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JUNE 30
1934

RADIO WORLD

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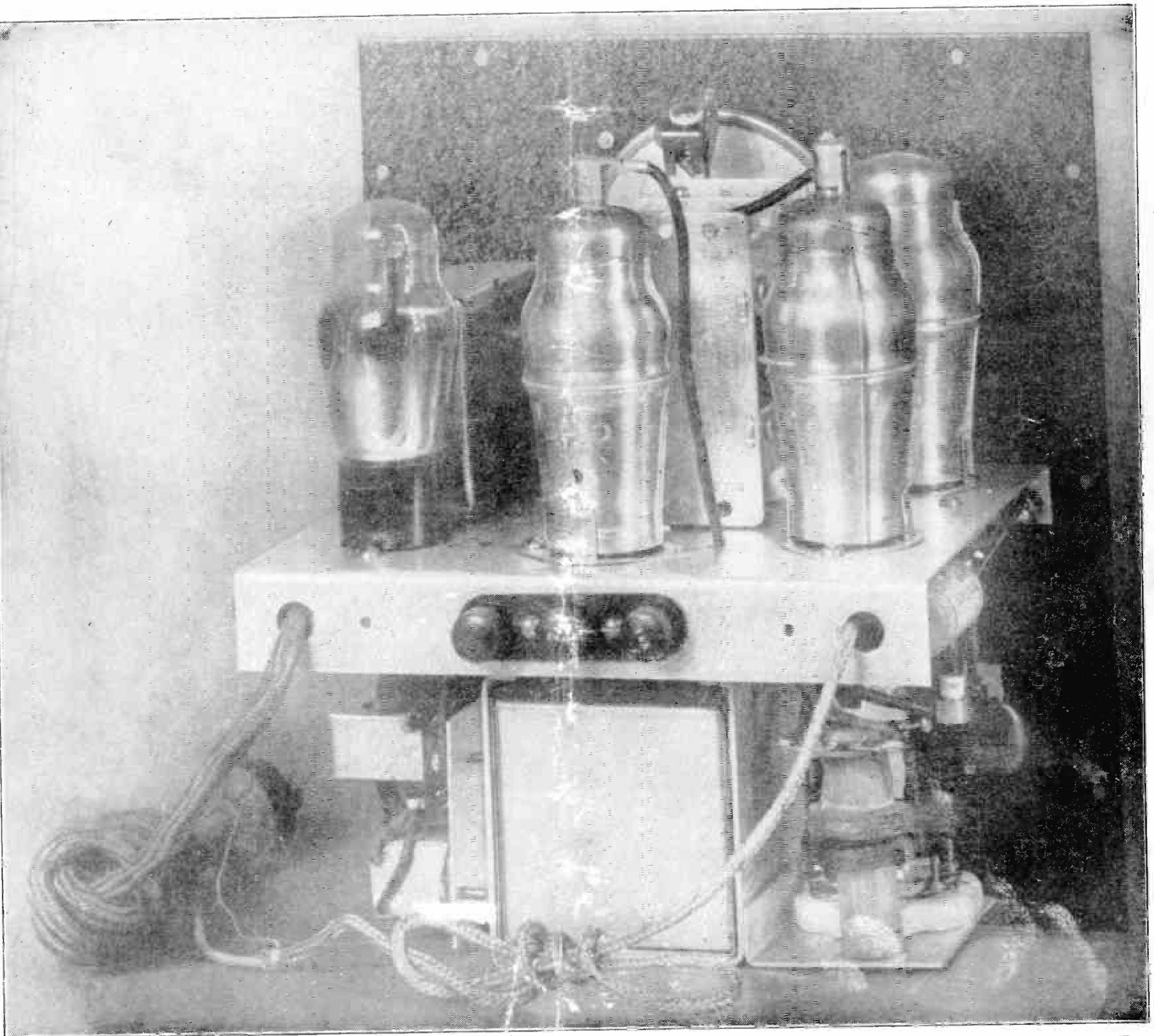
The First National Radio Weekly
640th Consecutive Issue Thirteenth Year

Basic Receiver Circuits for Short Waves

Underpowering of Tubes

AN ACHIEVEMENT IN SHORT-WAVE CONVERTERS



This a-c-operated short-wave converter yields exceptional performance, representing one of the few converters that enable results equal to those from a powerful short-wave set. See article on next page.

A Swell Converter

Four-Tuber Has Separate Modulator and Oscillator

By Samuel Miller
Postal Radio Corporation

THE question often arises as to whether or not a combination of high-grade converter and a fairly good broadcast set can perform as efficiently as a receiver designed specifically for short wave reception. The answer is emphatically, yes!

A properly designed converter, coupled to an average broadcast receiver may be more sensitive than an ordinary (or even expensive) short wave receiver because the use of a Deluxe Converter automatically changes an ordinary T.R.F. broadcast receiver into a super-het., or it changes a broadcast "super" into a double-shift short wave superheterodyne with three detectors and two different I.F. frequencies.

Actual performance tests have conclusively proven that a real high class converter will increase the overall sensitivity and selectivity of an ordinary broadcast receiver to such an extent that their combined operation will actually outperform many expensive short wave and all-wave receivers.

The basic function of all converters is primarily to invert the high frequencies of the short wave spectrum into lower frequencies of the broadcast band so that any broadcast receiver can amplify, detect and further treat the inverted frequency as an ordinary broadcast signal.

On What Reception Depends

When the action of a converter is definitely limited to its basic function (only that of frequency inversion) it adds nothing to the selectivity or sensitivity of the receiver with which it is used. In fact, successful reception of short-wave stations is entirely dependent upon the sensitivity and selectivity of the broadcast receiver. It therefore follows, that while many improvised devices may properly earn the name of "converter," few will dependably bring in weak foreign stations, with more than a satisfactory degree of volume, regardless of the receiver with which they are used.

The essential difference between this Deluxe Converter and the conventional type is that it performs THREE important functions, all of which are prime requisites for short wave reception on broadcast receivers.

A brief review of these functions will clearly indicate why this efficient device, and not the broadcast receiver, is the determining factor in the overall performance of the combination.

Functions of the DeLuxe Converter

1. *Driftless Frequency Inversion.*

Although frequency inversion takes place in all short wave converters, the term as used here applies to a precise form of dependable inversion all the way up to 20 megocycles (down to 13 meters), wherein the signal is not only first freed from interference and then continuously inverted to the exact predetermined intermediate frequency, but is also subsequently INTENSIFIED.

Such inversion can only take place when special precautions are taken to stabilize the oscillator and adjacent circuits against frequency drift. This involves the use of a mixing system to be later described, which presents an identical input impedance to the entire band of frequencies to be received, as well as the employment of an exceptionally well regulated power supply.

2. *Increases Sensitivity of Broadcast Set.*

However sensitive your broadcast receiver

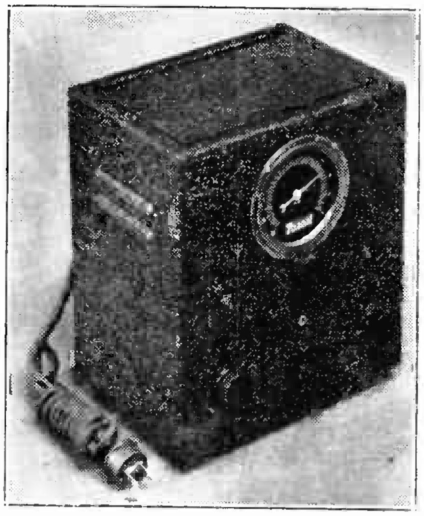


Fig. 1

may be, it can always be made more sensitive, for no short wave receiving system is ever too sensitive for 'round-the-world reception. Inasmuch as your broadcast set will not amplify or detect any signal that is fed into it below its response level, precautions must be taken to insure the transfer of the inverted signal from the converter into the broadcast receiver with maximum intensity and minimum noise. To accomplish this, an additional high-gain doubly-tuned I.F. stage is placed after the converter proper.

What Fixed Tuning Does

While it is true that ordinary converters, which do not employ a pre-tuned stage of I.F., will operate any broadcast receiver regardless of the frequency to which the set is tuned to, this condition prevents the user from properly resonating the input circuits of the receiver with the output circuit of the converter. When this detuned condition exists there is an apparent loss of sensitivity as well as a noticeable decrease in selectivity. In some cases, two stations may be received at the same time.

The fixed-tuned I.F. stage (545 kc.) employed in the Deluxe Converter is a feature of paramount importance for the following reasons: first, because it adds an additional high-gain stage to the receiving system and thereby increases its overall sensitivity; second, because a fixed tuned stage can readily be designed for maximum amplification and more effective suppression (rejection) of undesired adjacent frequencies; and, third, because the use of a pre-tuned I.F. output stage will enable the user to easily "resonate" the input circuits of the set to the tuned output of the converter (by tuning the broadcast receiver for "peak" volume.

When matched resonance is thus established, maximum transfer of energy takes place from the converter to the receiver, and perfect tracking of the oscillator is assured for the entire series of short wave bands.

Selectivity

3. *Increased Selectivity of Broadcast Set.*

Receiver selectivity is obviously of paramount importance in successful short wave reception because increased selectivity means elimination of signal interference.

As most forms of static appears simultaneously over the wide frequency band, it follows that the narrower the band of frequencies admitted by the receiver, the lower the noise level. Therefore, the more selective a receiving system is, the more effective will be its suppression of atmospheric disturbances.

The simple principle utilized by this Deluxe Converter to increase the selectivity of any broadcast receiver is based upon the fact that the degree of kilocycle selectivity of any superheterodyne receiver is determined by the frequency of the I.F. amplifier and not upon the signal frequency. (T.R.F. short wave receivers are dependent upon the signal frequency and tune very broadly at the higher frequencies).

A well designed broadcast T.R.F. receiver will completely cut off a powerful carrier when tuned approximately one per cent. of the signal frequency off resonance. In other words, a broadcast receiver with a 10 k.c. selectivity will eliminate the carrier frequency of a 1,000 k.c. signal when detuned one per cent of the signal frequency (10 k.c.).

Resultant Selectivity

If this same T.R.F. receiver were used, however, for short-wave reception, say on 15,000 k.c. (20 meters), a 150 k.c. (one per cent. of 15,000 k.c.) selectivity would result. A powerful station would therefore cover 150 k.c. on the dial, or about one-half the width of the 300 k.c. band. Because of certain limitations of coil construction there is no way that this selectivity could be materially increased.

Amazing as it may seem, this same receiver is actually made 28 times more selective when the Deluxe Converter is used with it. The reason for this remarkable increase of selectivity is due, as previously stated, to the fact, that the frequency selectivity of a superheterodyne receiver (which is what results when the converter is used with a standard broadcast set), is dependent upon the intermediate frequency and not upon the signal frequency. Thus with an I.F. frequency of 545 k.c. and a selectivity of one per cent., complete suppression of powerful carriers will take place when the I.F. (or the signal frequency) is off resonance 5.45 k.c., which is approximately one twenty-eighth of the 150 k.c. selectivity of the T.R.F. receiver operating on the same signal frequency.

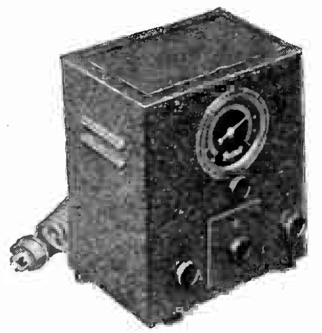
Coil Changing System

Notwithstanding the fact that coil systems represent the heart of short-wave equipment, it seems almost unbelievable that such an important item should receive such scant attention. The two most popular systems in use today, simple plug-in coils or some switching arrangement, are both representative of the improvised methods used for band changing in the earliest of radio receivers.

Simply because it has been customary to use either one of these systems for band changing it should not be assumed that better means cannot be found to accomplish the same objective with a decided improvement in performance and operating efficiency. A few words regarding the relative merits of switching arrangements and plug-in coils might not be out of place.

(Continued on page 19)

4 TUBE SHORT WAVE CONVERTER



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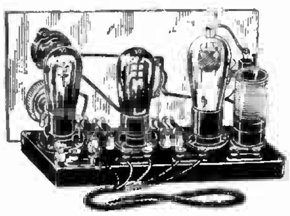

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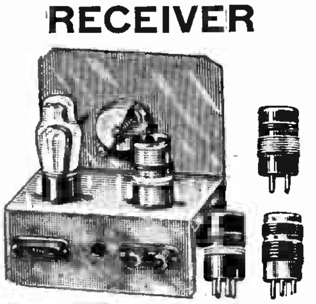

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Issue of June 9, 1934—Two Short-Wave Receivers Using 25Z5; Precision Calibration of High Frequencies; The 19-Tube for Short Waves; Short-Wave Midget; Short-Wave Tuners (Part V of "The Short-Wave Authority").

Issue of June 16, 1934—Finding Frequencies in a Small Short-Wave Set; Tuning Charts for All Plug-in Coils; The Mascot "Two" Short-Wave Set; Types of Receivers Used for Bringing in Short Waves (Part VI of "The Short-Wave Authority").

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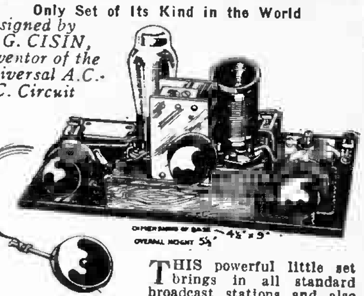

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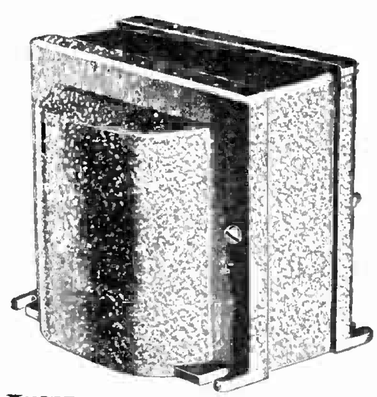

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The First National Radio Weekly
THIRTEENTH YEAR

J. E. ANDERSON
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Vol. XXV | JUNE 30th, 1934 | No. 16. Whole No. 640

Published Weekly by **Hennessy Radio Publications Corporation,** 145 West 45th Street, New York, N. Y.

Editorial and Executive Offices: 145 West 45th Street, New York

Telephone: BR-yant 9-0558

OFFICERS: Roland Burke Hennessy, *President* and *Treasurer*. M. B. Hennessy, *Vice-President*. Herman Bernard, *Secretary*.

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The Queer Behavior

of Oscillators at High Frequencies and How These Generators Change Their Nature

By J. E. Anderson and Herman Bernard

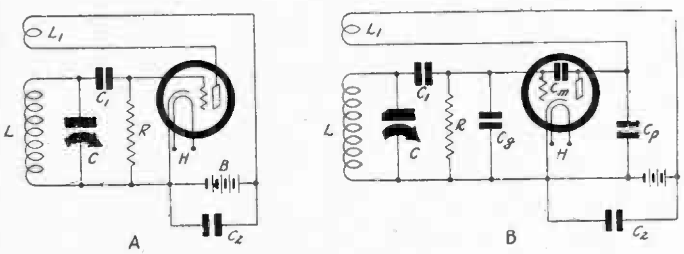

FIG. VIII-1
The tuned-grid oscillator. A, left, shows usual form, and B, right, the same form but with the inter-electrode capacities indicated.

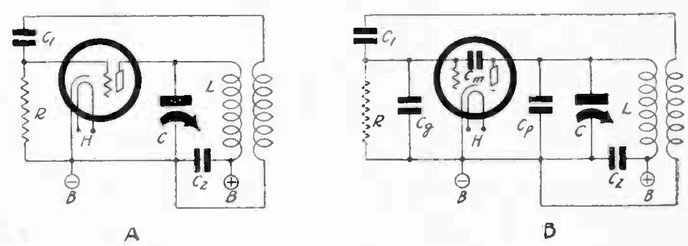

FIG. VIII-2
The tuned-plate oscillator. A, left, shows the usual form of it while B, right, shows it with the inter-electrode capacities.

OSCILLATORS designed to generate low frequencies, say those below 100,000 cycles, can be classified in certain definite types according to the manner in which energy is fed back from the plate to the grid to maintain the oscillation. The common types of vacuum tube oscillators are the tuned grid, the tuned plate, the Hartley, the Colpitts, and the Meissner. But when the frequency becomes high it is difficult to make such classification because an oscillator is seldom what it seems to be. It may have the appearance of a Hartley, yet it may actually be a Colpitts, which is the exact opposite. About the only classification that can be made in many instances is to say that the circuit is oscillatory or that it is not.

