built correctly according to the same pattern should not do as well. We might add, correctly manipulated, also, for much depends on the skill with which the operator of a receiver handles the set. The set will respond handsomely to skillful manipulation.

Building the Set

The best way of duplicating the receiver and its performance is for the prospective builder to procure a kit, for then the work is more than half done and the assurance goes with the kit that

A THOUGHT FOR THE WEEK

MAYOR FIORELLA LaGUARDIA of New York City has given WNYC, the municipal broadcasting station, until December 31 next to make good or be closed down. Of course, making good takes in various angles and it would be difficult to get a regular jury of citizens to agree on a basis for keeping WNYC on the map. Generally speaking, public interest and civic value are the two things most generally acknowledged to be essential in a station of this kind, but public interest and civic value could easily be rendered into so many channels of thought and expression that one might wonder if several millions of listeners-in are thinking in the same terms.

Anyway, Mayor LaGuardia has spoken and the final date for the decision comes before 1935 sings its way into the calendar. In the meantime, members of the WNYC staff may be expected to do their best to justify their retention on the municipal pay roll.

the replica will perform as well as the prototype receiver.

The chassis consists of a 5⅝ by 8⅝ inch panel, with a shelf 5½ by 4½ inches. The controls are mounted on the panel and the tubes on the shelf. The parts of the set have been assembled on the chassis, and wired in accordance with Fig. 1 or Fig. 2, the receiver is ready to be mounted in the carrying case. The size of the case used is 9½ inches long, 6 inches wide, and 4¾ inches deep, exclusive of the depth of the cover, which is 1½ inches.

The panel fits the case snugly all around and it is flush with the box top when the lid is open. There is ample room for extra coils in the lid recess.

Control of Set

Tuning is done with a single condenser, which is provided with a slow

motion dial. There is, however, an antenna condenser with which fine tuning can be effected. This condenser is of great help when weak stations are to be brought in.

The volume is controlled by means of a 50,000-ohm potentiometer in the plate circuit of the triode that is used for the regenerative detector. The potentiometer is so placed that the effective voltage on the plate is varied.

It will be observed that the circuit is well filtered. The 0.004 mfd. condenser connected between the plate of the second triode and ground is particularly important, for if this is omitted from the circuit there is a terrific howling. The output of the rectifier is also well provided with by-pass condensers. There is an 8 mfd. electrolytic from the positive side to ground. Then there are two 4 mfd. electrolytics connected from the filter choke to ground. Besides, the choke has an inductance of 30 henries. These filter precautions are necessary because of the a-c supply and because hum is more easily discernible in the headphones than in the loudspeaker.

Filament Arrangement

Note the manner in which the filament circuit is arranged. The 79 tube requires a current of 0.6 ampere whereas the 25Z5 requires only 0.3 ampere. A shunt must be provided across the rectifier filament to pass the extra current. Since the extra current required is just equal to the current required by the rectifier, all that is necessary is to shunt the filament by a resistance equal to the internal resistance of the tube, which happens to be 83 ohms. Now the heater circuit as a whole draws 0.6 ampere. Hence we must provide a ballast resistor which will drop the excess voltage when this current flows through it. The drop in the 79 is 6.3 volts and that in the 25Z5 is 25 volts. Hence the total useful drop in the heater circuit is 31.3 volts. If we assume that the line voltage is 115 volts, the ballast resistor must drop 83.7 volts. Since the current is 0.6 ampere, the required ballast is 140 ohms. If the line voltage is only 110 volts, the ballast should be only 131 ohms. This resistor should be built into the supply cord.