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SHORT-WAVE RECEIVING METHODS

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JUNE 9th 1934

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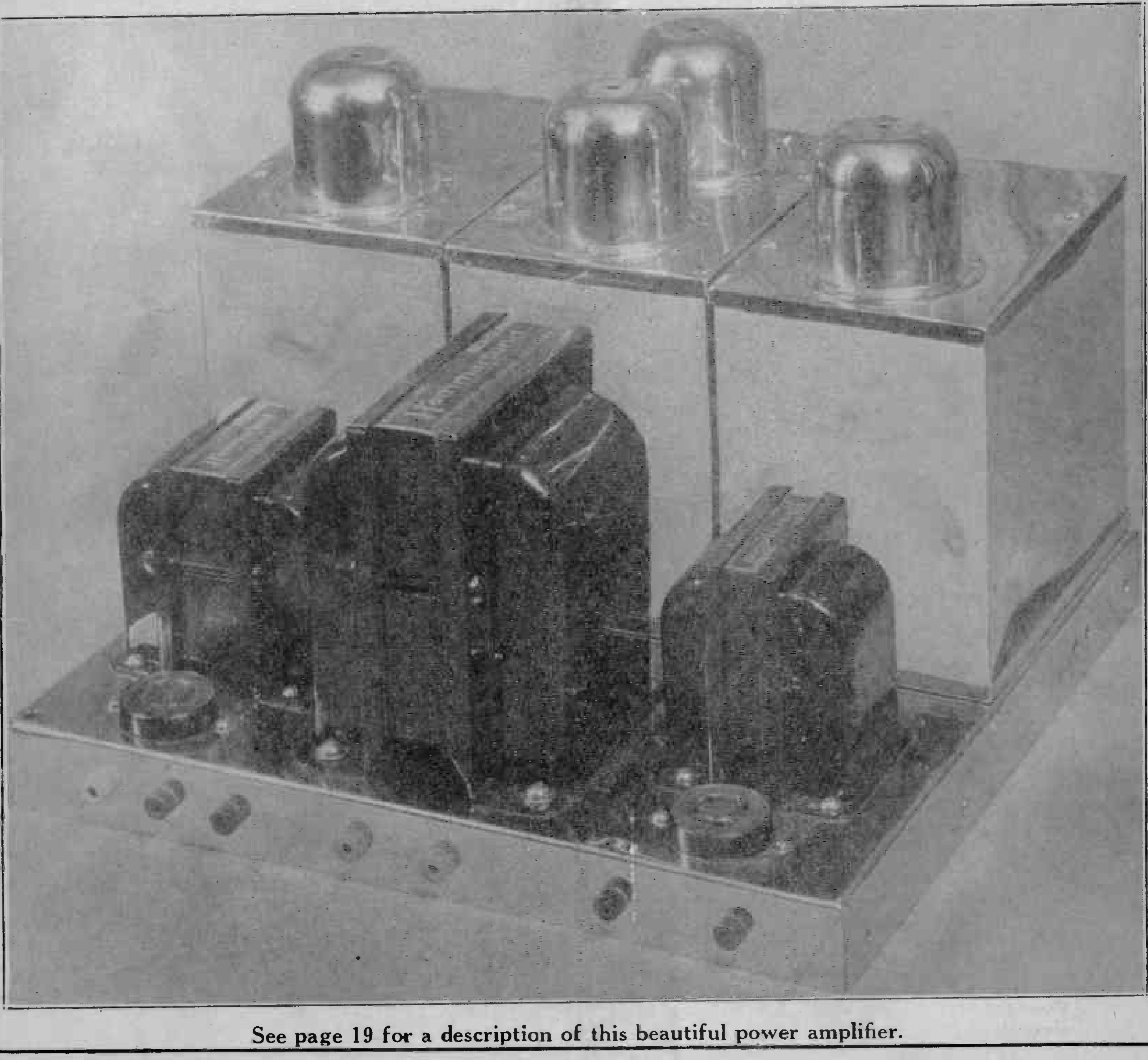
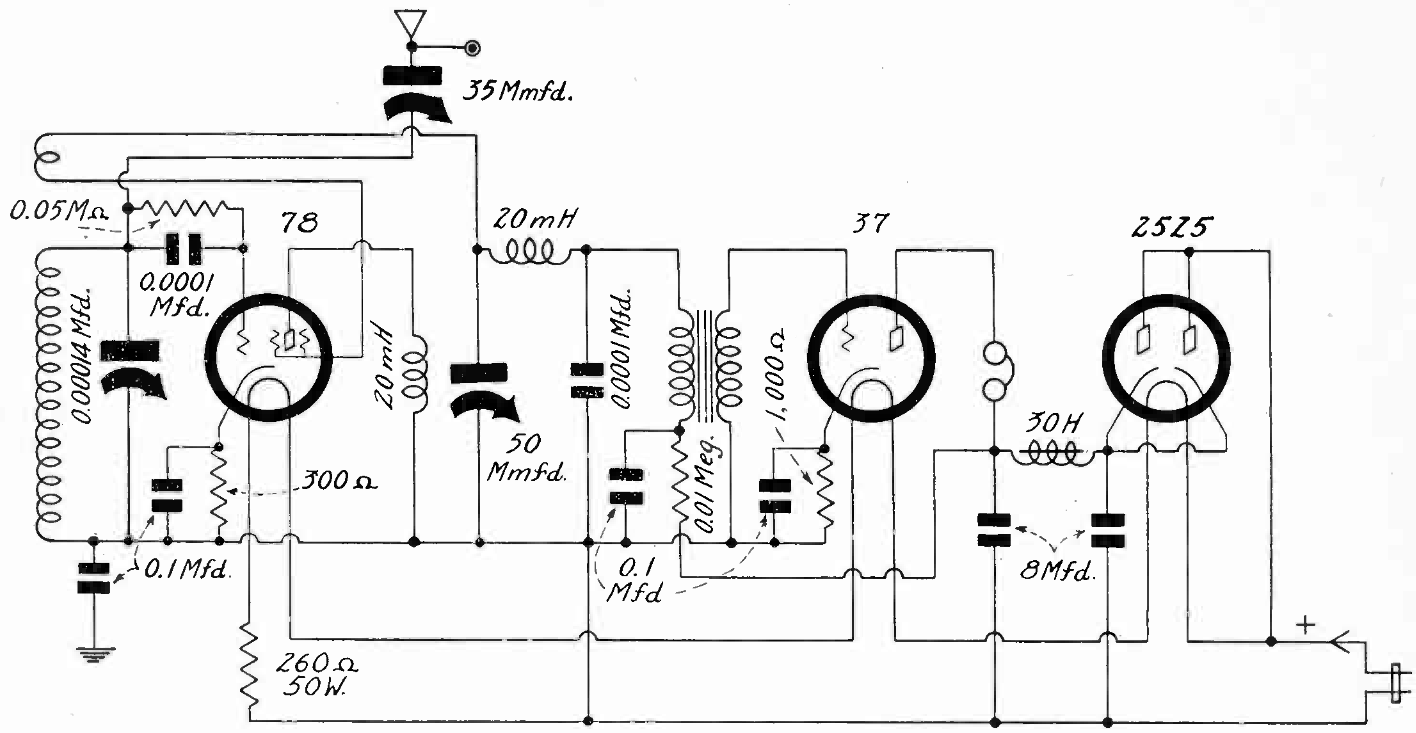
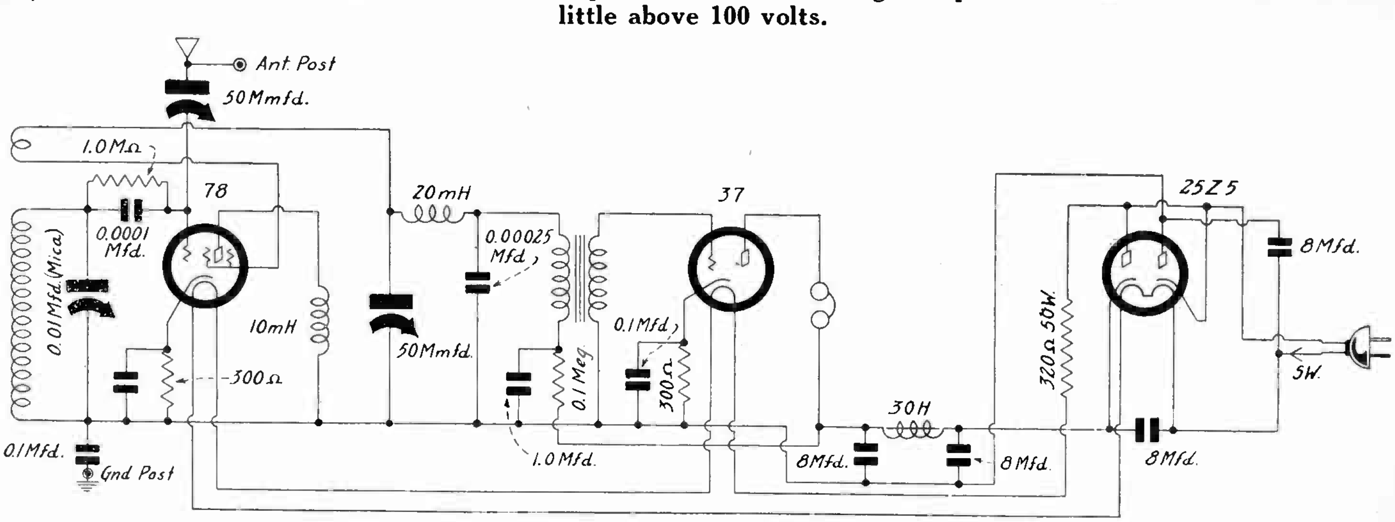


See page 19 for a description of this beautiful power amplifier.