The reason for this change of character in a circuit is that there are stray capacities, such as the capacity between the grid and the plate, that between the grid and the cathode, and that between the plate and the cathode. A Hartley oscillator is characterized by having a coil between the grid and the plate with the cathode connected to a tap on that coil, the tubing condenser being connected across the entire coil. The plate-grid capacity is usually added to this tuning capacity in the Hartley, so that does not cause any complications; but the grid-cathode and the plate-cathode capacities are connected across portions of the coil only, portions where no capacities should be. As long as the tuning capacity is large in comparison with these tube capacities the change in the circuit from the typical Hartley is negligibile; but when the tuning capacity is nearly the same as either of these, or even smaller than these, as it is likely to be in ultra-high frequency circuits, the circuit loses all characteristics of the Hartley except the appearance. In a similar way other types may change their nature.

Superficial Simplicity

An ultra-high frequency circuit is usually very simple in appearance, and it is certainly simple to construct. Yet nearly every such oscillator is extremely complex, especially from the viewpoint of mathematical analysis; and if analytical complexity is a sign of radical performance, which it usually is, then the ultra-high frequency oscillator is most unreliable. Examination of some of the typical oscillators will disclose the reasons why they may be erratic in performance.

In VIII-1 we have a tuned-grid oscillator, which is one of the more commonly used oscillators. At left (A) the circuit appears in its usual explicit form, and at right (B) is the same circuit but with the inter-electrode capacities indicated. If all the stray elements were to be taken into account there would be so much more to consider, but the three tube capacities are the main stray factors.

In most instances the stopping condenser C1 is large in comparison with the grid-cathode capacity Cg. Hence for practical purposes we may regard the grid-cathode capacity as an addition to the tuning capacity C—a part of the minimum capacity of the condenser. Cm, the grid-plate capacity, and Cp, the plate-cathode capacity, are in series, and this series is in shunt with the tuning condenser. Hence Cm and Cp in series combination may be looked upon as a part of the minimum capacity of the tuning condenser.

(Continued on next page)

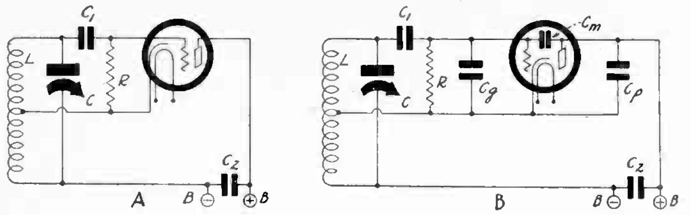

FIG. VIII-3
The typical form of the Hartley oscillator is shown at A and the same oscillator with the inter-electrode capacities indicated at B.

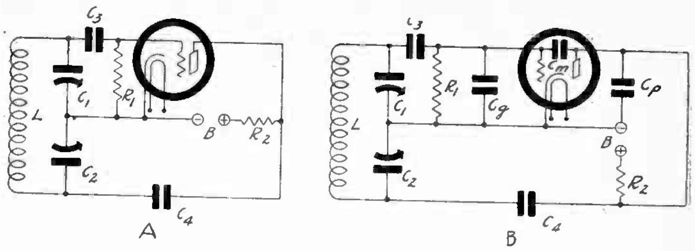

FIG. VIII-4
The Colpitts oscillator, A, as it is customarily represented, and B, as it appears when the inter-electrode capacities are indicated.

(Continued from preceding page)

No great disadvantage accrues from these additions to the minimum, for the only effect, except for ultra-high frequencies, is to lower the frequency ratio for a particular range of the tuning capacity. At very high frequencies the inductance L is small and the tuning capacity C is sometimes omitted. Because L is small the ratio of the inductance in the circuit to the capacity, which is now only the sum of stray capacities, oscillation can sometimes not be maintained. In other words, the stray capacities put a limit on the frquency that can be generated. Moreover, the relatively large value of capacity and small value of inductance make the circuit inefficient as an oscillator.

The plate-cathode capacity has another adverse effect, namely, the shunting of the feedback past the tickler L1. At low frequencies this shunting effect is negligible because the reactance of Cp is high, but as the frequency increases the shunting effect becomes greater and greater. A frequency will be reached at which not enough current will flow through the tickler coil to maintain the oscillation. This may be offset in part by increasing the number of turns on the tickler winding or by increasing the coupling between this winding and L. Even with these precautions the circuit will soon stop oscillating because of the shunting effect of the plate-cathode capacity. The cessation of oscillation will come sooner, the lower the L/C ratio in the tuned circuit.

Tune Plate Oscillator

Fig. VIII-2 shows the tuned-plate oscillator, A at the left as it is usually represented and B at the right as it is when the inter-electrode capacities are taken into account. In this case, it will be noticed, Cp is added directly to the tuning capacity C, whereas Cg is in series with Cm and this combination is then in shunt with the tuning capacity. The tuned circuit is practically the same as that in the tuned grid oscillator.

The essential differences between the tuned grid and the tuned plate oscillators is the position of the tuning capacity C. In the tuned grid circuit it is across Cg, which is much smaller than Cp, and in the tuned plate it is across Cp. Since Cp is larger than Cg, the ratio of the inductance to the capacity in the tuned circuit will be lower for the tuned plate than for the tuned grid. This has the effect of making the tuned plate circuit a less ready oscillator. However, there is a compensating feature. Cg is now shunting the feedback and reducing the tendency to oscillate at the higher frequencies. But Cg and the shunting effect are small.

In order to attain a very high frequency of oscillation it is necessary that the inductance be made as small as practical, but this should be done only after the total effective capacity across the inductance has been made as small as it can be made. Even when this has been done the capacity will be much larger than is desirable.

The Hartley Oscillator

The Hartley oscillator is usually represented as in Fig. VIII-3A when the tube used for it is of the heater type. The cathode of the tube is connected to a tap on the coil, the position of the tap being very close to the center for tubes ordinarily employed as oscillators. When the inter-electrode capacities are included explicitly in the diagram, the circuit appears as in Fig. VIII-3B. If we assume that C1 and C2 are so large in comparison with the inter-electrode capacities that their effects may be disregarded, which is usually justifiable, Cm is in shunt with C and is added directly to it, while Cg and Cp are in series with each other and the combination is added to the tuning capacity.

The capacity added to C by the tube is about the same in this circuit as in the preceding, for in each case one of the three is added to tuning condenser directly and the other two are added after they have been combined in series. The largest addition occurs when the plate-cathode capacity is added directly, as in the tuned plate oscillator. In the Hartley the smallest of the three is added to the tuning capacity.

The Hartley circuit is one of the easiest to build, especially when the tube is of the heater type, for the coil system consists of a single coil with a tap for the cathode near the middle turn. The use of the heater type tube has the advantage that the tuned circuit can be grounded on one side.

The Colpitts Oscillator

The Colpitts oscillator is the opposite of the Hartley in respect to feedback and in respect to many of its properties. The circuit is shown in its usual form in Fig. VIII-4A, while in Fig. VIII-4B it is shown with the three inter-electrode capacities. It will be noticed that Cg is added to C1 without much change, since C3 is comparatively large. Likewise Cp is added to C2, for C4 is so large that its effect can be disregarded. The series of condensers C3, Cm and C4 are added to the tuning capacity since the tuning capacity is across the coil L. As C3 and C4 are very large, the value of the capacity of the three condensers in series is not much different from the capacity of Cm alone.

As far as the inductance is concerned, the Colpitts oscillator is the simplest of all, for there is only one coil and that does not even have a tap. Yet the Colpitts is not the simplest oscillator in practice, since it requires two variable condensers in series, the rotors of which should be grounded. Notwithstanding this, the Colpitts has many advantages over other oscillators. For one thing, it is easily frequency stabilized to a very high degree; for another, it has a high ratio of inductance to capacity in the tuned circuit. Therefore it is a ready oscillator at the high frequencies.

The Ultraudion Oscillator

For very high frequencies the Colpitts usually takes the form of the ultraudion oscillator, shown in the two forms in Fig. VIII-5. That this oscillator is a Colpitts is not apparent when the circuit is represented in its usual form, as in Fig. VIII-5A, for then no feedback mechanism is indicated. It does become perfectly clear, however, as soon as the circuit is represented as in Fig. VIII-5B. In that form it differs in no wise from the recognized form of the Colpitts, except that the self-capacity of the coil has become variable and unusually large.

The ultraudion will oscillate effectively at very high frequencies because of a highly favorable ratio between the inductance and the capacity in the tuned circuit. The tuning capacity can be removed, leaving only the self-capacity of the coil, which can be made small, and the tube capacities. Now the grid and plate capacities are in series and therefore the effective capacity is smaller than the smaller of the two. The grid-plate capacity is directly across the coil, but it is small. For a 56 heater type tube Cm = 3.2 mmfd., Cg = 3.6 mmfd., and Cp = 2.5 mmfd. Cg and Cp in series will have a capacity of 1.48 mmfd. Therefore the tube contributes a capacity of 4.68 mmfd. A small coil suitable for very high frequencies might have a capacity of 2 mmfd., so that the total capacity would be approximately 7 mmfd. If we were to generate a frequency of 100 million cycles (3 meters) we should need an inductance of 0.362 microhenries. This is a small coil, yet it is not so small that it will not make the circuit oscillate.

Tuned Grid, Tuned Plate

The tuned grid, tuned plate oscillator is shown in Fig. VIII-6, the circuit at (A) showing it in the usual form and that at (B) in the form it assumes when the tube capacities are explicitly indicated. In these drawings C3 is supposed to be so large that its reactance is entirely negligible. Co may or may not be so large that its reactance can be disregarded.

This oscillator, which may also be referred to as the doubly-periodic oscillator, occurs just as often by accident as by design; but it occurs frequently, both in short-wave and medium wave circuits. It occurs especially, and by accident, in high-frequency amplifiers in which both the plate and the grid circuits are tuned.

The doubly-periodic circuit is closely akin to the Hartley oscillator, especially that form of the Hartley in which there is no mutual inductance between the two coils. The frequency of oscillation is determined in the same manner and changes

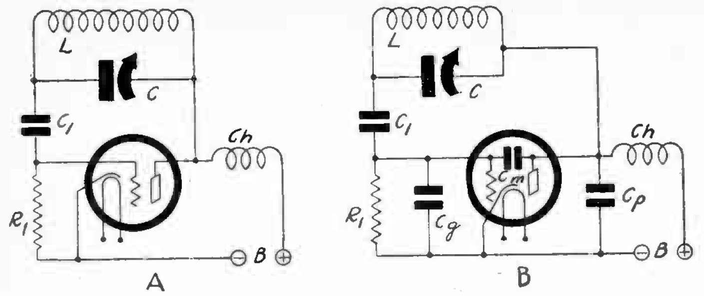

FIG. VIII-5
The ultraudion oscillator, A, is a special form of the Colpitts, which is shown clearly at B in which the inter-electrode capacities have been taken into account.

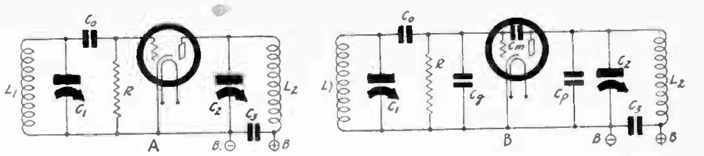

FIG. VIII-6
The tuned-grid, tuned-plate oscillator is closely akin to the Hartley. It oscillates always at a frequency lower than the natural frequencies of the tuned circuits. A shows simple circuit and B includes tube capacities.

in frequency due to changes in operating conditions are similar. The frequency is determined by all the reactances, as in any other oscillator, and not by either tuned circuit alone, as is often asserted.

Statements frequently are made that if the circuit is tuned by one condenser, say C1, the frequency of oscillation is one thing, and that if it is tuned by the other, C2, it is something else. The fact is that whether the circuit is tuned by C1 or by C2, there is only one circuit and only one frequency at which it can oscillate for any given value of the condensers. Whenever the circuit oscillates the frequency is such that the impedance of L1 and C1, in parallel, is inductive and that the impedance of L2 and C2, in parallel, is also inductive. In other words, the frequency of oscillation must be lower than the natural frequencies of both L1C1 and L2C2. This, of course, holds when these natural frequencies are equal as well as when they are unequal. The reactance from grid to ground must be positive and that from plate to ground must also be positive, when that between the grid and the plate is negative.

Under practical conditions, when the natural frequencies of the two circuits are nearly equal, the frequency of oscillation is very close to the natural frequencies of the circuits. Suppose, for example, that the two natural frequencies are the same, that the total capacity across the grid coil is 500 mmfd., that the total capacity across the plate coil is 525 mmfd., and that the grid-plate capacity of the tube is 3.2 mmfd. It can be shown that

$$\omega^2 = \omega_1^2/[1+C_m/C_1+C_m/C_2],$$

in which ω is the frequency of oscillation in radians, ω_1 is the natural frequency of either periodic circuit, also in radians, C_1 is the total capacity across the grid coil, C_2 the total across the plate coil, and C_m is the grid-plate capacity of the tube. Substituting the values assumed we have $\omega = \omega_1/1.00625$. Therefore the frequency of oscillation differs by less than one per cent. from the natural frequency of either of the two periodic circuits. In this instance the oscillation frequency is lower than the natural period. In other examples the oscillation frequency might be higher.

The reason for the small divergence is the small ratio of the grid-plate capacity to the capacity across either coil. To show this numerically let us assume that C_1 is 500 mmfd. as before but that C_2 is only the capacity of the coil and the capacity between the plate and the cathode, which we may assume to add up to 10 mmfd. The formula now yields

$$\omega = 0.867\omega_1,$$

which shows a much greater divergence between the two frequencies than the result in the preceding example.

Push-Pull Circuits

Nearly all the typical oscillators can be connected in push-pull. This is often done in transmitters, where the connection may have considerable advantage over a single-tube oscillator, but for the receiver there is little need of having two tubes in the oscillator. No appreciable power is required whether the oscillator is used as a regenerative detector or as a local or a beat oscillator in a superheterodyne. If the circuit oscillates with fair efficiency, that is all that is really needed.

There may be some advantage in a push-pull oscillator in respect to even harmonics. As in the push-pull amplifier, they should be weak or absent in the output of the push-pull oscillator. But this is a theoretical advantage, because if the harmonics are not generated strongly in the oscillator they will be produced elsewhere in the receiver; and their deleterious effect, if any, will be just as strong. Besides, it is practically impossible to balance a high-frequency circuit so well that there will not be a strong even harmonic content in the output.

Regenerative Circuits

Any of the oscillator circuits shown in the preceding drawings can be used as regenerative detectors provided that some means for controlling the oscillation intensity is introduced. This may be a means for varying the applied plate voltage, the screen voltage in case the tube has a screen, the suppressor voltage in case the tube has an externally accessible suppressor, the control grid voltage, and in filamentary tubes even the filament voltage. Other methods are to by-pass the tickler more or less, to varying the coupling between the tuned winding and the tickler, and to vary the resistance in the tuned circuit. The variation of the resistance can be accomplished in a circuit coupled loosely to the tuned circuit, that is, in an absorption circuit. Methods of regeneration control produce some detuning from oscillation frequency.

Stabilization of Frequency

Whether an oscillator is to be used in a transmitter or a receiver it is important that the frequency be constant once it has been adjusted to a desired value. In respect to the transmitter, a high frequency stability is required by law even when technical requirements do not impose the condition. In respect to the receiver, there are only technical requirements, but these are extremely strict in certain applications of oscillators.

Suppose, for example, that we are receiving a continuous-wave signal of 50 megacycles by the audible beat method, a local oscillator generating a frequency very close to 50 megacycles is required, say, 50,001 kc. A tone of 1,000 cycles will be heard in the output of the receiver so long as the two frequencies are present and differ by just this amount. Now suppose that one of the beating frequencies changes a little in respect to the other. There will be a change in the beat note, and it may easily be so great that the tone passes beyond audibility. Even if the change is so small that the tone remains audible, the pitch may vary so violently that the signals will be illegible. A very slight change in either of the high frequencies will result in a

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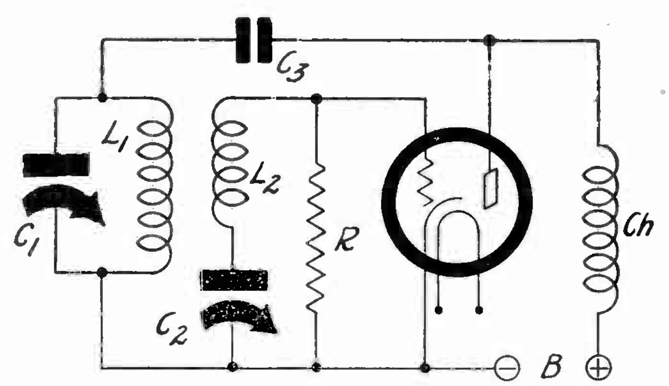


FIG. VIII-7
A simple way of stabilizing the frequency of a tuned-plate oscillator. The grid coil is tuned with the stopping condenser to the frequency of oscillation.

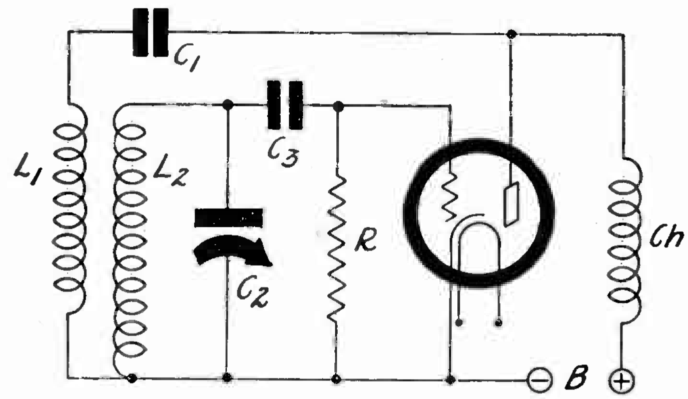


FIG. VIII-8
The tuned-grid oscillator is frequency-stabilized in a similar way to that of the tuned plate, but in this case the tickler is tuned to the frequency of oscillation.

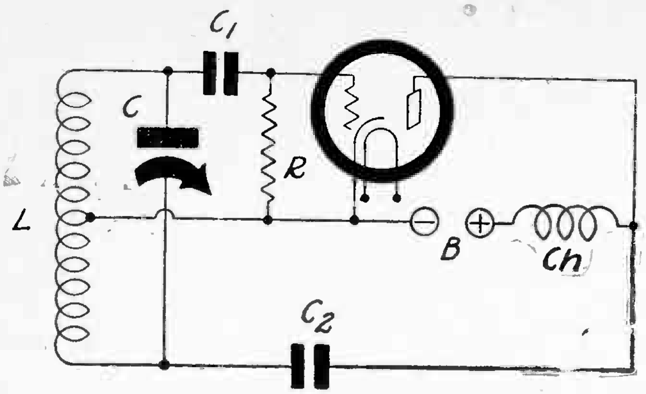


FIG. VIII-9

This illustrates how the Hartley oscillator can be frequency stabilized by means of phase-shifting condensers.

(*Continued from preceding page*)

variation of the beat tone that is exceedingly annoying, even though the signals are not unreadable.

The constancy of the two beating high-frequency oscillators must be of a high order. Let us say that the 1,000-cycle tone should not vary by more than 100 cycles. This means that neither of the high frequency oscillators should vary by more than this—100 cycles out of 50,000,000. The oscillators would have to remain constant to two parts in one million. Such a constancy is even greater than that usually ascribed to quartz crystal-controlled oscillator. However, over short periods, where a readjustment may be made occasionally, such constancy is attainable in a thermionic tube oscillator.

Stabilization

There are many ways of stabilizing the frequency of a thermionic oscillator, but they are not applicable to very high frequency generators. Usually they cease to be applicable when the inter-electrode capacities must be taken into account, and this is largely a matter of accuracy. An oscillator of 1,000,000 cycles may be stabilized sufficiently for its purpose, but if that oscillator is to be used to generate, by harmonics, a frequency of 10,000,000 cycles, the stabilization may be no longer adequate, because though the percentage deviation is the same at 10,000,000 cycles the absolute difference is too great.

Most stabilizing schemes depend on two principles, first, on the attainment of loose coupling between the frequency-determining circuit and the driving circuit, that is, the tube, and, second, on shifting phase so that the tube is in a resistive setting.

Of these the second method is the more easily applied. Fig. VIII-7 illustrates how it is done in a tuned plate oscillator. This is a typical circuit with one exception, it has a variable grid stopping condenser, C2. It is assumed that Ch is a choke of such a high reactance that it may be regarded infinite. Likewise it is assumed that C3 is a stopping condenser of such large capacity that the reactance may be regarded zero. The frequency of oscillation is supposed to be determined by the circuit L1C1. Ordinarily it will also be dependent on L2, C2, the coupling between L1 and L2, on the grid resistance (internal and external), and on the internal plate resistance. To stabilize the frequency it should be made independent of the tube resistances, for these will vary as the operating conditions change.

If C2 is chosen so that it resonates with L2 at the same frequency as L1 and C1 resonate, the frequency is stable to the extent that the approximations enumerated are valid. The grid condenser is put on the ground side of the secondary in order to facilitate adjustment. It may be well to point out that if L1 and L2 are equal, C1 and C2 are also equal, and they may be two sections of a tuning condenser gang.

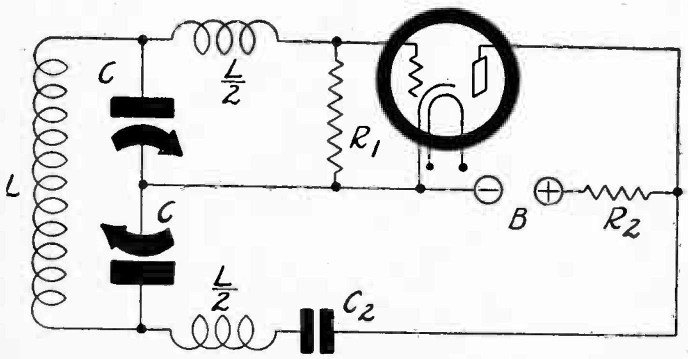


FIG. VIII-10

The Colpitts oscillator, being the opposite of the Hartley, is frequency stabilized by means of inductances.

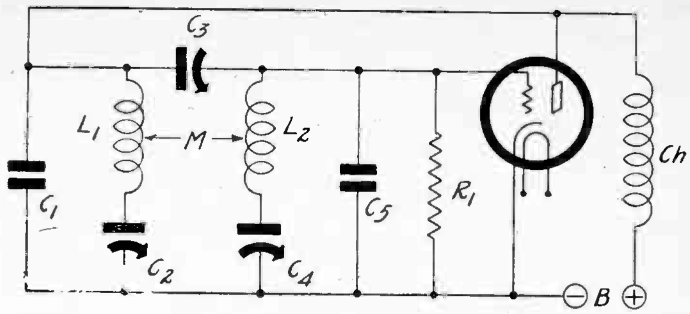


FIG. VIII-11

A complex oscillating circuit which can be stabilized although the inter-electrode capacities are taken into account.

In Fig. VIII-8 we have the tuned grid circuit. It can be stabilized in a similar way to that of the preceding circuit. If L2 and C2 are to determine the frequency, it is necessary to make L1 and C1 resonate at the same frequency. If the stabilizing condenser C1 is to be variable it may be put on the ground side of L1, when the rotor can be grounded. Of course, the limitations on Ch and C3 are the same in the tuned grid circuit as in the tuned plate.

Stabilization of the Hartley

The Hartley circuit can be stabilized as to frequency by inserting a condenser of suitable value in the grid lead, or in the plate lead, or by inserting one in each lead. There is an infinite number of combinations of these condensers that will lead to frequency stability. One of the condensers can be chosen arbitrarily and then the other can be computed so that the circuit will be stable when this condenser is inserted. The stabilization, of course, will obtain at only one frequency, for the adjustment is critical.

The simplest case of stabilization is that when the tap on the coil is in the middle so that the inductance of one part is equal to that of the other. For this case let us suppose that the plate condenser C2, Fig. VIII-9, is infinite, that is, very large. Then if k is the coefficient of coupling between the two parts of the coil, we have $C_1=C(1-k)/(1+k)$. If the circuit is tuned with the condenser C, which is the case in most instances, the stabilizing condenser C1 must be variable in order that the stabilization should obtain throughout the tuning range.

If the two parts of the inductance are entirely independent, that is, if there are two coils not coupled together, the coefficient of coupling, k, is zero, and the formula just given becomes $C1=C$. That is, if the stopping condenser in the plate circuit is very large, the grid condenser should be equal to the tuning condenser for stabilization. Further, if the grid and plate condensers are made equal, each should be equal to twice the capacity of the tuning condenser. These simple relations hold only when there is no coupling between the grid and plate coils and when the two coils are equal.

Stabilization of the Colpitts

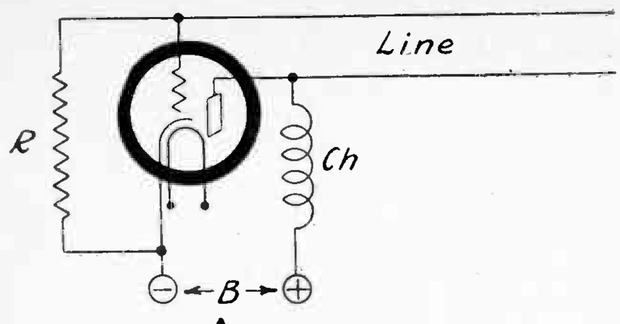
The Colpitts oscillator is more easily stabilized than the Hartley, provided that the frequency is so low that the inter-electrode capacities can be neglected. In Fig. VIII-10 is illustrated the simplest case. It is a symmetrical circuit with two equal tuning condensers, C, across the inductance L. Since the condensers are in series, then the effective capacity across the coil is one-half of the capacity of either condenser. There are two stabilizing coils, each of value L/2. It will be noticed that each of these coils tunes one of the series tuning condensers to the same frequency as the natural frequency of the circuit LCC.

The stopping condenser C2 is supposed to be so large that its reactance is entirely negligible at the frequency of oscillation. This condition is easily satisfied. The two resistors, R1 and R2, are not critical but neither can be too large. Values around 10,000 ohms are satisfactory for small oscillators.

When the two tuning condensers in the resonant circuit are not equal, the stabilizing inductances cannot be equal either, for the theory of stabilization requires that these inductances tune the condensers. For example, if C1 is the capacity of the condenser on the grid side, C2 that of the condenser on the plate side, L1 the inductance of the stabilizing coil on the grid side, and L2 that of the coil on the plate side, the following relation must hold: $1/L1C1=1/L2C2=1/LC$, C now being the value of the capacity of C1 and C2 in series. These relations suffice to give the values of L1 and L2 as soon as C1, C2, and L are known. The stabilizing inductances are: $L1=LC2/(C1+C2)$ and $L2=LC1/(C1+C2)$. These agree with the values given on Fig. VIII-10.

Stabilization of Ultraudion

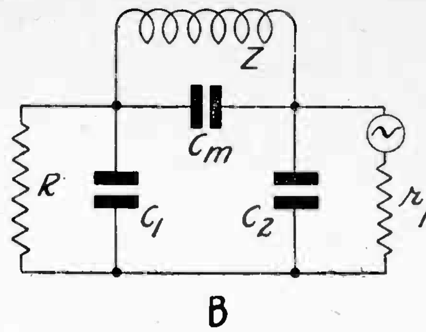
While the ultraudion is a special form of the Colpitts oscillator, it cannot be stabilized in the same manner because in the stabilized Colpitts it is assumed that the inter-electrode capaci-



A

FIG. VIII-12A

An ultraudion oscillator in which the inductance is supplied by a transmission line, such as Lecher wires. It may also be supplied by a small coil.



B

FIG. VIII-12B

The equivalent circuit of the transmission line ultraudion. By interchanging the grid and plate voltages the Barkhausen-Kurz oscillator results.

ties are negligible while in the ultraudion these capacities are of major importance. Stabilization is not possible by means of coils because the leads in which these coils should be inserted are not accessible.

Still it is possible to secure a certain order of stability even in the ultraudion by applying certain principles brought out by analysis of oscillators in general. Thus if the plate resistance, that is, the sum of the internal resistance of the tube and the external resistance of the plate circuit, is made large, the frequency of the oscillator will not fluctuate nearly as much as it will when there is a low plate resistance. Also, if the grid resistance is high, that is, the combination of the internal resistance and the external grid leak, the fluctuation in the frequency is very much less than when there is a low resistance in the grid circuit. Further, and this has already been pointed out, if the ratio of the inductance to the capacity in the resonant circuit is low, the frequency will be more nearly constant. Again, if the selectivity of the resonant circuit is very high, the frequency stability will be good. These stabilizing influences apply equally to all oscillators.

A Complex Short-Wave Circuit

When the frequency is so high that the inter-electrode capacities must be taken into account, there is no simple way of stabilizing completely. However, by means of a circuit like that in Fig. VIII-11 stabilization is possible in any case, for all the inter-electrode capacities are added to condensers in the circuit. The stabilization is effected by so choosing the various inductances and capacities as to eliminate any change of phase in the complex circuit. There are five condensers in the network, two inductance coils, and a mutual inductance, eight elements in all. Six of these can be chosen arbitrarily, but the other two must be manipulated for the desired frequency of oscillation and for frequency stability.

It is understood that the inductance of the choke Ch is so large that it does not affect the other elements. If there is any appreciable capacity across the coil, that is a part of C1.

Fig. VIII-12A is an ultra-high frequency oscillator in which a transmission line, such as a pair of Lecher wires, is connected to the grid and the plate. As in the preceding circuit, Ch is an inductance of large value, or a choke, at the high frequency of oscillation. R may be of about 10,000 ohms.

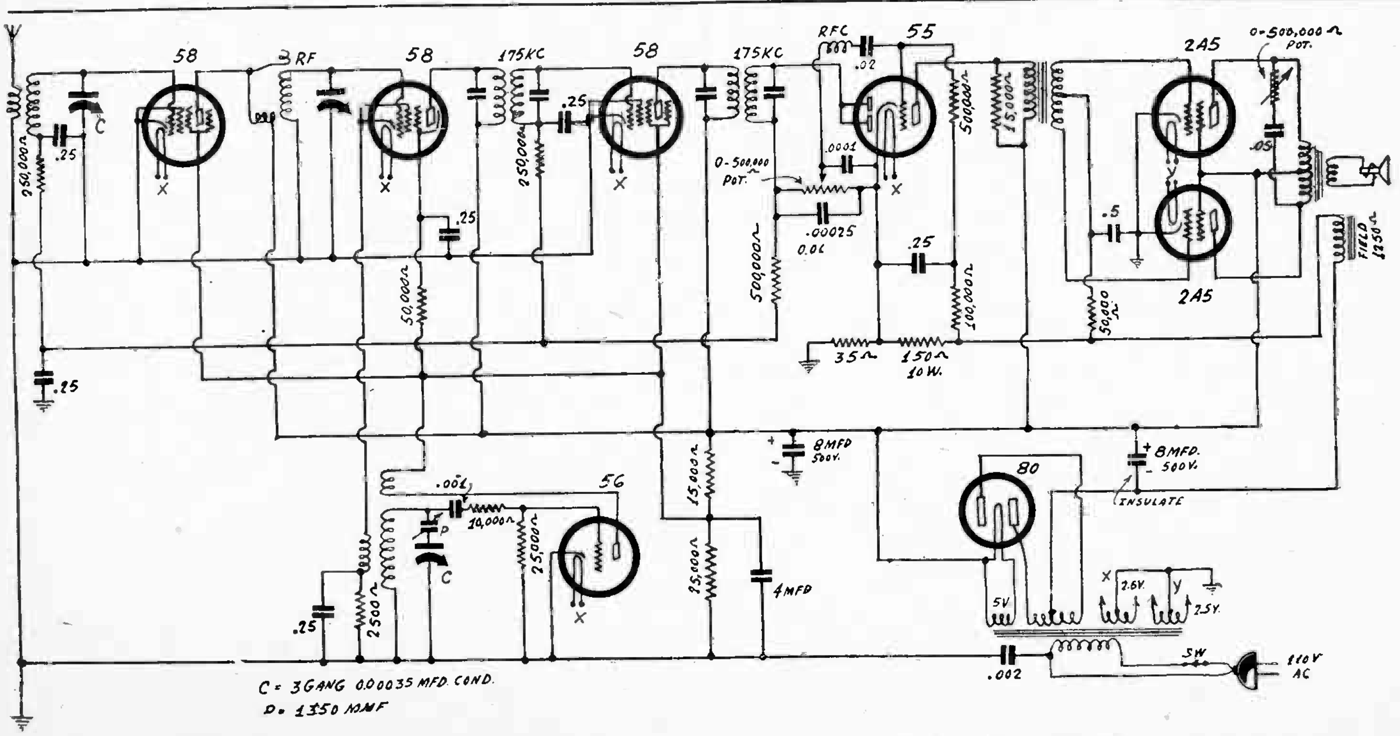
At first thought it would seem that this circuit could not oscillate, for there is no visible means of regeneration nor any resonant circuit. On analysis, however, we discover that the circuit is an ultraudion and that it may be represented as in Fig. VIII-12B. In this circuit Z is the impedance of the transmission line and is considered to be in parallel with the plate-grid capacity Cm.