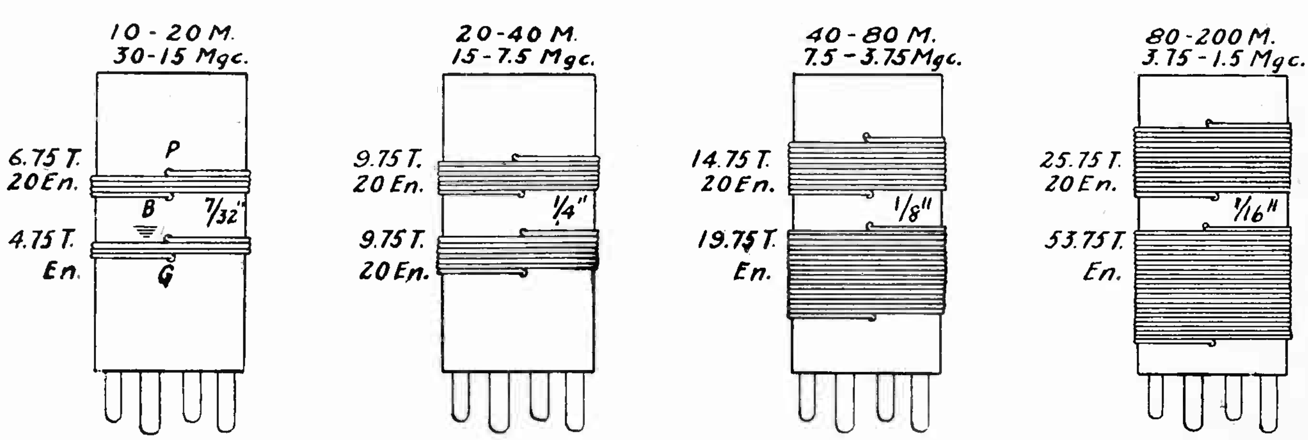
Short-Wave Receivers Using the 25Z5.



Here is a circuit diagram for a universal (a.c. and d.c.) short-wave earphone receiver, using the 25Z5 as rectifier, the 78 as detector and the 37 as audio amplifier. The d-c voltage output from the rectifier should be a little above 100 volts.



Here is substantially the same circuit as shown on top, except that the voltage doubler principle is used for the 25Z5, to attain an output from the rectifier of a bit more than 200 volts. The series antenna condenser may be 35 or 50 mmfd., but the 37 biasing resistor should be changed from 300 ohms to 1,000 ohms. This circuit is exclusively for a.c.



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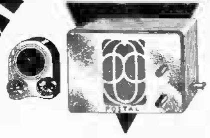

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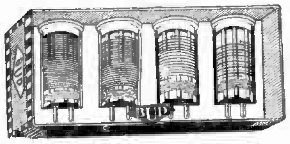

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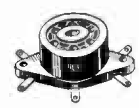

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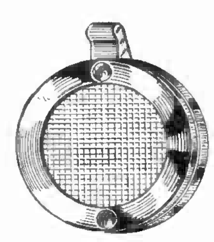

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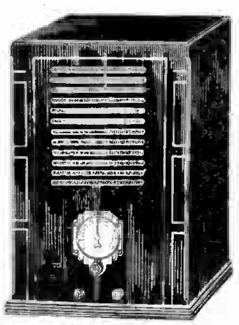

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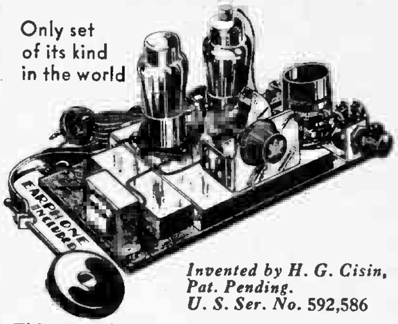

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The First National Radio Weekly
THIRTEENTH YEAR

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Short-Wave Tuners

Figures of Merit for Performance—Intermediate Amplifiers—Effect of Regeneration

By J. E. Anderson and Herman Bernard

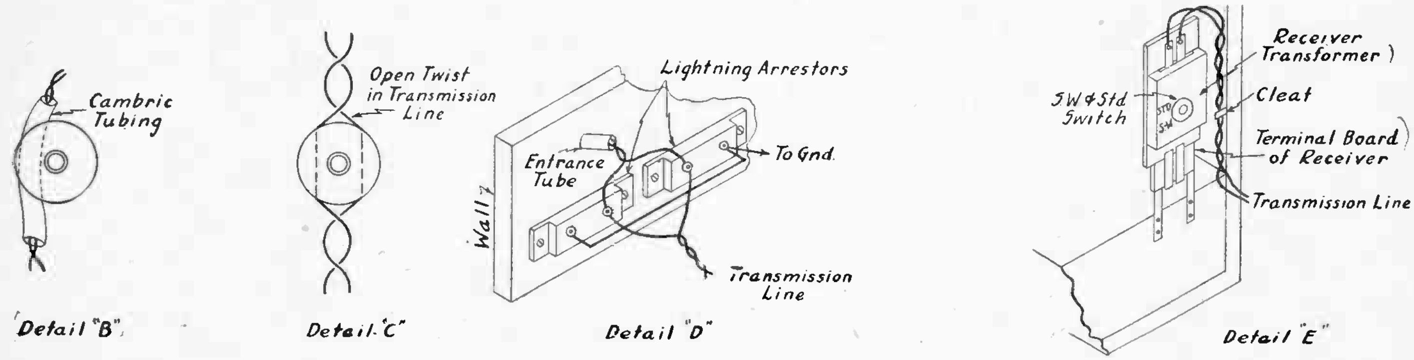

FIG. IV-17
Four details showing the construction and erection of the antenna in Fig. IV-16. Detail E, the matching transformer, is an important part of the system.

[Herewith is the fifth instalment of "The Short-Wave Authority," a treatise that covers the program receiving field. The serial publication was begun in the May 12th issue.—EDITOR.]

Fig. IV-16 illustrates an antenna installation as worked out by RCA engineers for short-wave reception. It consists of two equal wires 46½ feet long, connected so that two doublets are formed, one 58 feet long and the other 33 feet long. Six inches are allowed at each end of a wire for making connections, which accounts for the discrepancy between length of wires and length of doublets.

The uprights consist of galvanized iron pipes, as high as possible. Metal guys are used at the ends, and these should not be longer than 16 feet. If they are longer, they should be broken up by insulators, as indicated in the figure. The guys holding the 16.5-foot lengths to the poles should not be metal, but quarter-inch rope.

Detail A in Fig. IV-16 shows how the two wires are crossed at the center insulator. One wire comes from the top of the left pole and picks up A on the insulator. This wire then crosses over to D, under the block, and continues to end of the 16.5-foot length. The other wire comes from the top of the right pole and picks up B. Thence it runs to C and continues to the end of the left section of the 16.5-foot doublet. The transmission line is soldered to the two wires at A and B, non-corrosive flux being used.

Detail B, Fig. IV-17, shows how the transmission line is brought around the corner of the house. The knob represents a stand-off insulator. A short piece of cambric tubing surrounds the line for protection against abrasion. Detail C shows how the line is held by a stand-off insulator on the plain wall. More than one of these may be used if necessary. Detail D shows the entrance of the line through a porcelain tubing, together with two lightning arresters, one on each side of the line. Detail E shows the termination of the transmission line at the impedance-matching transformer together with that transformer. A switch is attached to the transformer for changing the ratio.

AN IMPORTANT requirement for the reception of short waves is a good antenna, one that will pick up the strongest possible signal and the least possible noise. In general we have the choice of a vertical or a horizontal antenna.

As a rule, the horizontal antenna is preferable because it picks up little noise and a relatively strong signal. There are three reasons for this. First, it is somewhat directional, and it may be erected so that signals desired are intensified and those not desired are partly suppressed. Second, interfering noises are usually vertically polarized and therefore are not picked up by a horizontal antenna. Third, the vertical lead-in employed as a transmission line with a horizontal antenna is non-radiating and non-receptive. These factors, and perhaps others, combine to make the ratio of the signal to the noise greater for this antenna than for the vertical type.

Yet the vertical antenna is not devoid of advantages. It is easy to erect, it is not directional, or it is only slightly directional. Therefore, if desired stations are located in all directions, the vertical antenna is preferable.