From the nature of the case it is obvious that the impedance of the line must be inductive. The line may have any impedance —pure resistance, inductive reactance, or capacitive reactance— depending on the frequency. Since the net impedance in this case must be inductive, such a frequency is selected as will make the line inductive and at the same time that will make the reactance of the circuit as a whole zero.

The line is shown to be open at the far end. The circuit will also function if the line is shorted. Indeed it will function better that way. But if the line is shorted conductively, a stopping condenser is necessary in one side of the line. The best way of shorting the line is to connect a large condenser across it at the far end, for this will not only provide the desired short but also the necessary stopping condenser.

The Lecher wire oscillator in Fig. VIII-12A is closely akin to the Barkhausen-Kurz circuit. Suppose that the grid is given a high positive voltage and that the plate is connected to ground, or to a slightly negative voltage. The circuit would oscillate just the same, and at a much higher frequency than it will as an ultraudion. When the circuit oscillates as a Barkhausen-Kurz, or as an electron oscillator, the inductance of the line does not play a vital role. Indeed, no inductance is needed. The elements that enter in this case are the inter-electrode capacities and the grid-cathode and plate cathode resistances. The line affects the frequency of oscillation a little, but its main function is to provide a means for showing the presence of oscillation, or for radiating.

[The foregoing is the eighth instalment of "The Short-Wave Authority." The ninth will be printed next week.—EDITOR.]



Circiut for a standard broadcast super with tone control and push-pull output.

Short Circui

For Various Types of S

By Jac

NO doubt the greatest trouble in receivers is short circuits, a subject usually not discussed on its own account, perhaps because it is deemed too simple to be worthy of notice. But it is not so simple that the shorts themselves are avoided, and therefore a great deal of trouble would be avoided if greater stress were laid on the necessity of such avoidance.

A short circuit is the elimination of the intended voltage drop between two or more points. That is, there is no difference in potential where there should be a

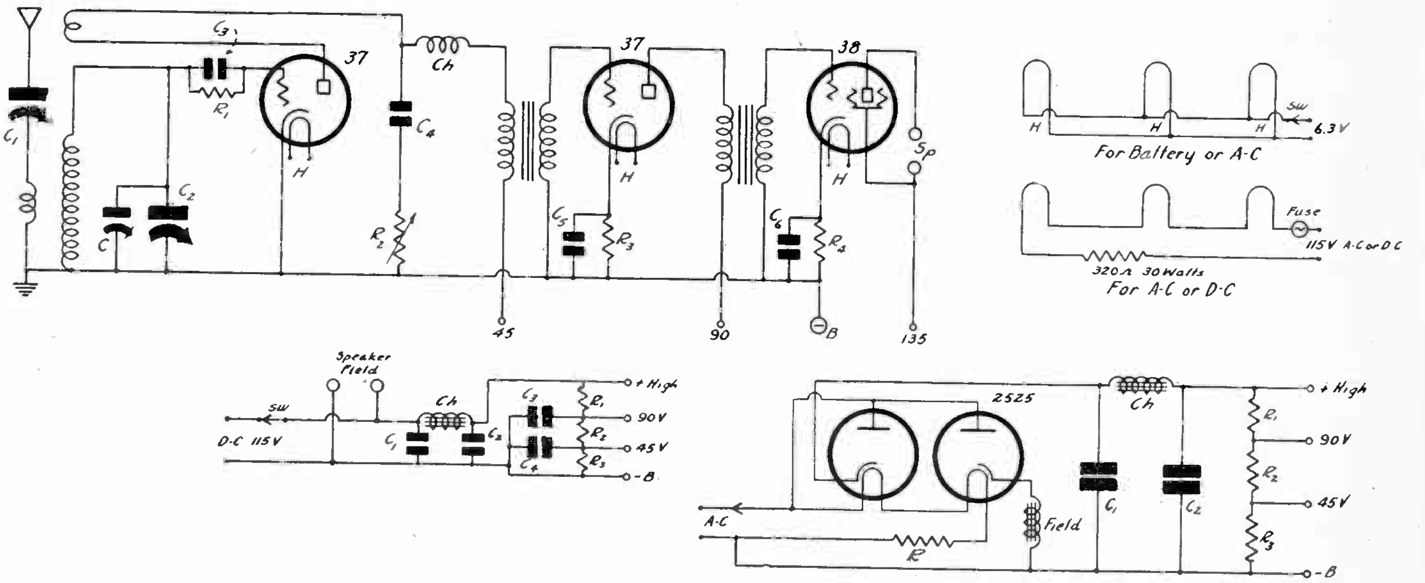


FIG. 1

The universal type receiver presents dangers of shorting. For instance, the above diagram contains a ground symbol, and if external ground is meant, since the line is also connected to this point, a line fuse could be blown. So ground symbol means chassis, and no external ground is used, except as explained in the text.

difference. Suppose that the plate of a tube is considered. If a piece of conductive wire is connected between the plate and the cathode there is a short circuit. If the tube is of the filament type the filament will burn out, due to application of the high voltage to the total filament causing complete incineration of the filament at some point. With heater type tubes it is possible there would be no damage to the tube, particularly if the heater is not connected to B minus or other d-c potential near B minus.

Interesting Universal Example

The universal type receiver brings up one of the most interesting cases, because the grid return side is practically always connected to one side of the line. Therefore some confusion may arise, particularly as the ground symbol is freely used. Does that symbol mean ground? It does. And does it always mean the same thing? Well, no. For a given diagram the ground symbol means only one thing, but for a variety of diagrams, since the meaning ascribed to the symbol differs with the designers, there is nothing about that symbol that can be taken for granted.

There are two grounds to bear in mind in connection with the receivers of the universal type. One is the radio-frequency ground. That might be established through a mica series condenser, or for frequencies in the broadcast band or lower, through almost any type of non-electrolytic condenser of any capacity above 0.001 mfd. Such a condenser could be put between the bottom of the antenna coil and the ground-symbol line at extreme left in Fig. 1, or it might be put between the ground-symbol line, leading to the right from the end of the antenna coil, and the ground symbol itself. That is, reading upward, first would come ground, then one side of the series condenser, then the other side of that condenser, which connection would be identical with the common return of the receiver circuits.

Therefore we can understand that one meaning of ground is the external lead we bring to the set from a cold-water pipe.

Power Line Grounded

However, the power companies almost invariably have one side of the line grounded. Therefore if we took no precautions, but connected a ground wire to the common B minus line of the receiver and rectifier, we would be all right if this connection coincided with that of the grounded side of the line. But if we picked up the ungrounded side of the line, would we not blow a fuse? Would not ground—at the set in one instance, on the power company's pole in the back yard in the other—be connected to opposite sides of the line, and would that not constitute a short circuit? It would.

We can understand that ground symbol means ground, but which ground? Then, too, we are confronted with ground symbol designating chassis. In that case whether actual ground is meant will have to be determined from looking at the diagram.

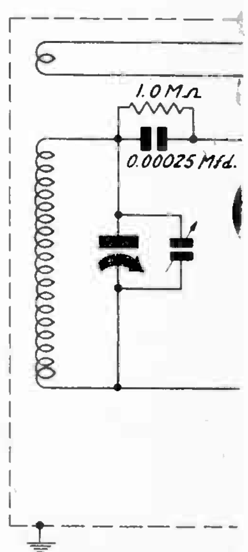
Battery Polarity

The only advice to give in respect to a diagram is to read it closely, see what is marked on the diagram regarding the significance of ground symbol, and respect that symbol. The same advice pertains to automobile sets as to home receivers, especially as in auto sets it is not unusual to have the chassis floating, meaning that it is not connected to either side of the heater circuit, and dissociated from B minus or any particular d-c voltage from the power source.

In this way auto sets may be connected to the storage battery in a car regardless of the polarity of the ground connection to the battery.

As you know, some cars have negative of A grounded to chassis of car, others have positive of A so grounded, but if you must take a chance, know that the cars run about fifty-fifty, so you have an even risk of making a disastrous connection. It is better to test out with an ohmmeter or other continuity tester, touching car chassis with one lead, and one battery terminal with the other lead. The presence of deflection, plus inspection of the

FIG. 2
Where there is universal operation, without rectifier the shielded cabinet is completely insulated from the oscillator proper, by using an insulating bracket or shelf.



t Precautions

ets, Especially Universals

:k Tully

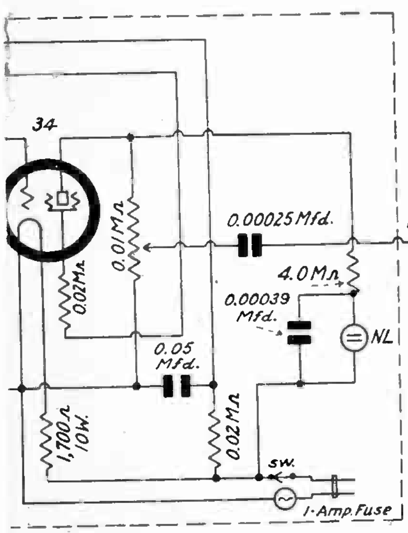
battery pole being tested, will disclose which side is grounded.

The car chassis is the only ground used, and it may be called a radio-frequency ground, arising from the grounding effect through the condenser formed by the earth and the chassis, with air and the rubber of shoes and tires comprising most of the dielectric. The whole grounding may be better considered as a counterpoise system, where the car chassis is the lower stretch, and the higher wire lead, or antenna, is the other. Thus the waves are effective principally because of the capacity between the antenna and the chassis, and the rubber-tire theory need not be considered too much, especially as cars high and dry on service elevators have about the same electrical capacity as when rolling along on the road.

The Makers' Warning

With the universal type sets it is different, because the shorting danger is ever-present if the proper precautions are not taken. One of these precautions may be offered by the manufacturer, if the receiver or line is not protected against possible damage due to such shorting. And that is the specific warning: "Do not connect external ground to this set." It is just as well not to make the connection for any reason, when that advice is given, except if the set performance is too poor to justify the installation, and the omission of the ground-wave reception is to be corrected, it is safe to connect one side of external ground to one side of a fixed condenser of 200 volts or more rating, or any mica-dielectric condenser regardless of voltage-rating (as they are not rated normally, yet stand 1,000 volts), and other side to chassis or grid returns.

If the choke or speaker field is in the positive leg, or the field across the line, additional choke in the positive leg, the danger already stated is present, unless the receiver is so made as to take care of the difficulty, by built-in series condenser. If d.c. is used the line current can not flow through the series condenser, as d.c. does not flow through condensers. If a.c. is used, the capacity of the condenser simply adds a bit of by-passing, if the condenser is across the line, or adds nothing, if both sides of the condenser are connected to the same side of the line. This is a short of the condenser, not of the line, and is harmless.



Separate B Supply

The universal sets using the 25Z5 or 37 have series-connected heaters, therefore the line voltage is reduced to the sum of the required heater voltages by a limiting resistor. For three tubes as shown in Fig. 1, upper left, roughly 19 volts would be dropped in the heaters, while the 25Z5 would require a 25-volt drop, total 44 volts. Assuming 115 volts for the line, the limiting resistor would have to drop the difference, 71 volts.

But assume that some means of B supply is at hand, whether eliminator or batteries. Then the heaters may be fed by 6.3 volts from a storage battery, or 6.3 volts from the secondary of a power transformer, the heaters being in parallel now, not in series. See upper right, Fig. 1. For universal, or, as it is called, a-c, d-c use, the series connection is necessary. See lower right of Fig. 1.

Shorts and No Shorts

Now suppose the choke were put in the negative leg of the rectifier. It would then go between B minus of the B supply diagram, lower center, Fig. 1, and the ground-symbol line of the receiver. Care would have to be exercised not to attempt to pass the heater current through the choke, as the friendly neighbor of a short—that is, an open—might result. The choke winding would burn out, in all likelihood.

But does the shorting danger persist? Remember that the choke is connected one side to B minus, other side to grid returns in the set. Suppose the line's grounded side is X for a-c, and the ungrounded side Y. Paying no attention to which direction the plug is inserted in the wall socket for a.c. (since it matters not which side goes where), the grounded X side of the a-c line may be connected to the lower side of the choke, hence ground is at both terminals of the choke, and is this a short? We learned that a short exists when there is zero potential difference. Yes, it is a short, but of the choke only, and is harmless, as then there is no voltage across the choke but simply a continuity of ground from line to ground-symbol lead of set. Suppose the ungrounded Y side is connected to the lower choke terminal, other side of choke to external ground through receiver connection and chassis. What does this amount to? Both sides of the line are connected, one to one side of the choke, other to the other side, but is this a short? It is not. The choke has a high impedance and the voltage across the line is maintained, just the same as it is maintained with the primary of a power transformer connected across the line. The choke will have a higher impedance even than the power transformer primary. Practically any B or audio choke that deserves either name—and they are not to be confused with radio-frequency chokes—will result in no short whatever under the outlined conditions.

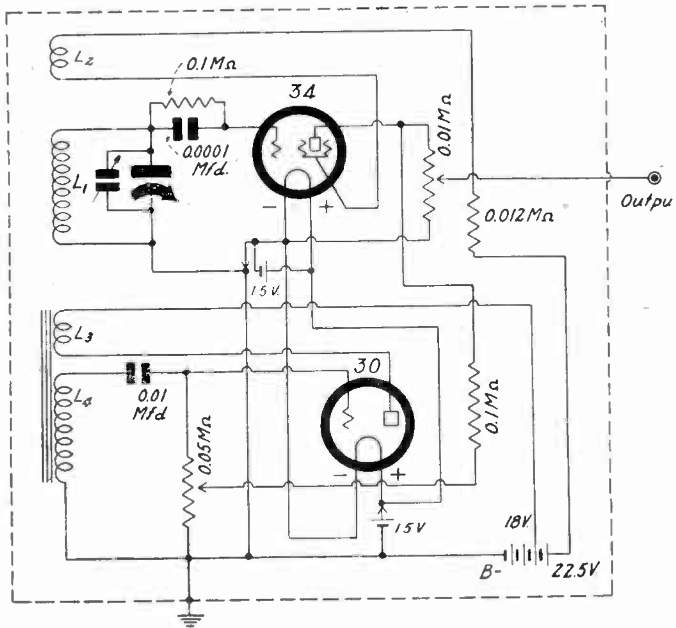


FIG. 3
This represents the general case of battery-operated devices. If metal chassis or box is to be grounded externally, there is a way to reduce danger of blowing tubes by accidental application of B voltage to the box. See text for details.

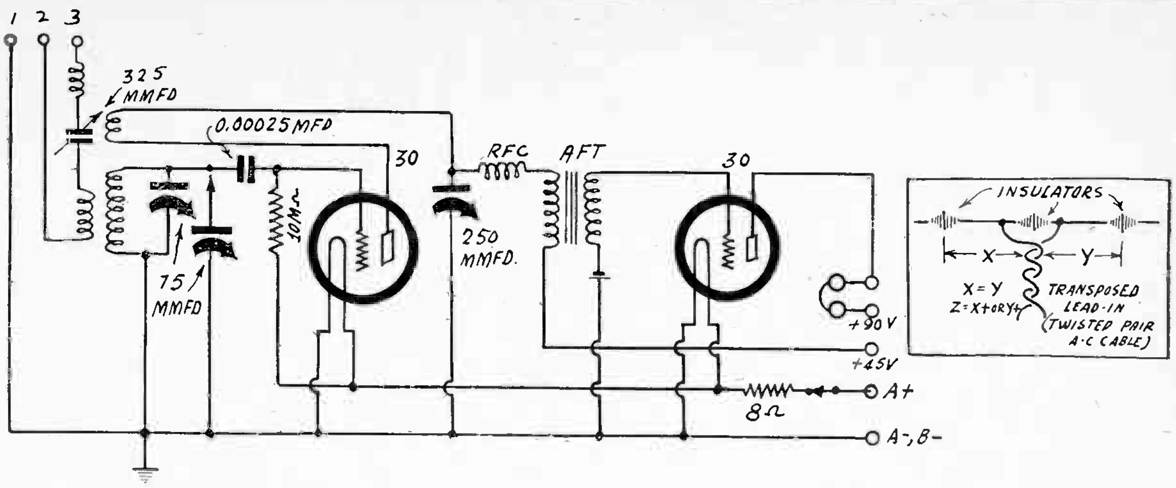
Rectifier Omitted

Where a.c. or d.c. is used directly—that is, rectifier is omitted—the problem continues, in fact, continues with emphasis. Therefore in Fig. 2 the test oscillator shield cabinet is shown connected to ground, meaning an external ground wire, but is not shown connected anywhere else, and the device is built with an insulating shelf to which the tuning condenser frame is bolted, using countersunk screw openings and flathead machine screws, and the connection of the insulating shelf to the box does not connect the condenser to the box.

A way of avoiding use of the insulating shelf would be to use a large mica condenser, 0.01 mfd. or higher, between rotor of the tuning condenser and left-hand

(*Continued on next page*)

FIG. 4
While touching of plates of the thottle condenser (250 mmfd.) does kill off the signal, hence produces a short in that sense, it does not actually short the B voltage, because of the presence of the audio transformer primary.



(Continued from preceding page)
side of the filament in Fig. 2, and ground the rotor externally, as well as having rotor connected to frame of the shield cabinet, as it would be anyhow without the insulation precaution. The fixed condenser stands between the oscillator and the line as a safeguard, and of course in addition the line is fused. A 1-ampere cartridge type auto fuse is used, in an insulated holder.

Goes the Tube

With battery sets the condition is familiar, and will be mentioned only slightly. A test oscillator gives as good an illustration as a high-powered receiver. The chassis or shield may be connected to B minus, and either A minus or A plus may be connected to B minus. Then the other material voltages are positive B. If the B voltage is connected to the side of the filament that goes to B minus, only the B battery is shorted, and there may be a spark, if the contact is suddenly made and unmade. In the phones or speaker there would be a severe click in a receiver. If positive B is connected to the side of the filament other than the one connected to B minus, the B voltage is applied across the filament, the filament is incinerated and the store or supply house makes an extra sale of a tube.

If a chassis or metal cabinet or the like is used, naturally there is an infinite number of places where a misconnection could result—all over the box or chassis, for instance, in respect to B plus. Accidental dropping of a B-plus wire could burn out all tubes. But it has been said that the side to which this B plus connection must be made, to destroy the tube, is the side other than the one of the filament going to B minus. Therefore, for grounded B minus, and maximum safety (but not fool-proof condition), negative A should be connected to negative B, and this common line grounded to cabinet or shield box. The only reason for using the other connection—B minus to A plus—would be to gain the little extra voltage, by addition of the A to the B voltage for effective B service. That is too trivial a gain for such a mighty risk.

Short-Wave Set

The battery example perhaps needs a little extenuation, in the light of short-wave popularity, and the use of throttle control of regeneration. A variable condenser is connected from one end of the tickler to ground to control regeneration by the bypassing effect on the r-f current. Naturally, since one side of the condenser goes eventually to B plus, and other side to ground, something happens when plates touch. It is not really a short, by our own definition, because between B plus and ground is the transformer primary. However, only d.c. is to be considered here, in the light of the short-circuit discussion, and the audio primary may have a d-c resistance of only a few hundred ohms. It is true that the potential difference does not become zero—there is no short of the B battery—but even at 45 volts, at say, 225 ohms primary, the B current drain would be 20 milliamperes, and besides the receiver would not be operative.

At right in the diagram, Fig. 4, is shown for the benefit of those whose attention previous articles have escaped, what a doublet antenna is—two equal horizontal wires, separated by an insulator, and upheld by poled insulators at the extreme right and left, the leadin being a two-wire transposition system, either of twisted pair or regular wire transposed on blocks, hence accounting for the optional antenna connections to the receiver.

For doublet use, transmission line terminals go to terminals 2 and 3 of the set input. For the other antenna type, so-called Marconi antenna, connect aerial's single leadin wire to 3 and connect the ground to 1, putting a short-circuiting wire between 1 and 2.

Negative-Leg Choke

The previously-mentioned possibility of a negative-leg choke is illustrated in the diagram of the a-c short-wave receiver using plug-in coils and bias-control of regeneration, Fig. 5. The previously-discussed shorting problem as applicable to

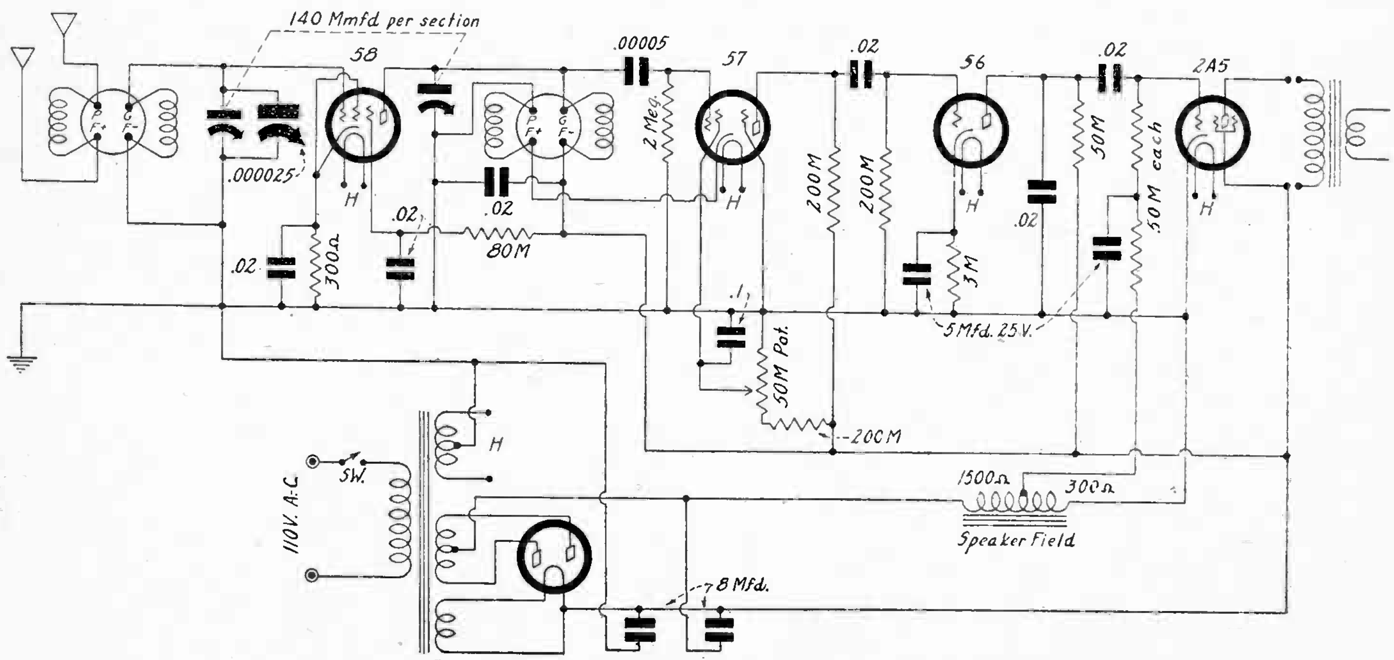


FIG. 5
Danger of a direct short due to grounding is avoided when a transformer is used, as in this a-c short-wave set, but shorting of any of the secondaries may put such a heavy drain on the primary as to open the primary, or, if the primary stands up, to blow a fuse.

universal sets is not present here, because of the exclusively a-c nature of the set, and the isolation of line from the voltages used, due to the transformer, but any short of any a-c voltage on the secondaries may put such a heavy drain on the primary as to open the primary, by incineration, or blow a fuse. Either the primary or the fuse will go, and more often it is the primary.

Besides the particular shorts mentioned there are innumerable other possibilities, but not of a difficult nature to consider or trace out. They include breakdown of filter condensers, electrolytic as well as paper types; breakdown of insulation between windings of r-f coils, where the B voltage is on one, and negative on the other winding, considering only the d-c aspects; troubles in tubes, due to elements touching; as well as shorts to radio frequencies, intermediate and audio frequencies which, while not dangerous to the line, do prevent reception.

A THOUGHT FOR THE WEEK

PRESIDENT ROOSEVELT frequently says a lot in a few words. The closing paragraph of his message to Fred. D. Williams, president of the Radio Manufacturers' Association, in convention in Chicago, is an answer to those critics who believe that radio broadcasting should be censored to the nth degree. The President said.

"Radio broadcasting should be maintained on an equality of freedom similar to that freedom which has been and is the keystone of the American press."

and there's a whole bookful of common sense in those words, which should be remembered and quoted whenever the narrow minded try to make radio the tool of a vociferous few.

CAN'T PLEASE ALL

Stations and commercial program sponsors are still struggling with the problem of pleasing everybody, but find that all that can be done is to afford a wide variety, so everybody is pleased by at least some offering.

Literature Wanted

B. F. Wilkinson, 506 East Union St., Jacksonville, Fla.
M. S. Cohn, 1687 Bathgate Ave., Bronx, New York City.
Albert Torrese, 1528 Wolf St., Philadelphia, Pa.
H. MacLean, 2139 Laurel St., Napa, Calif.
E. Conway, 6911 Irving St., Philadelphia. Pa.
Albert Van Nesse Greene, Chester Springs, Pa.
Paul Cardin, 5943 St. Hubert St., Montreal, Canada.
J. J. Black, 1773 Marks Ave., Akron, Ohio.

Station Sparks

By Alice Remsen

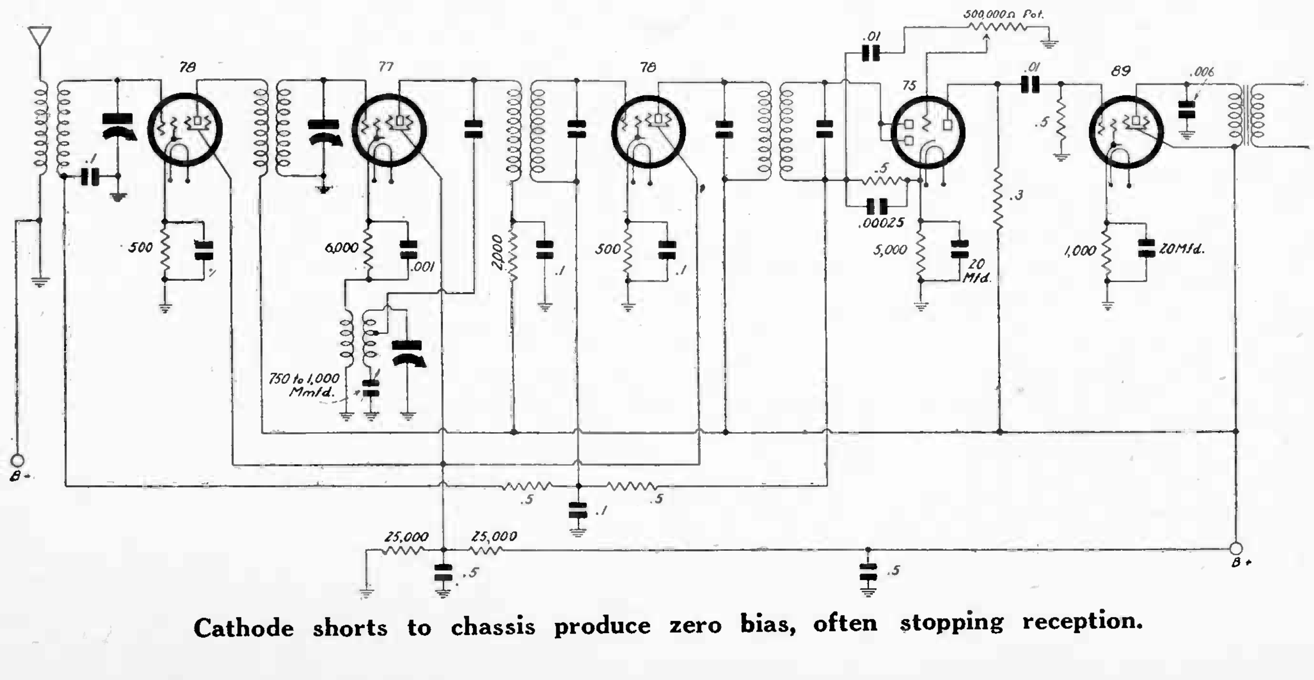
RAY HEATHERTON, romantic young NBC baritone, added to the Wife Saver's program, is Allen Prescott's latest prescription for overworked housewives. Heatherton is one of the most popular of radio's baritones, besides being featured with Prescott on the Fels Naphtha Wifesaver program, he is also co-starred with your correspondent on "Castles of Romance" each Tuesday and Thursday morning over an NBC-WJZ network, 10:15 a. m. EDST. . . . Al Llewelyn, lyric tenor and comedian, sold cemetery plots before going on the air. . . . A new Tastyeast series has been inaugurated over an NBC-WJZ network, in which distinguished actors from the Broadway stage in one-act plays by famous playwrights will be featured; each Sunday at 9:30 p. m. . . . Ernest Cutting is bringing many novelties to his "Airbreaks" program, the latest being the Singing Letter Carrier, a young New Jersey postman named Ross Evans. . . . Another Metropolitan Opera star has joined the group of noted singers heard over NBC networks. Doris Doe, well known for her rendering of leading Wagnerian roles, may now be heard in a series of concerts over an NBC-WJZ hook-up each Friday at 10:30 p. m. . . .

The Goldbergs are taking a sixty-day vacation after their third consecutive and uninterrupted year of broadcasting. They will play some vaudeville dates during their offtime, returing to the microphone again in the Fall for Pepsodent. . . . Clara, Lou and Em are now in their fifth year of broadcasting under the sponsorship of the Palm-Olive-Peet Company. They celebrated with appropriate ceremonies and a birthday cake with five candles. . . . The Princess Pat Players have changed their time for the weekly half-hour presentation of original three-act dramas and are now heard Mondays at 9:30 p. m. EDST. . . .

The chatter around the Columbia Broadcasting System's studios these days is all of railroad, steamship, plane and automobile trips. Buck Rogers goes to Omaha; Bob Sherwood to Stoneybrook, Me.; Lazy Bill Huggins to Virginia Beach; Bert Parks to Atlanta; Tony Wons to Wisconsin; Lillian Roth to Hollywood; Burns and Allen, well—it may be a gag—but they are planning a trip to Russia. . . . From the Columbia "quotes of the week," Vivienne Segal, famous star of the musical stage, says: "Radio's requirements are far more exacting than those of the stage. If necessary, a singer in the theatre can get by with a certain amount of personality, expression or antics of some kind when the vocal chords are under par. But not in radio—no, siree; I had a cold once—I know." . . . The fantastic adventures of "Buck Rogers" will be resumed on September 3d, with a setting called "Trouble on Saturn." . . . There is another addition to the dance broadcasting over the Columbia network—Buddy Welcome, from the Alamac Hotel, New York. Buddy is more than welcome, for he has a danceable band. You may hear him on Tuesdays and Thursdays, 5:45 p. m.; and Saturday from 4:30 to 5:00 p. m. EDST. . . Gertrude Niesen is now on a vaudeville tour, since the "Big Show," in which she was featured, has gone off the air. . . . Jimmy Kemper, star of "Music in the Air" is to undergo a tonsil operation on July 1st, at the Harbor Hospital; Jimmy has put it off for months; let's hope it will not keep him off the air; he is one radio artist I would miss. . . . Schlitz Beer has a new 45-minute program, starring Stoopnagle and Budd, Everett Marshall, Frank Crumit, Parker Fennelly, the Eight Gentlemen from Milwaukee and Victor Young's Orchestra; each Friday at 10:00 p. m., EDST; WABC and network.