The vertical antenna is slightly directional when it has a horizontal portion. The direction from which signals are received best is opposite to that in which the horizontal portion points. Thus if the hori-

(Continued on next page)

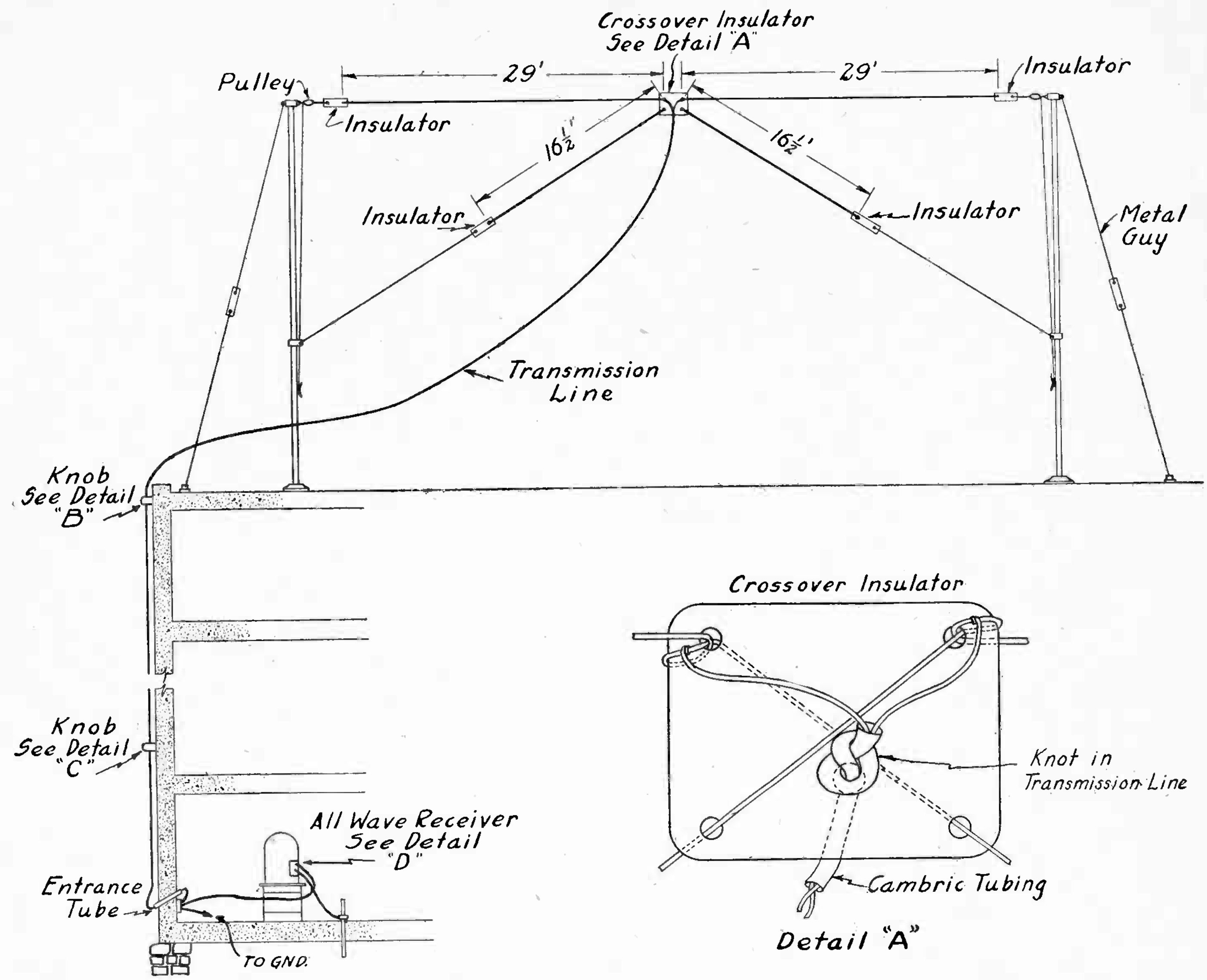

FIG. IV-16

A doublet type antenna and transmission line for the reception of short waves. The line should be 110 feet long or multiples of this unit.

(*Continued from preceding page*)

zontal wire is run east and west and the vertical wire is brought down at the east end, signals from the east are received best. If the vertical wire is brought down from the middle of the horizontal wire, thus making the antenna the T-type, there is practically no directional property, but even then the reception is slightly better in the plane of the antenna than at right angles to it.

A vertical doublet antenna, fed by a non-radiating transmission line, is non-directional, and at the same time is relatively free from disturbing noises, provided that it is erected at a considerable altitude. But if it is sufficiently high up to avoid noises, it becomes difficult to erect. Usually, it is necessary to erect an antenna of this kind on a high wooden pole.

The most practical antenna for short waves, and the one most frequently used in good installations, is the horizontal doublet, with a non-radiating transmission line connecting it to the receiver. We have already described such an antenna in detail. In discussing short-wave receivers in the following sections we shall assume that a good antenna is available.

Short-Wave Tuners

If we are to receive one frequency at a time, and only one, but that any frequency that we may care to select, we must have a very good tuner. Just what constitutes a good tuner depends on many factors, depending on conditions surrounding reception. It depends on the sensitivity of the receiver with which the tuner is to be used; on the nature of the radio traffic; on whether the receiver is to be used in a congested locality or in a congested region of the frequency spectrum; on the kind of modulation used on the carrier wave, and on other factors. The tuner must have the necessary selectivity to accept only the desired frequency and to reject effectively all other frequencies.

A simple tuner, regardless of the frequency to which it resonates, consists of a coil and a condenser, or their equivalents. In Fig. V-1A is given the symbolic form a simple tuned circuit in which L is the inductance and C the condenser. In B of the same figure is shown the same circuit in pictorial form.

A simple resonant circuit such as that in Fig. V-1 is not sufficient to separate stations close together in frequency, or even to separate stations fairly far apart in frequency if one of them is very much stronger than the other, for effective selectivity is not only a matter of frequency difference but also a matter of relative intensity of signals tuned in. It frequently happens that one signal is thousands of times stronger than another, measured at the point where the tuner is. If we desire the stronger of these signals, it is not necessary to have any tuner, assuming there is no other interference, for if one signal is a thousand, or even a hundred, times stronger than another, we do not even notice the weaker signal. On the other hand, if we desire the weak signal to the exclusion of the stronger, the tuner must be very selective, indeed, for the stronger signal must not only be reduced to equality with the weaker but it must be reduced to such an extent that it is not noticed when compared with the weaker, which now has become the stronger.

Figure of Merit of Tuners

It is convenient to have a figure of merit for tuners which will tell us to what extent it suppresses interfering signals and accepts the desired one and such a figure, called the selectivity of the circuit, or the Q of the circuit, is obtained by taking the ratio of the inductive reactance to the effective resistance. The inductive reactance is the product of the inductance of the coil in the circuit, expressed in henries, and the frequency of the signal, expressed in radians per second. One cycle is equivalent to 6.28 radians, approximately.

The Q of circuits intended for tuners may vary from 25 up to as much as 250. If the selectivity is less than 25, the circuit is of little use as a tuner, for it has little discrimination. Selectivities as high as 250 are not easy to obtain, and attempts in this direction lead to expensive and unwieldy coils. Values of 100 are not difficult to attain with reasonable coils, and circuits with such selectivities are fairly good as tuners.

A tuner of fixed frequency employing a crystal of quartz instead of inductance and capacity is sometimes used when extreme selectivity

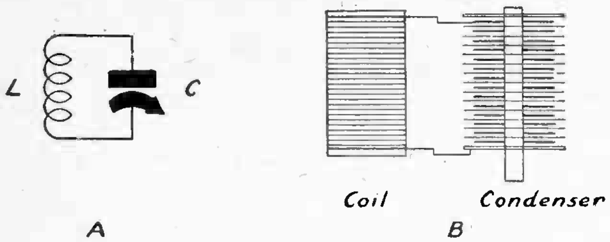

FIG. V-1
A simple resonant circuit containing a coil, L, and a condenser, C. A—The symbolic form of the circuit. B—Pictorial view of the circuit.

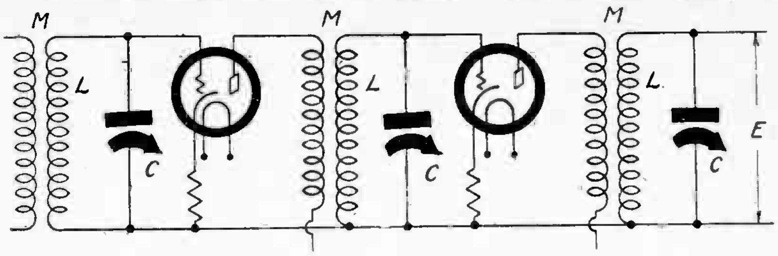

FIG. V-2
A tuner consisting of three simple tuned circuits, with tubes seperating them. Greatly increased selectivity may result from tandem connection of circuits.

at a given fixed frequency is necessary. A single crystal of quartz may have a selectivity, or Q, as high as 30,000.

Need of High Selectivity

Selectivities of various degrees are demanded by signals of different kinds. For the very best television signals, scarcely any selectivity is tolerable if any detail is to appear in the picture. For speech and music a medium selectivity must be used. It cannot be too great, for then the musical brilliance is sacrificed; yet it must be fairly high in order that not more than one signal of this kind shall be received at once. For telegraph signals, the selectivity may be almost as high as we please, and often it must extremely high in order that interference shall be eliminated. It is mainly for telegraphic signals that quartz crystal resonators are used in place of inductance and condensers.

As an illustration of the enormous selectivity that may be required at times, let us assume that one station is located one mile away and another 2,500 miles away. Suppose that the intensity of the signals falls away inversely as the distance. Further, let us assume that the distant station has a power of 500 watts and that the local station has a power of 50,000 watts. Let the frequencies of the two stations be 1,000 and 1,010 kilocycles. What must be the selectivity of the tuner if the signals from the local station shall be suppressed to the point where they are only one per cent. as strong as the signals from the distant station?