Selectivity Improved By Series Condenser

In dialling for distant stations, if one finds interference from an adjoining channel, it may be reduced considerably by using a series antenna fixed condenser of 50 mmfd. This is a fixed condenser. Its use reduces volume by about the same amount it increases selectivity.



Cathode shorts to chassis produce zero bias, often stopping reception.

Underpowered Tubes

Advantages Gained in Oscillators and Amplifiers

By Einar Andrews

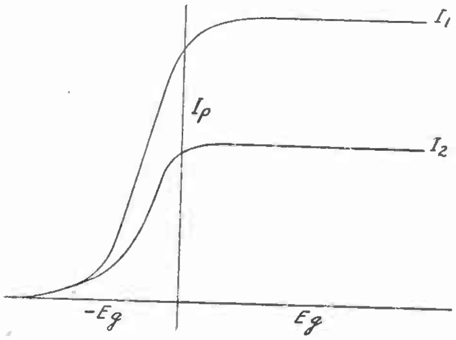


FIG. 1 (left)
Two plate - current, grid-voltage curves for two different cathode temperatures.

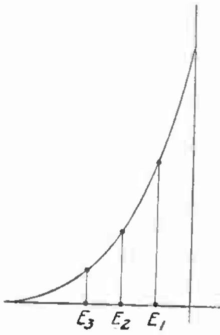


FIG. 2
The plate current in an amplifier is reduced by increasing the bias.

SHORTLY after vacuum tubes were made available to the general public, the discovery was made that by driving a tube to the danger point much louder signals could be obtained and much greater distances covered. There has been a tendency ever since to drive every tube in the same reckless manner. If a tube manufacturer specifies that the highest plate voltage should be 250 volts, this voltage is usually the minimum that is applied to that particular tube. The manufacturer may also state the conditions of operation when the plate voltage is three-fourths, one-half and one-fourth of the maximum, yet nobody pays any attention to such statements.

Just why are tubes overpowered rather than normal-powered or under-powered? Perhaps the reason is—and it is only a suspicion—that the user of the tube is entertaining the notion that he is getting something for nothing by driving a tube beyond its rating.

Does More Voltage Help?

Would it not be the height of folly to use only 115 volts on the plate of the tube when 250 volts can be used as well! Everybody knows that with 250 volts on the plate, the tube will amplify more, it will do it with less distortion, it will put out more power, and, above all, it will perform these functions without extra cost! Why should the maximum recommended voltage, or even a higher one, not be used when all these desiderata accrue without extra cost?

There are many reasons. First, the cost of overworking a tube is very high. It will not last nearly as long if it is abused as if it is used rightly. Replacements cost money, and the more a tube is overworked the oftener the money must be expended. Second, we do not get the extra power for nothing; the electric meter ticks off every extra watt-hour just as faithfully as it registers the normal watt-hours. While overworking a tube in the sense that it is given excessive voltages may increase the amplification, may decrease the distortion, may increase the output power, it does not inevitably result in these advantages. The net result in the receiver may be undesirable. For example, the increased amplification, assuming the amplification is increased, may cause distortion a hundred times more severe than that which it sought to avoid. It may even start oscillation that cannot be controlled, and the result of that is a total loss. Third, sometimes satisfactory results can be obtained only by underpowering the tube. For instance, an oscillator that is to be operated without any grid current must be operated with a sub-normal cathode temperature while the plate voltage is either normal or super-normal.

Eliminating Grid Current

This method of suppressing grid current in an oscillator by the use of sub-normal filament temperature deserves careful consideration. In Fig. 1 we have two curves showing the relation between the plate current and the grid voltage for two different filament temperatures. When the filament temperature is normal the saturation current, I_1, is not reached until the grid potential is much positive, but when the temperature is sub-normal, the saturation current, I_2, is reached when the grid potential is zero or even when it is negative. It is assumed that the applied plate voltage is high in both instances.

Now, how are these facts related to the suppression of grid current in an oscillator? In the first place, grid current will not flow unless the grid becomes positive during part of the oscillation cycles. In the second place, the extreme values of the grid potential are limited in one direction by the plate current cut-off voltage and in the other direction by the saturation. If saturation occurs for a negative value of the grid potential, the instantaneous grid potential cannot become positive during any part of the cycle. Hence no current will flow in the grid circuit. On the other hand, if the filament temperature is normal saturation will not occur until the grid potential is much positive and therefore the instantaneous grid potential will be positive during a large part of the oscillation cycle, perhaps during the greater part, and the grid current will be heavy.

Why Suppression

Why is it so important to suppress grid current in an oscillator? Because it is one of the easiest ways of stabilizing the frequency of an oscillator. If the grid circuit resistance is infinite, the circuit is practically frequency stable without any other means. If at the same time the plate resistance is very high, the stability is vastly improved. The fact that the cathode temperature is sub-normal, by virtue of a sub-normal filament or heater current, makes the internal plate resistance very high. In one instance, the heater current was reduced to one-third normal value and the internal plate resistance increased 50-fold. Of course, it must be realized that if the cathode temperature is reduced too much, oscillation will not be possible.

The Class B amplifier is an instance in which a reduction is made in one direction in order to gain in another. The object of the Class B amplifier is to make tubes more efficient. If steady current flows all the time in an amplifier no useful work is accomplished in so far as sound generation is concerned. In the Class A amplifier a comparatively high current flows all the time, and it is only the variation in this current that constitutes the sound current. In the Class B amplifier the steady current is practically eliminated by increasing the bias on the grids. While there are two tubes in the Class B stage, just as there is in the Class A push-pull amplifier, the two draw almost no direction current. But when a signal comes along and makes the instantaneous grid potential of one tube larger and that of the other less, a large current flows in the first tube and none at all in the second. During the next half cycle the tube that had done the work becomes idle and the previously idle tube takes up the load. The plate current in the two tubes is all variation and is all available for sound generation.

A to B

The change from Class A to Class B in the simplest case is illustrated in Fig. 2. The curve represents the grid voltage plate current for either tube, as well as for each. At first the grid bias may be E1. A large steady current flows in each tube, and the circuit is very inefficient. Yet the quality of the output may be excellent. If the bias be increased to E2, the plate current will be only about one half of what it was before. The amplifier is now much more efficient for the variation in the current is a larger percentage of the steady current. The distortion may be slightly greater now, but not appreciably if we make the comparison at equal output volumes. The second case is an approach to Class B operation.

Now suppose that the bias be increased to E3. The steady plate current is now very small. Yet the output of the stage may be several times greater now than it was before. The efficiency has been increased, but so has the distortion, especially on low signal levels. Even now, however, the quality is excellent if two tubes are equal. The bias can be increased still further, or until the plate current is just reduced to zero. In this manner, by increasing the bias in a push-pull amplifier, the wasted power is decreased and the efficiency is increased.

Power Saving

There are many opportunities in a radio receiver for saving power without sacrificing desirable qualities, such as selectivity and sensitivity. There is, for example, no good reason why the oscillator in a superheterodyne should be operated with high plate voltage and high plate current. On the contrary, there are good reasons why it should not be so operated. A high plate voltage leads to intense oscillation. The high oscillating voltage will seriously overload the mixer tube, and may even overload tubes which

(*Continued on page* 18)

Crystal Microphone Uses

Pointers on Public Address Systems and Phonograph Pickups

By J. E. Anderson

(Continued from last week's issue.)

IT should be pointed out that Fig. 6 is not the best arrangement because if there is grid current this will flow through the leak and there will be a voltage across it, which means that this voltage will also be across the microphone. However, the grid current is extremely small.

An improved connection of microphone to amplifier was shown in Fig. 7. A stopping condenser of 0.01 mfd. was connected in series with the lead between the microphone and the grid and a grid bias battery is connected in series with the grid leak. By this method the proper grid bias could be applied to the tube without impressing any voltage on the microphone. The 5-meg. grid leak is so high in value that even on the lowest audio frequencies there will be no appreciable reduction of the output by the series condenser.

While both Figs. 6 and 7 show filament type tubes, the microphone may, of course, be used with heater type tubes; and when such tubes are used, a cathode resistance may be employed for providing bias, for this does not impress a voltage on the crystal.

Distance Transmission

When the microphone and the amplifier are to be more than thirty feet apart, it is necessary to use a transmission line if best results are to be obtained. The reason for this is that the line will have such low impedance that the microphone would be working at a disadvantage. Two transformers would be required, one a microphone-to-line transformer with a primary impedance of about 100,000 ohms, and the other a line-to-grid transformer. The second may be just like the first, but used in reverse.

When this microphone is used in a public address system a three-stage amplifier is recommended, such as that shown in Fig. 5. In this circuit the crystal microphone delivers its output to an arrangement such as that in Fig. 6, the tube being a 56. This tube is then resistance-capacity coupled to another 56, which in turn is coupled by transformer to a stage of push-pull with 2A5 tubes.

The design of the amplifier is typical. Thus the plate coupling resistor of the first tube is 100,000 ohms and the grid leak for the following tube is 0.5 megohm. A rather large stopping condenser, 0.1 mfd., connects the plate of the first 56 to the grid of the second. In the plate of the second 56 is a coupling resistor of 30,000 ohms and a stopping condenser of 0.25 megohm, but this condenser is in series with the primary of the push-pull input transformer.

Bias Voltages Used

The first 56 tube is not biased, but a small bias could be applied by means of a cathode resistor. The second tube is biased by a 2,750-ohm cathode resistor, and this resistor is shunted by a condenser of one microfarad. This condenser might be made larger. The push-pull stage is biased by means of a 200-ohm resistor in the common cathode lead. This resistor need not be shunted by any condenser because the circuit is push-pull, and none is used.

Attention is called to the manner in which the circuit is filtered to avoid undesired feedback. First of all, the primary of the push-pull input transformer is connected to the cathode rather than to ground, as is often the case. When the connection is made to the cathode the a-c component of the signal is kept out of the grid bias resistor and reverse feedback is eliminated. Of course, this connection is possible only when parallel feed is used for the plate and when there is a stopping condenser in series with the transformer primary.

In addition to the filtering used with the second 56 tube to minimize feedback, there is careful treatment of the plate supply with the same object in view. The plates of the output tubes are connected directly to the 300-volt supply, and of course there is filtering in the supply. In the line to the plates of the remaining two tubes is a 10,000-ohm resistor and after this there is a 2 mfd. by-pass condenser directly to ground. Another 10,000-ohm resistor is then connected to the lead to the plate of the first 56, and for this too there is a 2 mfd. by-pass condenser. It is because the circuit has a high voltage gain that all this filtering is necessary.

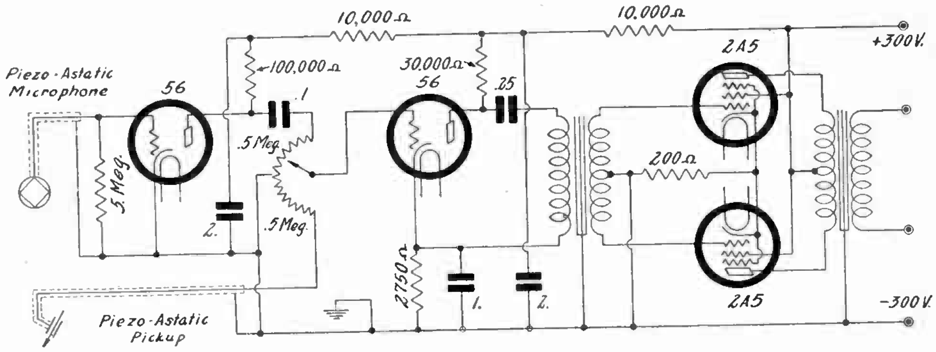


FIG. 5

Phonograph Pick-Up

The circuit has been arranged also for amplification of signals from a phonograph pick-up. Since the voltages derived from this source are much greater than those from the microphone, the pick-up unit is connected in the grid circuit of the second tube. Across the pick-up unit's terminals is another 0.5-megohm resistor, which in reality is a part of a double potentiometer to the slider of which the grid of the second 56 is connected. The output of the amplifier can be controlled by this double potentiometer regardless of whether the signal comes from the pick-up or the microphone. The changing from one to the other can be effected by merely turning the slider through the neutral point.

The pick-up unit suggested is also of the piezo-astatic type, that is, one that is working on the principle described at the beginning of this article. In this case it is not the sound waves that cause the composite, or bi-element, bar to bend, but the undulations in the phonograph record. Much greater mechanical forces come into play on the sensitive bar when it is actuated by the needle of the phonograph, and therefore less amplification is required.

Quality of Crystal Microphone

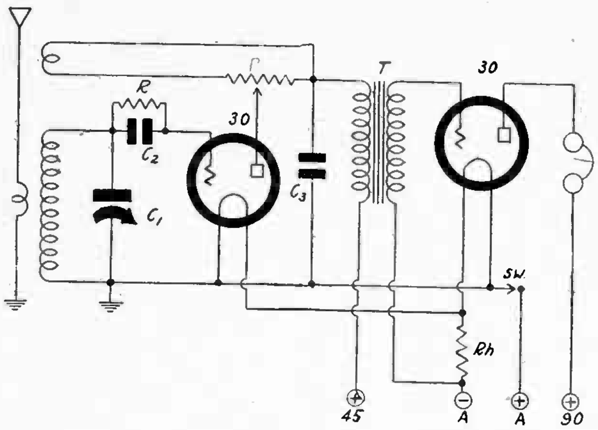
The piezo-astatic microphone has many inherent advantages over some of the other microphones. No adjustment is necessary to keep it in order once it has been put in operation. There is no rushing noise as there is in the carbon microphone, neither is there any packing or freezing as in this instrument. Polarizing current, as in the carbon microphone, and polarizing potential, as in the condenser microphone, are unnecessary. No field current is required as in the dynamic or ribbon microphones that are operated by electro-magnets. Blasting is eliminated by the damping of the bars. The frequency response of the piezo-astatic microphone is excellent up to 5,000 cycles.

One of the practical advantages of this microphone is that it is rugged and easily carried about without danger of damage. The full size microphone, the Type D-104, is no greater than that it can be held in the hand.

Microphone Uses Increase

Microphones of various types are obtainable at low prices for experimental or fun-making uses, besides having real practical value. These include lapel mikes for a few dollars. The use of microphones for other than direct use in transmitters is growing fast.

Radio University



A method of regeneration control, using series resistance. The unit is a potentiometer, the total resistance in parallel with the tickler winding, but the effective resistance in series, because between the arm of the potentiometer (plate of tubes) and high or "hot" side of the tickler.

Monitors, Frequency Meters

WHAT IS the difference between a monitor and a frequency meter, and are there different types of frequency meters?—O. P.

A monitor is an accurately calibrated receiver of the oscillating type. A frequency meter is any device for measuring frequency. If it is a receiver it is of the absorption type, e.g., wave trap, or an acceptor filter, such as a tuned circuit in a cascade. If the measurement is made in the device itself it is a frequency meter, no matter what the method, provided the calibration is present, whether the device is of the oscillating type or not. If the response is in the measured circuit, that is, the calibrated device is a small transmitter in reality, then the device is a test oscillator, or, if modulated, a signal generator. A monitor is used, for instance, by amateurs, so they can check the frequency of their transmitters, particularly to insure keeping within the legally allotted bands of frequencies, and phones are used in the monitor to detect the beat between the oscillator in the monitor and the oscillation voltage from the transmitter. By suitable switching the listening may be done in the transmitter, when the erstwhile monitor is used as a test oscillator or signal generator. Therefore the same instrument, by slight changes, may be put to both monitor and test oscillator uses.

* * *

Leak and Condenser

FOR THE SAKE of simplicity, in the construction of a test oscillator for the short-wave frequencies, is it not permissible to omit leak and condenser? I have seen several such circuits, using the 99 tube and later the 30 tube, and thought that I might follow the practice.—J. F. C.

It is bad practice to omit the leak and condenser, because the grid current change then becomes very considerable. In other words, the leak and condenser tend to stabilize the circuit, so that when the oscillator is set for a particular frequency, that frequency of generation will be maintained, and will not wobble or shift a great deal. For ordinary use, such stabilization, if the leak and condenser constants are properly chosen, will be satisfactory. Values for the 30 tube are: tuning condenser, 0.00014 mfd., grid condenser; 50 mmfd., grid leak, 200,000 ohms; plate voltage 90 volts; grid returned to negative filament. The inductance will depend on the desired frequencies. If the grid is negatively biased, the grid current problem is not so important, but the output is low if the negative bias is steadily great enough to prevent flow of grid current.

* * *

The Amateur Bands

WHAT ARE the amateur bands, and how can their frequencies help me in calibrating a short-wave receiver?—I. K.

The amateur bands are as follows:

1,715 to 2,000 kc	14,000 to 14,400 kc
3,500 to 4,000 kc	28,000 to 30,000 kc
7,000 to 7,300 kc	56,000 to 60,000 kc
400,000 to 401,000 kc	

These bands are generally known by the lowest frequency of each, excepting that the first is referred to as the 1,750 kc band, because all the others are related to 1,750 kc by an harmonic order. Thus the designation of the low frequency in the case of the 3,500 kc band represents the second harmonic of 1,750 kc; the 7,000 kc band the fourth harmonic; the 14,000 kc band is the eighth harmonic; the 28,000 kc band is the sixteenth harmonic and the 56,000 kc band the thirty-second harmonic. The frequency ratios of the bands differ, you will notice. Some aid in calibration may be achieved especially in the first four bands, due to the bands not being wide absolutely, as when amateurs are heard they may be deemed to be well within their band allotment.

* * *

Oscillator Difficulties

ARE THE ELECTRICAL difficulties severe, in the construction of a calibrated oscillator, or are the mechanical difficulties worse, and how may one solve them both?—W. E.

The electrical difficulties are not severe for ordinary purposes, but the mechanical ones are more so. It is assumed broadcasting stations or regular frequency-standard stations, are used as frequency standards, and that the constructor can run the calibration curves all right. Then the problem is to have the mechanical aspects equal to the electrical ones, or as near so as practical. The accuracy finally an be no better than that which mechanical methods will provide, and this relates largely to the dial, scale and pointer. There should be full opportunity to read the dial closely, and the index should not introduce any possibility of confusion in reading. The electrical difficulties are practically solved when the oscillator is made to oscillate all over the dial, is frequency-stabilized, and has output attenuation free from detuning effects. The mechanical difficulties are solved when a rigid and precise dial is used that will not suffer warpage or slippage or shift.

* * *

Regeneration Control

PLEASE SHOW a method for using a high-resistane potentiometer for regeneration control.—T. D. W.

The accompanying diagram shows this method. The two extremes of the potentiometer are connected to the tickler terminals. As usual, the tickler must be connected properly, otherwise the tube can not oscillate. If no oscillation is present, reverse the tickler connections. It might seem that such a circuit would oscillate, no matter which way the tickler is connected, because the arm may be slid so as to introduce the correct polarity, but if P is high resistance, and the arm is slid to right, the oscillation current (if any) would have to flow through the high resistance, and this resistance would be sufficient to stop oscillation at least over the greater portion of the tuning of any particular band, and most particularly at all high frequencies.

* * *

Tank Circuit

WHAT IS a tank circuit, and is it any different from a flywheel?—J. K.

A tank is a parallel tuned circuit. So is a flywheel.

* * *

Wave Polarization

WHICH ARE more effective, horizontally or vertically-polarized short waves?—R. E. F.

Both types are about equally effective. The vertical type polarized waves are usually better received with a vertical aerial, and the horizontally-polarized waves better with a horizontal antenna, due to the twisting or shifting of the plane of polarization during the process of propagation, on account of intercepting objects. Both types have their drawbacks, and dead spots may be expected. Only they will appear at different frequencies when the planes of polarization differ.

* * *

Percentage Modulation

HOW MAY I measure the percentage of modulation, and is the formula applicable to voltage and current?—I. H.

For sine-wave modulation measure the amplitude in peak volts without modulation (carrier alone) and then with modulation, subtract the carrier-alone value from the other, divide by the carrier voltage alone, and multiply the result by 100. The answer is percentage modulation. The same method applies if current is considered and measured, instead of voltage. For 100 per cent. modulation the d-c plate voltage should be at least twice the a-c voltage in the plate.

* * *

Body Capacity Cure

IN MY short-wave receiver I get body capacity effects from the phones and would like to install something to get rid of this nuisance.—O. D.

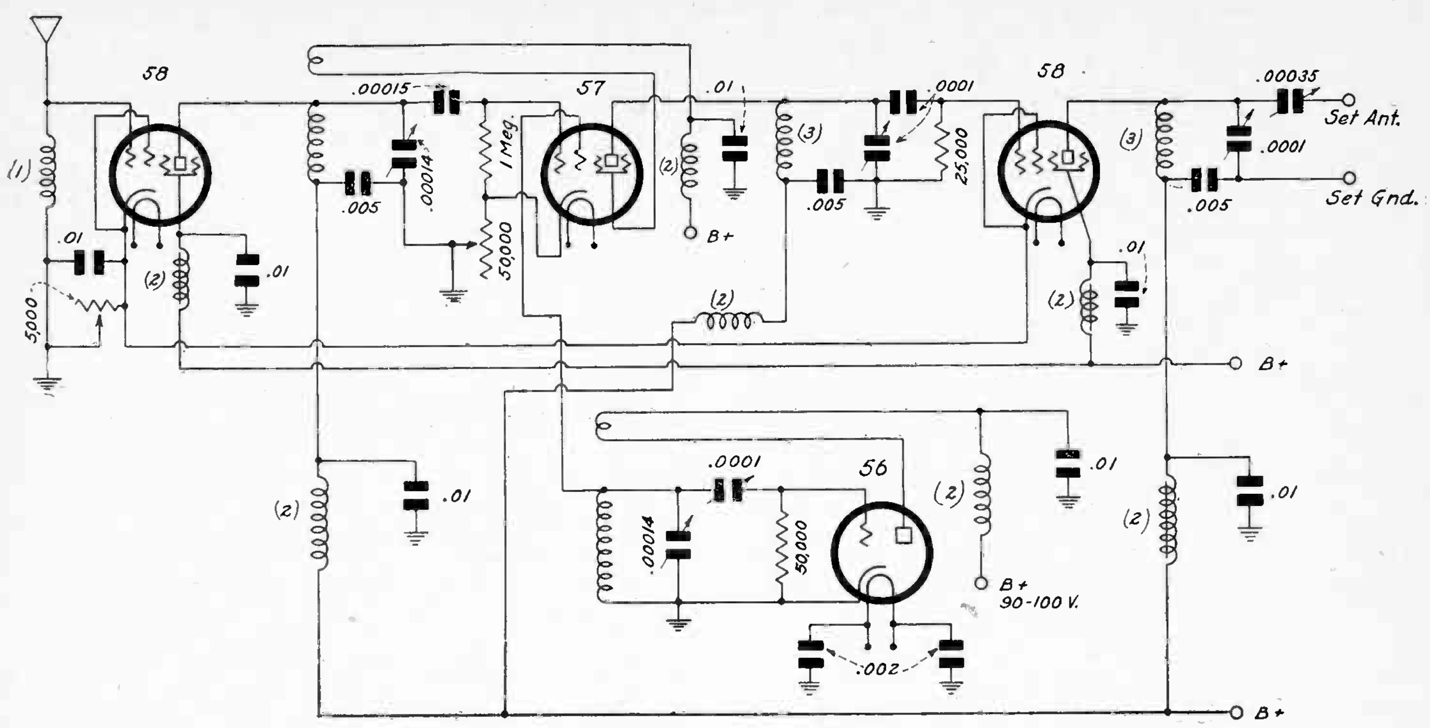
Put an r-f choke coil between the plate of the tube and the phone lead that now goes to the plate, and besides put a small condenser from plate to ground. The choke may have an inductance of 10 millihenries up, and the condenser may be 0.001 mfd. or thereabouts.

* * *

Quadrature

WHAT IS the meaning of quadrature? Is it equally applicable to time and space?—H. I.

Quadrature means at right angles. It is equally applicable to time and space. Usually the type is mentioned, e.g., space quadrature, time quadrature. If it is not mentioned, it is understood from the text. Thus, if time alone is being considered, quadrature would mean time quadrature.



A short-wave converter of advanced design.

Converter Too Simple

CAN NOT a converter for short-wave reception be made of a single tube, merely making it oscillate? I figure it out this way: if the tube oscillates it may be made to do so at practically any desired frequency, and if this frequency differs from the desired signal or carrier frequency by the amount of the intermediate frequency, I would get reception. It ought to be pretty good. Thus even a service oscillator, if unmodulated, or, if modulated, of the type where modulation may be removed, could be used, could it not? Has this idea been tried? Also, the voltage can be obtained direct from the receiver for all operation purposes. One tube makes that easy. Several tubes would make it dangerous. What do you say?—I. H.

We say no. The system you outline works, of course, but only in the sense that mixture takes place, that a single-frequency output is obtained at any particular time, and that this may be of a frequency in the range of a broadcast set, the r-f channel of which thus becomes the intermediate-frequency amplifier. Beyond that the system is hopeless. First, there is no pre-selection. Thus two stations could come in at once at one setting, one being lower than the intermediate frequency, the other higher. And even if no second station were there, a response called an image, and constituting interference, would be heard. It is indeed desirable to have not only pre-selection, but also a stage of intermediate-frequency amplification in the converter, and build the small B supply in the same box. The circuit above shows such a converter, with B supply omitted.

* * *

Frequency Stability

WHY IS IT so important to have frequency stability in a beat oscillator?—K. W. C.

Because the beat depends on the stability of the generated frequency. Suppose a wave of 1,000,000 cycles is generated, and another of 1,000,100 cycles. The beat is audible, that is, a note of 100 cycles. If one oscillator varied 1 per cent. and the other 1 per cent., at some obnoxious instant they might vary the maximum in opposite directions. Then the first frequency might be 1,010,000 cycles and the second frequency 990,099 cycles, yielding a beat of 19,901 cycles, instead of 100 cycles, or practically removing the beat from the audibility range.

CORPORATE ACTIVITIES

FINANCIAL REPORTS

Crosley Radio Corporation—Net profit for the year ended March 31, 1933, after taxes and charges, $413,107, which equals 75 cents a share on 545,800 no-par shares of capital stock. In the preceding fiscal year there was a net loss of $291,061. Net sales for 1933, $10,637,366, as compared with $5,277,686, in the year 1932.

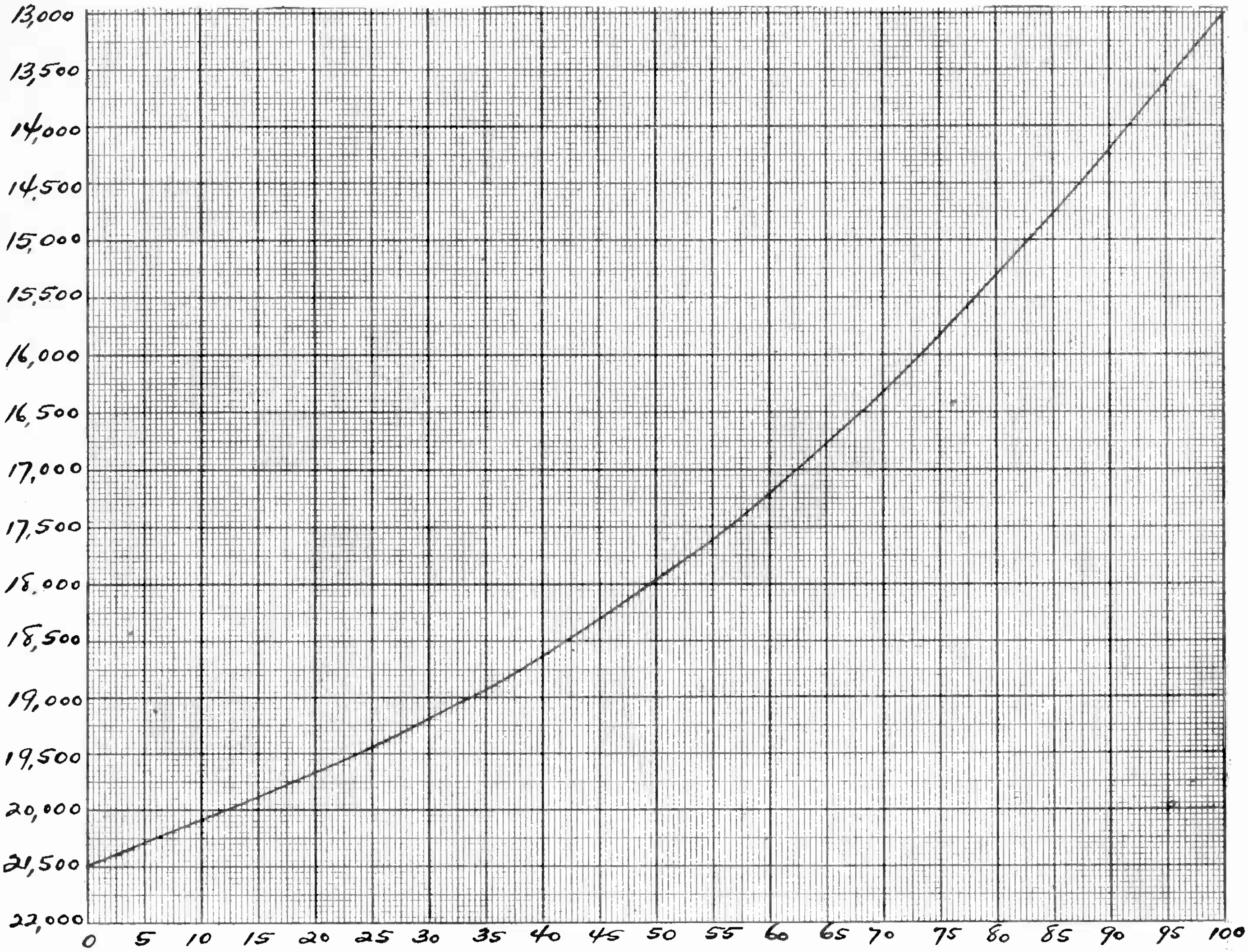
B. F. Keith Corporation—Net loss for the year 1933, after taxes and charges, $580,387. This compares with net income for the year 1932, of $209,782, which equals 52 cents a share on 400,000 shares. Cash, $731,540, as against $587,561; assets, $32,482, against $40,687; current liabilities, $421,241, against $409,544.

Keith-Albee-Orpheum Corp. and Subsidiaries—For three months ended March 31, 1934: Net profit of $167,522 after depreciation and other charges, but without provision for Federal income taxes. Net loss in the corresponding quarter of 1933, after depreciation and other charges, but before subsidiary preferred dividends, $76,742. This included $124,836 loss on Orpheum Circuit, Inc., and its subsidiaries from January 1, to January 27, 1933.

PETITION IN BANKRUPTCY

Stanley-Warren Co., Inc., 922 Irving Park Blvd., Chicago, filed a petition in involuntary bankruptcy on May 23. The Continental Corporation are among the creditors.

13,000 to 21,500 Kc Chart for Hammarlund 0.00014 Mfd. and Alden Blue-Ringed Coil



The three other ranges for the Hammarlund junior midline condenser and Alden plug-in coils, for short waves, were printed last week, as part of a series of charts giving the tuning characteristics of all popular brands of condensers and plug-in coils.

Advantageous Undervoltaging of Tubes

(*Continued from page* 14)

are not intentionally coupled to the oscillator circuit. Overloading causes squealing, growling, hissing, and various other forms of distortion, but it does not increase the sensitivity or the selectivity. If the oscillator tube were operated with a lower voltage, many of these undesirable phenomena would be absent and there would be a saving of power besides.

True of Amplifiers

What is true of the oscillator is also true, to a limited extent, of the amplifiers and detectors in a receiver. At first, the signal is extremely weak—a very small fraction of a volt, perhaps not more than a few microvolts. The maximum coltage recommended for the plate of a 58, for example, is sufficient for an input signal of about two volts assuming correct bias. Why then is it necessary to operate the tube full blast when it will be required to perform a miniature job? There is about as much logic in operating a tube in this manner as to hitch an elephant to a toy wagon. The proportion is all wrong. If anything worthwhile were gained by doing it there would be sufficient justification, but the only thing that is gained is a little more noise and overloading of other tubes in the circuit.

When Power Is Needed

There are times, of course, when tubes are underpowered when this works to the detriment of the signal. The most likely place is in the last stage. As an example, let us take the case of an output tube fed through a resistance when the load circuit is connected between the plate and the cathode, a stopping condenser being used to prevent direct current flowing through the speaker transformer. The applied voltage in series with the resistance might be very high, and yet the tube is not supplied with enough power to operate the speaker properly and without distortion. The arrangement is equivalent to operating the power tube with a voltage which is only a small fraction of what it ought to be. Power gets to the speaker by way of the plate supply, and only that way. The grid of the power tube only controls the power—converts it to alternating current and voltage so that it may be transferred to the loudspeaker and thence to the air as sound. If the flow of power from the plate supply is limited, as by a high resistance in the plate circuit, an insufficient amount gets to the speaker. The grid has an inadequate supply to control.