At the start the local signals are 100 times stronger than those of the distant station in its own locality. The ratio of the distances is 2,500, and since the signals fall away inversely as the distance, by the time the desired signals have reached the receiver, they have attenuated to the point where they are only 1/250,000 part as strong as the signals from the local station. To suppress the local station so that its signals are only one per cent. as strong as those from the desired station, we must introduce another factor of 100, making the ratio 1/25,000,000. The selectivity that will satisfy this requirement is about 1.25 billion. To approach a selectivity of this order it would be necessary to use two very good quartz crystal resonators in tandem and to adjust them precisely to the same frequency. Of course, a selectivity so high would be entirely unpractical, except for slow telegraphic signals.

Selectivity Variable

The selectivity, as defined above, is not a constant quantity in any circuit, but depends on the frequency. Since the selectivity is proportional to the inductive reactance, it would be directly proportional to frequency if it were not for the fact that the resistance varies with frequency. The resistance increases more rapidly than the frequency, and for that reason the selectivity decreases with frequency.

This decrease in the selectivity of a circuit is unfortunate, because a higher selectivity is required the higher the frequency. This follows from the facts that the separation of two stations depends on the ratio of their frequencies and that stations are spaced in the frequency spectrum according to frequency differences. Therefore the higher the frequencies the closer are the station on a ratio basis, and a greater selectivity is required to separate them.

No single coil and condenser circuit is capable of yielding sufficient selectivity for modern needs. Therefore two or more must be used in tandem. This may be done in two ways: by matched filters and by simple tuned circuits between amplifier tubes. Both methods are used but the second is by far the more common.

A Ganged Tuner

In Fig. V-2 is a tuner-amplifier consisting of three simple tuners and two tubes. If the selectivity of all these tuners is the same, the selectivity of the combination may be much higher than that of any one tuner. In order that the selectivity of the combination should be much higher than that of one circuit, it is necessary that the product of L and C in all circuits is the same and also that there is no interaction among them. There should be perfect shielding.

The condensers in Fig. V-2 are shown to be variable, thus indicating that the tuner is to be used for any one of a large number of frequencies in a given band, determined by the ratio of the maximum and minimum capacities of the condensers. When the condensers are variable, the products of L and C should be the same regardless of the actual value, for if they are not, the selectivity will be less for the combination than for a single tuner. If the condensers are separately adjustable, there is no great difficulty making the adjustment. Yet separate adjustable condensers are not used for the reason that it is not practical. In all modern sets the condensers are ganged so that they are tuned simultaneously.

In order that high selectivity should be obtainable in a ganged circuit, the inductances L should all have one value, the capacities C should be equal, and the rate of change of these capacities should be the same. The last condition is essential because if the rates of change are not the same, the values of the capacities will not remain the same. By holding the inductances equal in manufacture and by making individual adjustments on the minimum capacities in the circuits, it is possible to hold the circuits very closely equal, provided that the condensers used have been made for this service.

If the various tuned circuits are lined up exactly, that is, if they are made to resonate exactly with the same frequency, and if there is no interactions among the tuners that should not be, the selectivity of the combination can be obtained by multiplying together the relative responses of the separate circuits. In Fig. V-3 are two resonance curves which illustrate the effect of adding tuners in tandem, the outer curve being that for a simple resonant circuit having a selectivity factor of 10 and the inner curve being that for three such tuners in tandem.

These curves bring out one important fact, namely, that near resonance the frequency discrimination is not widely different in the two cases whereas remote from resonance the discrimination is much greater for the three tuners than for one. Thus by adding tuners interfering frequencies are eliminated more rapidly than frequencies close to resonance, which may be part of the desired signal. It is better to have many moderately selective tuners in tandem than to have a single tuner of high selectivity.

A resonance characteristic such as that represented by the inner curve in Fig. V-3 would be of little value in separating broadcast channels. Suppose, for example, that we wish to separate 990 kc from 1,000 kc, the two signals being equally strong at the antenna. The ratio of the these frequencies is 0.99. At this abscissa the ordinate is 0.94. Therefore the interference is 94 per cent. as strong as the desired signal. This could not be tolerated.

The situation is much more favorable when the frequency of the carrier is low. Suppose, for example, that we are dealing with an intermediate frequency tuner, and that the intermediate frequency is 100 kc. The desired signal is converted to this frequency and at the same time the interfering signal is converted to 90 kc. The frequency ratio is now 0.9. At this abscissa the inner resonance curve of Fig. V-3 shows a relative intensity of 0.1. In terms of power and decibels, the interference is down 20 db. While this discrimination is not sufficient to eliminate all interference from the adjacent channel, it represents about a ten-fold improvement over the case when the frequency was ten times higher.

Although the discrimination is not sufficient even at 100 kc from the point of view of eliminating interference, it is already excessive from the point of view of quality of voice and music. If we agree that the highest sound frequency transmitted is 5,000 cycles, the lowest side frequency is 95 kc. The ratio of this to the carrier is 0.95. The inner curve of Fig. V-3 gives a relative response of 0.366 at this detune. Thus the upper side frequencies are reduced appreciably. As the selectivity increases, the suppression of the side frequencies increases rapidly.

Regenerative Circuit

Instead of using many simple tuners in tandem to obtain selectivity, we can also use regeneration in a single tuner. A simple regenerative circuit is shown in Fig. V-4. LC is the tuned circuit, T is a tickler winding whereby a part of the output of the amplifier can be returned to the grid to be amplified again, and P is a potentiometer by means of which the amount returned is controlled. Regeneration has the effect of reducing the resistance in the LC

(Continued on next page)

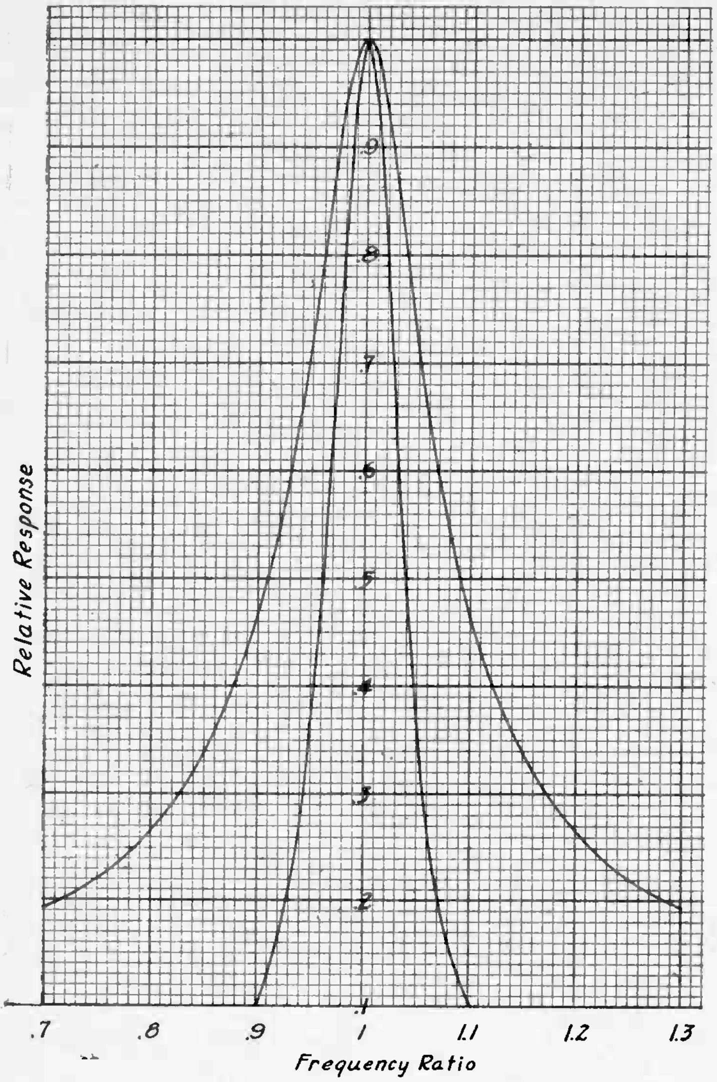

FIG. V-3
Resonance curve of a simple circuit having a selectivity of 10 (outer curve) and of three such circuits connected in tandem (inner curve).

(Continued from preceding page)
circuit and therefore of making the selectivity higher. At the same time the selectivity is increased, the intensity of the signals is also built up. These are the two great advantages of regeneration—increased selectivity and increased sensitivity.

Fig. V-5 shows how the selectivity and the response increase as the regeneration is increased, or, what is the same thing, as the resistance in the tuned circuit decreases. The curves are actually plotted for different values of the selectivity factor Q. It is noticed that the curve for $Q = 10$ is nearly straight, or that there is practically no increase in the response by resonance. When Q has been increased to 20, by regeneration or otherwise, there is appreciable increase in the response due to resonance. The highest curve is for $Q = 150$. At this value of the selectivity the gain due to resonance is manifold. Perhaps it should be said that the gain is due to regeneration, but it would be the same if the resistance in the circuit were as low as the effective resistance is in the regenerative circuit. It makes no practical difference whether we view regeneration as a reamplification of a given signal voltage or as a reduction in the resistance in the resonant circuit.