Power Limitation

In the same way the power may be limited by a sub-normal filament or heater current. This never causes any difficulty, however, for everybody knows that the output of a tube will not be sufficient unless the filament or the heater current is large enough. With the plate supply it is different, for very many think that if there is enough voltage on the plate of the power tube there will be ample output. They forget, it seems, that power is the product of two factors, current and voltage. We could have a million volts on the plate, if the insulation were good enough, and yet not have a single microwatt output. Or, we could have a million amperes flowing without the dissipation of any power at all, provided that the resistance were low enough. There must be the product of the two—current and voltage—if there is to be any power expended.

(*Continued from page* 2)

Both have their advantages—and disadvantages. Plug-in coils, although conceded to be the more efficient, are nevertheless usually improperly adapted for use in short wave receivers for a number of reasons. First, because some improvised method for holding the coil is nearly always used, such as tube-like prongs on the coil and form and tube sockets in the receptacle.

Contact Question

It should be borne in mind that tube socket contacts were primarily designed for use with tubes which are rarely withdrawn from and inserted into their respective sockets.

Such receptacles lack a number of important characteristics (described later) which are necessary for a perfect plug-in system. Plug-in coils are also usually unprotected from mechanical injury. It being, of course, known that the handling of exposed coil windings invariably produce a detrimental change of inductance by some slight shifting of the wires or accidental abrasion. Such a condition naturally greatly impairs the performance of any short wave device.

Switching arrangements on the other hand, although free from the evils associated with plug-in coils, and extremely convenient, are nevertheless characterized by a number of losses usually inherent to noisy switch contacts, objectionable stray capacity of the switch and its associated wiring, as well as the "dead end" effects of unused turns or other coupling losses introduced by "idle coils."

From a standpoint of radical design, we feel that the coil changing system employed in the Postal Deluxe Converter has many noteworthy and commendable features.

Duplex Drawer Type Slide-in Coils

In order to combine into one band-changing system the convenience of switching arrangements, together with the efficiency of plug-coils, an improved type of shielded duplex coil catacomb and receptacle were developed.

The duplex drawer coil unit employed in this Deluxe Converter is essentially composed of two precision space-wound coils fully shielded from each other, but contained within one catacomb drawer with its contacts so arranged that the entire unit slides into its receptacle through the **front of the panel,** in a manner similar to changing drawers of a miniature desk.

Although this system leans toward the plug-in arrangement (for sake of efficiency and elimination of losses introduced by switches, etc.), it nevertheless retains nearly all of the convenience of switching arrangements, for both coils and their combined shields are placed into correct position by one simple insertion of the drawer without opening the cover of the receiver or otherwise disturbing its position or arrangement.

Channel Drawer Receptacle

The cadmium plated steel receptacle into which the duplex drawer coils slide acts as an additional coil shield and is equipped with eight specially designed **double-spring** butt-wiping and self-cleaning contacts, which are in no small measure responsible for the unusual performance and **permanent** operation of this band-changing system.

Tension Spring Contacts

Needless to say, the subject of contacts is of utmost importance in any short wave plug-in or switching device and deserves considerable attention, for the efficiency of the most elaborate equipment is definitely limited by the contacts employed therein.

Inasmuch as most circuit noises in short waves devices are traceable to varying resistances at points of "change-over" contacts, the prime requiste for such contacts is obviously the maintenance of a perfect non-reactive and unvarying path of conduction throughout its useful life.

The resistance and reactance of contact points are dependent upon several factors; namely, pressure, surface area, and the condition of the contacting surfaces. In order to obtain maximum pressure at the point of contact, the recptacle for the drawer coils is equipped with contact compacts composed of two springs; one made of phosphor bronze, for contact; and the other made of tempered high carbon steel (similar to clock springs), for tension. This tension spring (T) (see Fig. 1) absorbs all bending stress, so that the phosphor bronze contacts spring (C) is relieved from most all pressure strain and is primarily used to present a large self-wiping, clean and non-oxidized surface to the coil studs. (The phosphor bronze spring is formed into a flare "U"-shaped trough in order to present maximum area for contact). Ueedless to say, the wiping action is made doubly effective by the added pressure supplied by the tension spring. This type of contact is capable of passing 200 amperes and has actually been found to **improve** with age because continued use gradually wears off slight irregularities of both the contact spring and coil stud until both surfaces are in exact conformity with each other.

Shielding

Let us for a moment consider the importance of shielding in short wave equipment. Improper shielding is responsible for a large share of noise introduction and divided loss of selectivity. Stray feedback always caused by improper shielding or wiring, reduces the gain ahead of the first detector. While it is true that shielding generally prevents feedback, it does so by by-passing stray and some useful R.F. currents to ground, particularly if the narrowest side of coil shield measures less than twice the diameter of the coil. It is for this reason, that the coils employed in the Deluxe Converter are wound on special sized forms in order to minimize eddy current losses.

For a long time, aluminum has been considered the ideal shielding material for high frequency work. Experiments have proven, however, that cadmium or copper-plated steel is just as effective at high frequencies, and, because of its magnetic properties, is infinitely better for elimination of human and other low frequency interference. Inasmuch as flimsy shields are worse than no shields at all, because they introduce considerable noise by imperfect contact, the duplex drawer coil shields are made of one-piece construction with a twelve-point welding compartment separation.

Tuning Circuit Features

The difficulty of tuning in short wave stations has been effectively eliminated by carefully coordinating the capacitative and inductive relationship of tuning system.

In order to produce a high R.F. voltage on the grid of the first detector, a high L.C. ratio is employed, that is, a large inductance and small capacity is used in preference to a small inductance and large capacitity. This favorable condition is brought about by using space wound coils utilizing solid enamel covered copper wire, together with a two-gang tuning condenser rated at 140 mmfd.

In order to further increase the voltage on the grid of the detector tube, the input antenna "loading" is kept unusually low.

Loose inductive coupling is used in preference to capacitative coupling, so as to eliminate the introduction of any capacitative losses in the grid circuit of the detector.

Four coils are used to cover the short wave spectrum in the followng steps:

Coil "A"—
13 to 30 meters....23,000 to 9,994 k.c.
Coil "B"—
28 to 60 meters....10,710 to 4,997 k.c.
Coil "C"—
57 to 130 meters....5,260 to 2,300 k.c.
Coil "D"—
120 to 299 meters....2,499 to 1,030 k.c.

It will be noted that each coil has an approximate frequency ratio of 2.3, which provides for broad separation of the congested bands so as to greatly simplify the process of tuning as well as the problem of accurate oscillator tracking over the entire tuning range.

The Circuit

The circuit of this converter is shown in Fig. 2. It will be noted that it is appreciably different from the usual run of converter circuits, particularly in respect to the use of a separate oscillator and tetrod detector as well as the inclusion of high gain I.F. stage.

Good engineering principles were adhered to when it was decided to use two separate tubes for the first detector and high frequency oscillator, principally because separating the two jobs provides for a greater oscillator stability. In most pentogrid converter circuits, employing one multi-purpose tube for frequency inversion and detector, the oscillator efficiency of the tube rapidly diminished as the frequencies increase, due to decrease of capacitative reactance of the input circuit. The employment of a separate triode oscillator and a separate tetrod mixer (first detector), provides for an unusually efficient form of frequency inversion, in fact, continuous and dependable reception can be maintained on the 14-meter band (20 megocycles)!

The antenna feeds into the primary of the first detector coil O (Fig. 2), the secondary of which is coupled into the tetrod mixer 77 (UT.). A bias resistor of 3,000 ohms is used in the cathode lead of the tube, providing suitable bias. The biasing resistor is shunted with a .001 mfd. condenser (c). The screen is given a lower positive potential than the plate, the voltage being reduced by a 350,000 ohm resistor (R5). A by-pass condenser of .1 mmfd (C9) is connected across the voltage reducing resistor in order to insure feedback from signal fluctuations of the screen potential.

The Oscillator

The oscillator cathod is grounded through a 250 ohm resistor (R2), across which is developed the oscillator voltage (heterodyning frequency). The high-frequency voltage is impressed upon the cathod of the "mixer" through C, which acts as an R.F. by-pass across R, in order to avoid high frequency losses. It will be noted that the oscillator is of the tuned grid type with a 100,000 ohm grid resistor connected between grid and ground, while a .0001 mfd. blocking condenser (C3) completes the high frequency oscillatory circuits. Note the series padding condenser (C2), which is contained within the coil catacomb.

The output of the first detector is coupled into a doubly tuned 545 k.c. I.F. transformer (LC), which in turn is coupled into a 78 super control tetrod I.F. amplifier. The resistor (R4) provides a suitable bias for maximum gain, while by-pass condenser C5 completes the I.F. circuits.

545 k.c. I.F.

Most popular all-wave receivers employ I.F. frequencies of 175 k.c. There is not much difference in the performance of the two, with the possible exception that the inter-channel selectivity is higher for the

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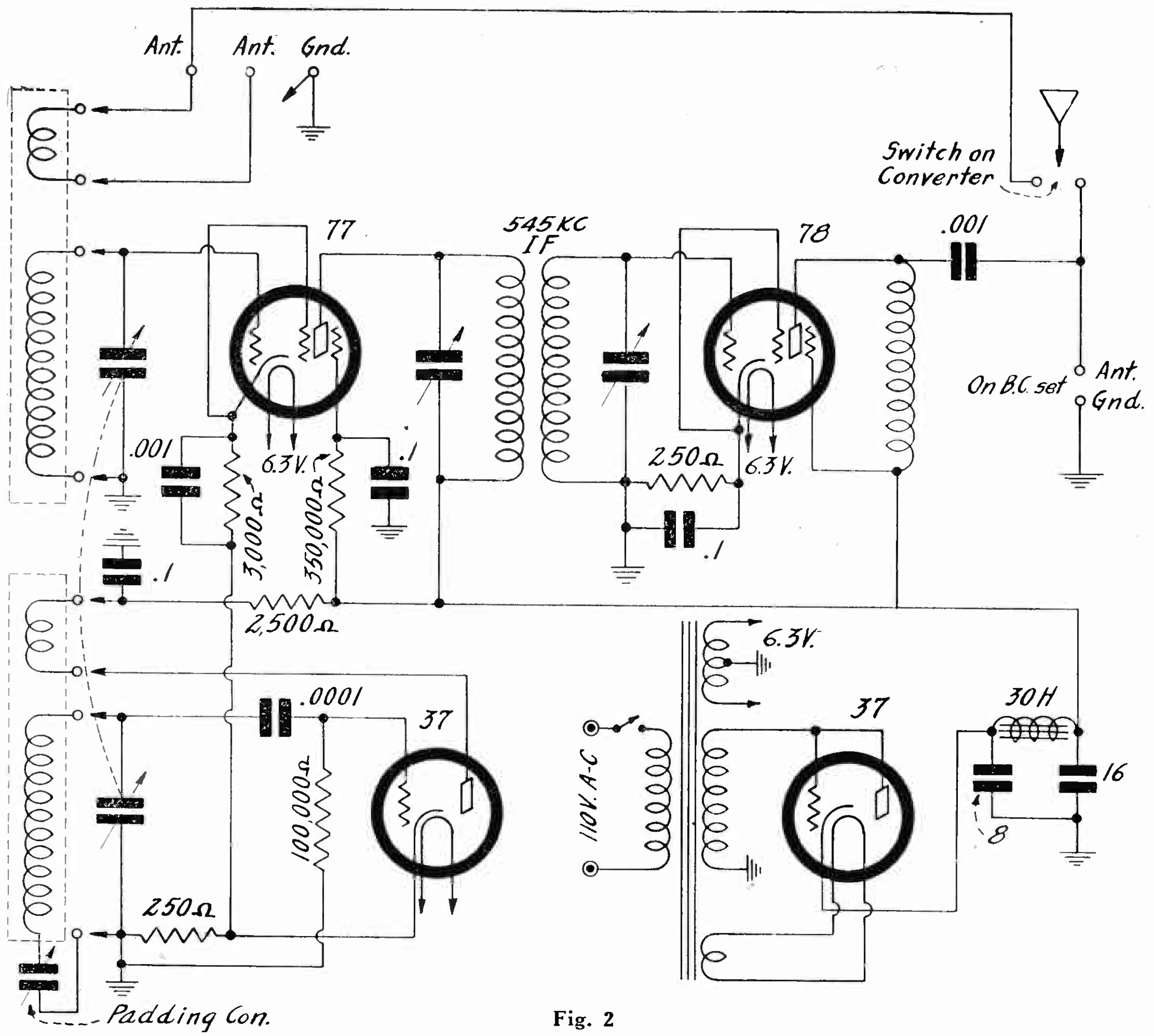

Fig. 2

(Continued from preceding page)

broadcast band with 175 k.c. I.F., while the 465 k.c. I.F. is more effective in the elimination of image frequency reception.

For short wave coverage, however, a higher intermediate frequency is always preferable in order to avoid interlocking between the carrier frequency and the oscillator frequency. The Deluxe Converter employs a 545 k.c. because of the following reasons: First, because it is the lowest frequency bordering the broadcast band (there is no danger of any broadcast or police call signal forcing its way into I.F. amplifier and causing interference); second, because a more stable gain is possible at this frequency than at any other broadcast frequency: third, because a greater interchannel selectivity (5.45 k.c.) is available at this frequency as compared with 15 k.c. selectivity at the opposite end of the broadcast band (1,500 k.c.).

The output of the I.F. amplifier (UT3) is impedance capacitatively coupled to the input circuit of the broadcast receiver through choke and condenser.

A single pole double pole switch (Sw1) provides for optional connection of the antenna either to the converter or to the broadcast receiver.

Power Supply System

The Deluxe Converter is completely self-powered. The standard model operates from 110 volt A.C. power lines, and consumes less than 25 watts. Its operation, however, is not restricted to 110 volts A.C. only, for models are available for operation from 32 to 110 volts D.C., or from two-volt air cells as well as six-volt storage batteries.

The A.C. model, as diagramed employs its own rectifier and hum-free filter systems. This feature produces the necessity of using adapters or otherwise tampering with the wiring of the receiver. When the Deluxe Converter operates in conjunction with your broadcast receiver it does not lower any set voltages, upset any circuit balances, or otherwise overload the receiver. The power transformer PT1, furnishes 6.3 volts, on two separate windings, for the 37 rectifier as well as for the oscillator and detector. The plate and grid of the triode are tied together in a half-wave rectification system. A 30-henry filter choke (Ch2) is by-passed by 8 and 16 mfd. electrolytic condensers (C7 and C8), which completely eleminate all traces of residual hum.

Universal Antenna Provision

Another valuable feature of great importance in the Deluxe Converter is the provision for use of any type of antenna, including doublet, transmission line, shielded systems and special noise-reducing antenna. Practically all former converters have one side of the antenna coil grounded, a condition which necessitates wiring alterations for use with doublet antenna. The Deluxe Converter isolates the antenna primary from the chassis by bringing both end leads out to two insulated binding posts BP1 and BP2. A third post (BP3) is connected to the chassis.

When transmission lines are used the line leads are connected to BP1 and BP2. A single wire antenna is connected to BP1, while BP2 is grounded to BP3. If special noise-reducing antenna with coupling transformers is employed, the output of the transformer may be treated as a transmission line or single wire aerial, depending upon the best results obtained from compositive tests. It can therefore be seen that the Deluxe Converter will operate efficiently with any existing type of aerial without necessitating any internal wiring changes.

Simplicity of Operation

All tuning is accomplished with one full vision illuminated vernier aeroplane dial. Both the oscillator and mixer tuning condensers are "ganged" to this one control —no additional external compensators or trimmers are employed. Perfect tracking is made possible by the use of precision coils and factory-aligned circuits, wherein due compensators is provided for any discrimination over any portion of the tuning range. In Fig. 1 (Front View of Converter), the left-hand knob operates ON-OFF switch (Sw2). The right-hand knob operates the "cut-out" switch (Sw1), which connects the antenna back to the antenna post of the broadcast receiver so that broadcast stations may be received without disconnecting the converter.

It should be remembered that this converter will work well on any set.