The upper curve in Fig. V-5 by no means gives the limit of regenerative amplification. A gain of 1,000, or even of 10,000, is possible, provided that the circuit has been designed so that the regeneration can be controlled closely.

Changing the Frequency

Still another way of obtaining selectivity is to change the frequency of the signal and taking advantage of the more favorable frequency ratio. This is the superheterodyne method, which is the most satisfactory way of obtaining both greater selectivity and greater sensitivity, provided that the principle is correctly applied.

We have already referred to the effect of changing the frequency of the signal, but it will bear repeating. Let us assume that we have a short-wave signal of 10,000 kc modulated by audio frequencies up to 10,000 cycles. Also let us assume that the nearest interfering frequency is removed 50 kc from the 10,000 kc, in either direction.

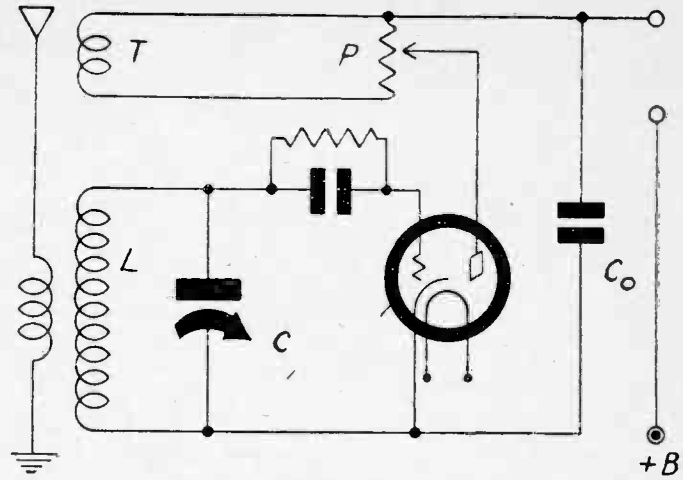

FIG. V-4
A regenerative circuit by which the effective resistance in the LC tuner can be reduced until self-oscillation occurs. The gain and the selectivity can be controlled by means of the potentiometer P.

The 10,000 kc carrier is to be changed to a lower frequency, and this lower frequency may be selected arbitrarily. As a means of reducing certain types of interference, it would be desirable to select a rather high intermediate frequency, say 1,000 kc, but on this frequency neither the gain nor the selectivity will be as high as at lower frequencies. Due to other complications, however, it is not practical to go much below 1,000 kc. Hence we shall assume that intermediate frequency.

In order to produce this intermediate frequency we must have an oscillator generating a pure wave of either 11,000 or 9,000 kc and couple this to the detector on which the signal is impressed. In the output will be, among many other frequencies, one of 1,000 kc, and this will contain the original modulation that had been impressed on the 10,000 kc carrier. Therefore if we select and amplify the 1,000 kc signal and ultimately detect it, we obtain the sound we desire.

Let us assume that the local oscillator generates the higher of the two possible frequencies, that is, 11,000 kc. Since we assume that the nearest interfering frequency was 50 kc removed from the desired carrier, it is either 10,050 or 9,950 kc. The 11,000 kc locally generated oscillation beats with this interfering signal, producing a beat of either 950 or 1,050 kc. The carrier has been reduced to 1,000 kc. Therefore the interference is still 50 kc either side of the carrier, but the carrier has been reduced in the ratio of ten to one, and the ease of separating the desired signal from the interference has been increased in about the same ratio. Moreover, the chances of securing a high gain with a stable amplifier has been increased greatly.

Without frequency reduction we have to separate 10,050 kc from 10,000 kc. The ratio of these is 1.005. After frequency reduction the 10,050 kc interference becomes 950 kc, and the corresponding carrier 1,000 kc. The ratio now, for the same two signals, is 0.95. In the one case the ratio is 0.5 per cent. greater than unity and in the other it is 5 per cent. less than unity. Therefore, for the same selectivity of the tuner, the interference will be reduced ten times more effectively after the frequency change than before it.

There is another great advantage in changing the frequency of the carrier, and that is that it can always be changed to the same value regardless of what the carrier may be. For example, we select an intermediate frequency of 1,000 kc, and with this intermediate we can receive any higher frequency. The principal tuner, then can be adjusted once for all, and this adjustment can be done with much greater care and exactness than would be practical if the tuner were to be adjusted each time a new carrier frequency were to be tuned in. For this reason the high gain and selectivity indicated by theory can actually be obtained in practice.

Pretuning

Considering the ease with which a high selectivity can be obtained by reducing the frequency, it appears at first though that no other selectivity is required. But with a little experience with superheterodyne receivers we soon conclude that additional selectivity is necessary—selectivity in the radio frequency level where selectivity is not so easy to obtain.

This pre-selection, as it has been termed, is necessary both in broadcast and short-wave superheterodyne. When receivers of this type were first built it was thought that no pre-selection was needed, but this was changed as soon as stations began to multiply. Then for a while it was considered sufficient to have a single tuned circuit adjusted to the carrier. Broadcast superheterodynes did not become practical until at least two circuits in tandem tuned to the carrier were used.

The same process development took place, or is taking place, in

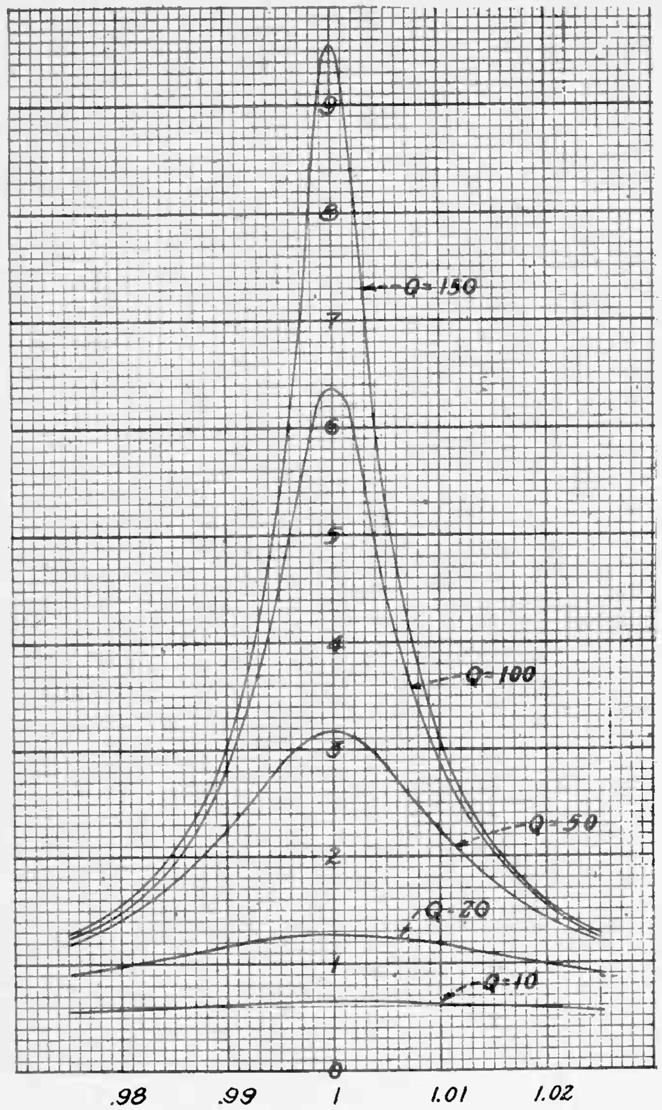

FIG. V-5
Five resonance curves illustrating the effect of various degrees of regeneration or of different values of resistance in the tuned circuit.

short-wave superheterodynes. Simplicity of design and low cost demanded that the radio-frequency tuner be left out, using only the oscillator control for tuning. Satisfactory results demanded pre-selection even in short-wave receivers.

Just why is pre-selection necessary in a superheterodyne? Well, suppose again that we have a 10,000 kc station which we wish to get with a 1,000 kc intermediate frequency superheterodyne. If we set the local oscillator at 11,000 kc we get the station. Also, if we set the local oscillator at 9,000 kc we get it just about as well. In each instance the 1,000 kc intermediate is produced. Therefore there are two possible settings of the oscillator at which the same signal frequency will be brought in. The converse is also true, that is, every setting of the local oscillator is the correct setting for two different signal frequencies. Thus if two stations are operating within reception range and if they have the proper frequency separation, both may come in when the oscillator is set to receive one of them. This would be intolerable interference.

A numerical illustration will help to show how this interference comes about. Let the local oscillator be set at 11,000 kc so as to receive the 10,000 kc signal. But 11,000 kc is also the correct setting for 12,000 kc, for when 11,000 is subtracted from 12,000 we get 1,000. Thus if there are two stations within range, one on 10,000 kc and the other on 12,000 kc, both will be received on a 1,000 kc intermediate frequency superheterodyne, assuming that there is no pre-selection.

In what way does pre-selection prevent this interference? Just as any tuner discriminates between frequencies. If we want the 10,000 kc signal we tune the pre-selector to this frequency and we attempt to make it so selective that the signal on 12,000 kc cannot come through, not even to the extent of a heterodyne whistle. In this particular case we have a frequency ratio of 1.2. Suppose, then, that we have a pre-selector with an overall Q of 250. What is the suppression of the 12,000 kc signal in relation to the 10,000 signal? It is 0.00373, or the amplitude of the interfering signal is reduced about 0.4 per cent. of what it would be if there were no tuning.

The effectiveness of the pre-selector obviously depends on the intermediate frequency, for the higher this is the more does the ratio between the interfering frequency and the desired frequency differ from unity. The increase of the intermediate frquency from 30 kc to 450 kc in broadcast superheterodynes was due to the necessity of providing effective pre-selection. For short-wave reception it will ultimately become necessary to increase the intermediate frequency above that now ordinarily used, namely 465 kc. It is quite probable that we shall have intermediate frequencies as high as 5,000 kc for the reception of waves of the other of 10 meters.

The name "image interference" has been applied to that peculiar interference in a superheterodyne which is due to the fact that every setting of the local oscillator is the correct setting for the reception of two different signal frequencies, which are so related that their difference is equal to twice the value of the intermediate frequency. The only way of eliminating image interference is to provide sufficient selection ahead of the frequency changer while the signal has its original value.

While the choice of the intermediate frequency is arbitrary, there are, nevertheless, certain restrictions. We have just found that the necessity of suppressing image interference is an argument for using as high intermediate as possible. What, then, is there against increasing the frequency to an extremely high value? First, it cannot be made higher than the signal frequency for then the resulting frequency ratio would be less favorable for good selectivity rather than more favorable. Moreover, the intermediate frequency, or fixed frequency as it would be, cannot be in the band of frequencies to be received by a given set, for then there would be one band within this band in which no signals could be received because of heterodyning.

There is also a limitation in the downward direction. If it is less than 100 kc, say, the desired signal and its image become inseparable neighbors by any resonable pre-selector. Besides, the lower the intermediate frequency the greater is the cut-off of high tones essential to natural reproduction.

A Superheterodyne Tuner

A complete superheterodyne tuner consists of three parts, the pre-selector, which operates at the carrier frequency, the oscillator tuner, which usually operates at a frequency higher than the carrier frequency, and the intermediate tuner, which operates at the difference frequency between the carrier and the oscillator. All superheterodynes contain these parts, but not all to the same extent. There may be a single tuned circuit in the intermediate frequency tuner, but more frequently there are two or three, with amplifier tubes between them. It is seldom that more than three intermediate tuners are used because of the difficulty of stabilization in such cases.

Intermediate circuits, or couplers between tubes, may be singly or doubly tuned. When they are singly tuned, the tuning condenser may be either across the primary or the secondary of the transformer. Primary tuning yields somewhat higher gain but a slightly lower selectivity than secondary tuning. About the only

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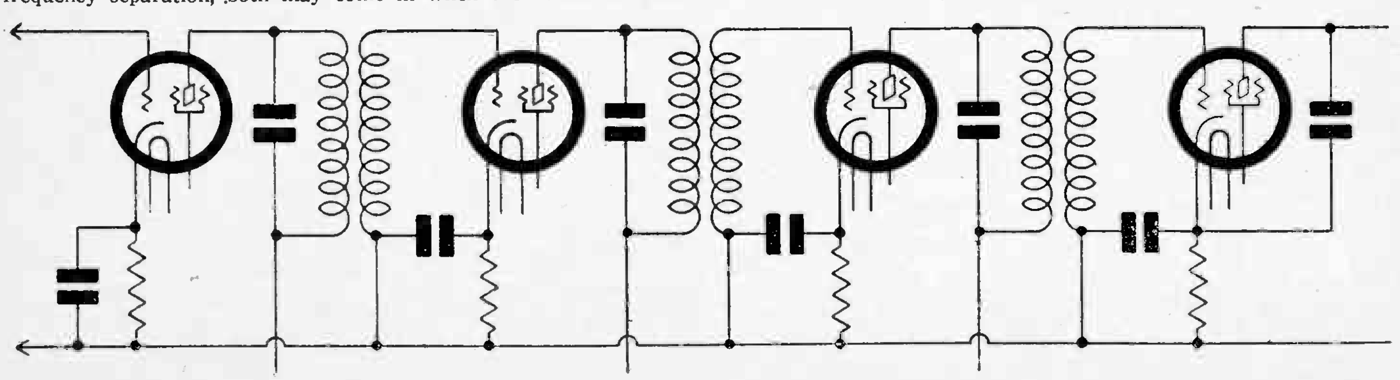

FIG. V-6
An intermediate-frequency tuner-amplifier in which the tuning condensers are put across the primaries of the coupling transformers. This is plate tuning.

Grid Circuit Tuning in I-F Channel

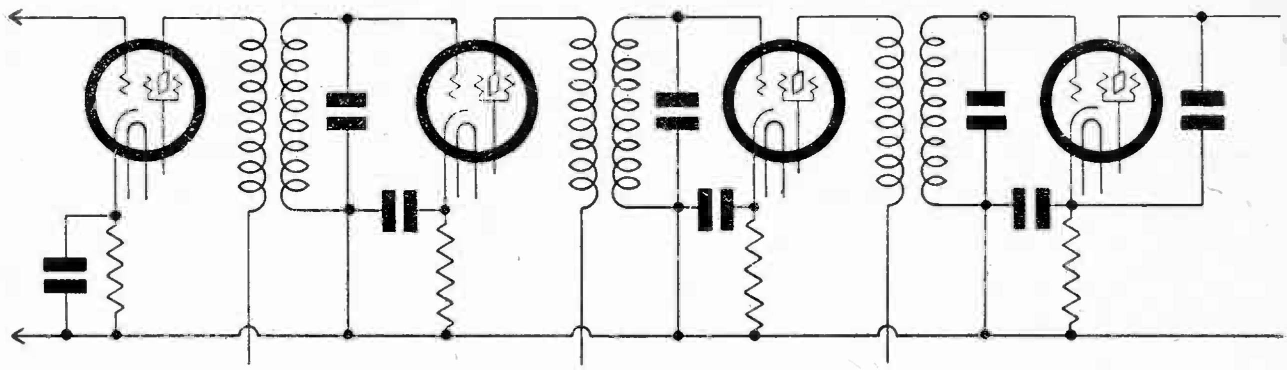

FIG. V-7
An intermediate frequency tuner-amplifier in which the tuning condensers are put across the secondaries of the coupling transformers. This is grid tuning.

(Continued from preceding page)
time that the tuning condenser is put across the primary is when it is desired there for the purpose of by-passing higher radio frequencies. When only one winding of the transformer is tuned the coupling between them is rather close. When the coupler is doubly tuned there is a condenser across each winding. Fig. V-6 shows a tuner and amplifier in which there are three simple circuits with the tuning condensers across the primaries. In Fig. V-7 is the corresponding circuit with the tuning condensers across the secondaries. Fig. V-8 shows the doubly tuned circuit having three couplers.

Band Pass Tuning

It has already been pointed out that when the tuner is sufficiently selective to eliminate satisfactorily stations on adjacent channels, there is too much elimination of the higher audio frequencies for natural reproduction of the original sound. One method for remedying this effect has also been pointed out, namely, the use of many moderately selective circuits in tandem. This, however, is not practical partly because it would require more tubes for amplification and more tuned couplers, but primarily because there is a better way.

The superior way is the use of the doubly tuned circuit mentioned in the preceding paragraphs. If the two windings be tuned to the same frequency when one is not affected by the other, there will be two points of maximum gain when the two are coupled together in the normal manner. The combination forms a band-pass filter having a transmission characteristic somewhat like the curve in Fig. V-9. The two peaks of gain occur at f_1 and f_2 and a minimum occurs at f_r. If either of the two circuits were alone, there would be a single peak, and that would coincide with f_r. The closer the two tuned circuits are coupled together, the farther apart will be the two peaks be, and the deeper will be the depression between them. Also, the more selective the two circuits are, the steeper will be the sides of the transmission curve, and the deeper will be the depression in the middle.

By choice of coupling between the two circuits, the peaks of gain can be placed any desired distance apart; and by simultaneous choice of selectivity of each circuit, the depth of the depression can be made any desired value. Suppose, for example, that it is desired to receive all audio frequencies up to 8,000 cycles and to cut off sharply above that frequency. The coupling is then chosen so that the peaks are 16,000 cycles apart, one 8,000 cycles above f_r and the other 8,000 cycles below it. Side frequencies corresponding to tones higher than 8,000 will be cut off sharply and these tones will not be reproduced. The side frequencies corresponding to the low notes will not be reproduced as strongly as those corresponding to the higher. Therefore there will be a certain compensation for the opposite frequency distortion in the pre-amplifier and also in the audio amplifier, assuming the tuning characteristic of the high frequency tuner is of the type shown in V-5.

A composite tuner in which the transmission within a certain band of frequencies is sensibly uniform and is negligibly small outside is called a band-pass filter. One of the simplest of these is the doubly tuned transformer with loose coupling between the two tuned windings. According to Fig. V-9, the transmission within the band is not exactly uniform, but if the resistance were a little greater or the coupling a little looser, the two peaks would merge and there would result a single broad peak.

At this point it is well to point out that although doubly tuned circuits are employed in superheterodynes, they are not often tuned so as to yield the band-pass characteristic at the frequency to which they are tuned. Usually one circuit is tuned after the other

Station

By Alice

BRAD BROWNE and Al Llewelyn, pioneer comics of the air, who have been heard by listeners in numerous programs over the major networks during the past eight years, have returned to the microphone with a new series of original songs and patter. After a six months' absence they are now heard over an NBC-WEAF network, each Tuesday evening at 7:30 p.m., EDST, under the sponsorship of Tastyeast, Inc. . . . The summer series of religious broadcasts to be heard over the NBC networks will bring a half-dozen distinguished ministers to the aerial pulpits, including Dr. Ralph Sockman, Dr. Charles L. Goodell, Dr. William Hiram Foulkes, Dr. Frederick H. Knubel, Dr. Paul Scherer, Dr. Frederick K. Stamm, the Rev. Daniel A. Lord, and the Rev. Peter J. Bergen. . . . Countess Albani will again be the summer star of the Cities Service Hour, while Jessica Dragonette takes a nine-week vacation. . . . Jack Arthur, the popular young baritone of the Sweetheart Melodies, heard over WEAF each Wednesday, has added another broadcast to his schedule; he is now heard on Thursday also, but over WJZ and the Blue network. . . . Mme. Sylvia, famous health and beauty expert, has been signed for next season by her radio sponsors, the Ralston Purina Company. Her present series terminates on June 22; she will return early in the Fall.

The young Russian baritone, Igor Gorin, recently featured by Rudy Vallee in a Fleischman program, now has a spot of his own, on Thursdays, at 8:45 p.m., over WJZ. He will also be heard on the International Tidbits program each Sunday at 5:30. . . . A new series of sketches will be presented over an NBC-WEAF network from WGY, Schenectady, each Thursday and Saturday at 9:30 a.m. They will feature the character of a French-Canadian, played by Waldo Pooler, and two typical Times Square song and dance men, played by Jerry Brannon and Tom. . . . David Guion, America's foremost authority on native melodies, has several new songs with Schirmer's. They include some very fine Louisiana slave songs. . . . Fred Allen and his troupe of enter-

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Grid and Plate Tuning Enable Band-Pass

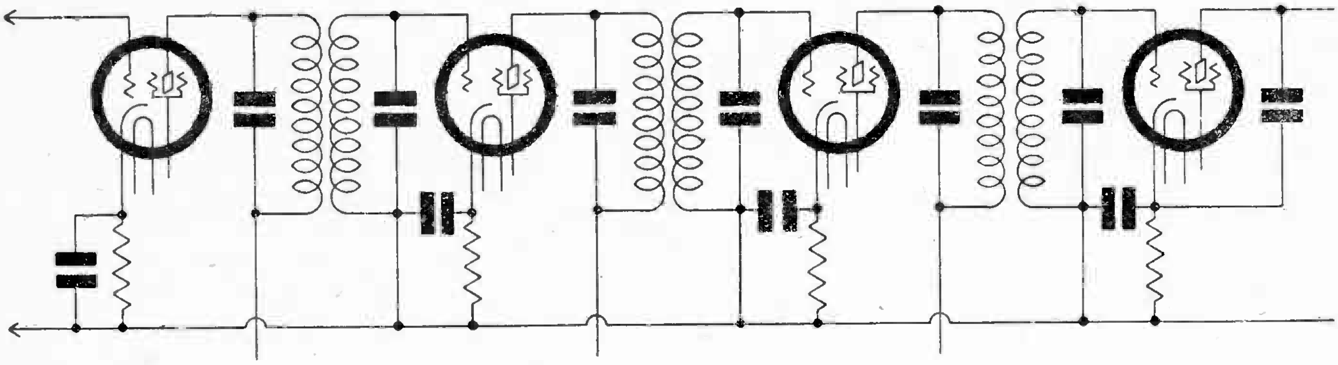

FIG. V-8

A tuner-amplifier in which both primaries and second-aries are tuned. This is sometimes referred to as doubly tuned. The characteristic is of the band-pass type if tuners are properly adjusted.

for maximum response on the selected intermediate frequency, which is suppled by an oscillator, but no attempt is made to remove the effect of the presence of the other circuit. The correct method of tuning would be to remove the tuning condenser across one, then tune the other to the frequency required. This done, the condenser on the tuned circuit should be removed temporarily and the condenser on the untuned should be connected. Now this condenser should be tuned until the signal is maximum on the same frequency. When this has been done the first condenser should be connected as it was the first time. This method is not employed because it is troublesome and very often the condensers are not accessible except for making capacity adjustments.

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FOR THE WEEK

HE NEWSPAPERS BOUT. To listen to think that radio's spon- cutting into their adver- uinous extent. Yet the sing of the American rs Association asserts canvass recently made ber of active American that $113,440,000 was , $49,896,626 in maga- in radio broadcasts. ves that radio will be lot more sponsors, and before the American to do much worrying ns and the wholesale

tainers will continue to be heard over the NBC networks during the summer months. Allen has just signed for another thirteen weeks of broadcasting under the sponsorship of the Bristol-Meyers Company. . . . Ray Heatherton has been engaged by Warner Brothers for a series of short subjects opposite Mitzi Mayfair. Ray is heard regularly with Eddie Duchin as baritone soloist, and as the romantic lover in Castles of Romance, each Tuesday and Thursday morning over an NBC-WJZ network, with your humble correspondent. . . . The Voice of Experience has had his contract renewed by his sponsors, Wasey products, so that he will continue to be heard over the WABC-Columbia network throughout the summer, five times a week, Monday through to Friday at noon, and Monday evenings at 8 p.m. . . . Oh, before I forget; discovered our congenial NBC control man the other evening; Carl Henry Lorenz is a "ham" and runs his own station, with call letters "W2FE"; he talks to such countries as Spain, New Zealand, England, etc., as nonchalantly as though he were making a five-cent 'phone call. . . . Tony Wons said a mouthful in Columbia's weekly quotes: "Many a radio star has been yessed to failure; there is no practice more pernicious than meaningless flattery, and no greater compliment than the gift of constructive criticism." . . . Richard Himber and the Studebaker Champions with Joey Nash, have changed their broadcasting time; now heard on Tuesdays at 9:30 p.m., WABC and network. . . . The nimble fingers of Ralph Waldo Emerson, organist, and John Brown, pianist, are called into play each Tuesday at 11 a.m. CST, when they are heard in a quarter-hour of duets over Station WLS, Chicago. . . . Helen Nugent, who was very popular over the WABC-Columbia networks for several years, is now in Cleveland, O., delighting the audiences of WTAM, in that city. . . . Trudy Thomas, hostess of melody and rhythm, has been known to WMCA listeners for the past two years as Gertrude Thomas; she changed her name recently to Trudy on the advice of a numerologist.

I-F Channel Needs Filteration For Full Capitalizatiom of Gain

Considerable trouble is experienced in the construction of intermediate-frequency amplifiers due to oscillation. If there are two stages of amplification the filtration must be excellent, otherwise the gain can not be realized, and some loss-provoking method must be employed, such as detuning. While a set should not be too selective, the intended selectivity should exist, but is absent if even a trifle of detuning has to be the expedient substitute for proper plate, screen and cathode circuit filtration. The filters may conist of high-inductance chokes and medium-capacity condensers. Usual values are 20 millihenries and 0.1 mfd.

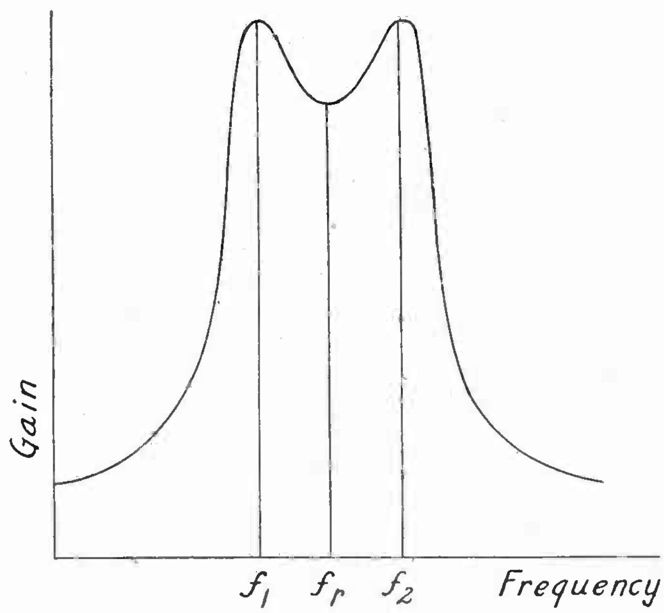


FIG. V-9

A double-peak transmission characteristic such as results when both the primary and the secondary of a transformer are tuned to the same frequency. The peaks do not coincide with this frequency, one being above and one below.

Precision Calibration

of Low and High Frequencies, Principally Using Harmonics

By Herman Bernard

TABLE I

For Calibration of Low-Frequency Oscillator

H represents the harmonic order of the test oscillator fundamental frequency to the right of it that beats with the station frequency on top line.

H									
1	570	660	710	760	810	860	940	1180	1250
2	285	330	355	380	405	430	470	590	625
3	**190**	220	**236.666**	255	270	286.666	313.333	393.333	416.666
4	**142.5**	165	**175.5**	**190**	202.5	215	**235**	295	312.5
5	**114**	132	**142**	152	162	172	188	236	250
6	**95**	110	**118.333**	126.666	135	**143.333**	156.666	196.666	208.333
7	**81.428**	**94.286**	**101.428**	**108.571**	**115.714**	122.857	134.286	168.555	**178.555**
8	71.25	**82.5**	88.75	**95**	**101.25**	**107.5**	117.5	147.5	156.25
9	63.333	73.333	78.888	84.444	90	**95.555**	104.444	131.111	181.111
10	57	66	71	76	81	86	**94**	**118**	125

TABLE II

For Calibration of High-Frequency Oscillator

H represents the harmonic order of the station frequencies on the first line that produces the high frequencies to the right.

H									
1	570	660	710	760	810	860	940	1,180	1,250
2	1,140	1,320	1,420	1,520	1,620	1,720	1,880	2,360	2,500
3	1,710	1,980	2,130	2,280	2,430	2,580	2,820	3,540	3,750
4	2,280	2,640	2,840	3,040	3,240	3,440	3,760	4,720	5,000
5	2,850	3,350	3,550	3,800	4,050	4,300	4,700	5,900	6,250
6	3,420	3,960	4,260	4,560	4,860	5,160	5,640	7,080	7,500
7	3,990	4,620	4,970	5,420	5,670	6,020	6,580	8,260	8,750
8	4,560	5,280	5,680	6,080	6,480	6,880	7,520	9,440	10,000
9	5,130	5,940	6,390	6,840	7,290	7,740	8,460	10,620	11,250
10	5,700	6,600	7,100	7,600	8,100	8,600	9,400	11,800	12,500

AFTER one has calibrated oscillators to cover intermediate, broadcast and some of the lower brackets of short-wave frequencies, he may pursue the same method of "beating up" oscillators for higher frequencies. This method consists of using harmonics of a lower-frequency oscillator to measure the higher-frequency one, and it is handy to have the standard fundamental frequencies in the next lower band as represented by the tuning ratio. Suppose that we have calibrated with a tuning condenser that normally yields around 3-to-1 frequency ratio. So, if we wound up the broadcast band at 1,600 kc, and wanted 100 kc overlap, the next band would be 1,500 to 4,500 kc. Each time we desire to "beat up" this way we shall build a new oscillator, but later on, with this equipment, we could construct a switch-type oscillator that would cover all the bands, provide the option of modulation, include amplification of the oscillation frequency, if we like, and of course attenuation.

As soon as we get higher than the first or intermediate short-wave band we may desire to contract the ratio, which can be done with parallel or series capacity, so frequencies will not be greatly crowded on the dial, when they are so high that large absolute differences in frequencies result from tiny mechanical displacements of the tuning condenser rotor.

Using 2-to-1 Ratio Now

It is well, to avoid multiplicity of padding, to select some ratio now for the rest of the tuning. When this decision has to be made it is best to select the desired ratio for the highest frequency band to be covered, say 2 to 1, and then we would tune in bands to bands approximating 4,400 to 8,800 kc, 8,000 to 16,000 kc and 15,000 to 30,000 kc, although we would designate these for convenience in megacycles, 4.4 to 8.8, 8 to 16 and 15 to 30.

If we have a suitable broadcast-band oscillator we may use that always for checking these high frequencies, as the harmonic response, when beating with another oscillator as at present, is practically without limit, results up to the 150th harmonic having been verified time and again, and higher order harmonics could be reached of course, if there were any necessity. Always the broadcast-band oscillator is made to beat with a t-r-f receiver first, to register an exact zero beat, then the set is turned off, and the test oscillator used alone.

The harmonics become numerous and one may not know what they are, but has the means of determination from the oscillator covering the next lower band of frequencies compared to the oscillator now being calibrated. Thus if we used a certain station frequency, beating the broadcast-band oscillator with that, and it was 660 kc, we know that for higher than 4,400 kc we shall strike frequencies of 4,620, 5,280, 5,940, 6,600 kc etc., or, in megacycles, 4.62, 5.28, 5.94, 6.6 etc. Exactly these points may not be preferred, but their places on the curve are just as important as any other frequencies in the span, if we can locate conveniently on plotting paper just where they should fall. For the high frequencies the paper should be large enough to provide 100 kc separation in this band, at least, and later 250 kc separation may be used, meaning that one horizontal line compared to the next represents a difference of 250 kc.

Selecting Broadcasting Stations

For ease of determination it is well to select the frequencies of the broadcasting stations regularly received at your location, and tabulate both the fundamentals of low-frequency oscillators that will beat with those station frequencies, as well as harmonics of the station frequencies themselves. For low frequencies this is a simple task of division. For high frequencies it is multiplication.

The two tables are shown herewith for stations brought in clearly at a point of reception in New York City. The stations used were WMCA, 570; WEAF, 660; WOR, 710; WJZ, 760; WNYC, 810; WABC, 860; WAAT, 940; WINS, 1,180, and WNEW, 1,250.

This assortment gives a fairly expansive selection. For the low-frequency purposes, already discussed, each station frequency is divided by 2, 3, 4, 5, 6, 7, 8, 9 and 10, for as low frequencies as one would need ordinarily. Remember that low-frequency oscillators (Table I) will yield harmonics that will beat with these station frequencies, and that the harmonic order can be identified by the method previously told, of measuring the difference in frequency on a calibrated broadcast-receiver or broadcast-band oscillator.

For the higher frequencies we know that the broadcast-band oscillator will yield its own harmonics, and that these will give the results expressed in Table II for the selected nine stations.

Different harmonics of different orders rarely represent the same ultimate frequencies for different station fundamentals, as can be seen by exploring Table II for repeats. Not one is encountered in the ninety examples therein included, where the fundamental is in the count, too, as the so-called "first harmonic."

Common Points

But in Table I it will be seen that there are exact zero-beat repeats for different harmonics of different low-frequency fundamentals, beating with different station fundamentals. Besides zero-beats there are finite beats. Both groups are represented by bold-face type for the oscillator fundamentals. Differences up to 2 kc are included, for a zero beat between one oscillator harmonic and a particular station, if changing to a beat 2,000 cycles higher or lower, when using some second station, is still serviceable, as the 2,000-cycle note is distinct. Differences up to almost 10,000 cycles could be used, but results are probably more closely verified by using the lower difference value as optimum.

Therefore besides the method of checking the low frequency by measuring the frequency difference between two settings on a broadcast set or broadcast-band oscillator, there is the additional check of using the same test oscillator fundamental, but different harmonics of it, related to different station fundamentals. Observe in Table I, that under 570 kc appears 190 kc, so that when the test oscillator is at 190 kc its third harmonic is beating with 570 kc. Some other harmonic of 190 kc will beat with some other station frequency, and by observation of a list one prepares for himself he can ascertain these duplications or checking-points.

Using Two Stations

Under 760 kc, in Table I we find the fourth harmonic of 190 kc (760/4=190), so if we leave our test oscillator going at some seemingly unknown frequency, and get a beat with 570 kc, and then tune the broadcast receiver and get a beat with 760 kc, we know that the fundamental is 190 kc, or some quotient resulting from division of 190 by a whole number, i.e., 95 kc or 63.33 kc in this example. We can eliminate the possibility of a lower frequency than 190 kc by the difference method of measurement on the set. This is not as closely accurate for other purposes, but completely satisfactory to the extent of eliminating the possibility of error due to half-frequency or third-frequency of what is expected.

Just one more example. Suppose the low-frequency oscillator gives a zero beat with 570 kc, also with 810 kc, and some distinctive-note beat (not zero) with 660 kc and 860 kc. What is the fundamental? Look at Table II and you find zero beats for 95 kc under 570 and 760, and under 660 is a beat of 714 cycles and under

(Continued on next page)

The 19 for Short Waves

Tube Used as Regenerative Detector and First Audio Amplifier Consists of Twin Triodes

By Jack Tully

THE 19 tube was introduced as a Class B twin amplifier. It is of the 2-volt series and draws 0.26 ampere in the filament circuit. There is no notation in the manuals as to its operation for detection or Class A work, but the tube can be used for such purposes, and when resistance-loaded the plate current at stated battery voltage is low.

Due to the high emission, it was believed that the tube would work out satisfactorily for regeneration on short waves, and it did. The circuit used is shown herewith. One section of the double-triode tube was used as detector, the other section as first-stage a-f amplifier, and then a 30 tube was added, to provide still more volume, although only for earphone use. The reason was that plenty of volume is always acceptable, and the quantity was found not to be excessive. With most of the two-tube short-wave sets the volume could stand a bit of a boost, but here, though only two tubes are used, in the mechanical aspect of counting the tubes, of course there are three tubes electrically.

Smallest Coil on Top

The circuit was built of home-wound coils, on 1-inch diameter tubing, placed underneath a metal chassis some 3 inches high. That condition was completely satisfactory for four coils, but for the fifth one, for the highest-frequency range, it was found necessary to put the coil atop the chassis, elevated midway between that plane and the inside of the upper metal cover into which the chassis fit. Otherwise there wasn't satisfactory regeneration all over the dial for the last or smallest coil.

A switch that has good contact and low resistance is requisite, and two companies that make such a switch are Central Radio Corporation, of Beloit, Wisc., and Oak Manufacturing Company, of Crystal Lake, Ill.

The tuning ratio never did quite attain 2 to 1, which is all right, too, since then there is a smaller spread of the frequencies on the dial. That is why five coils were used instead of four. The metal box no doubt contributed some capacity, as did the method of winding the tickler, which was to interwind it with the secondary. The tuning condenser was 0.00014 mfd.

The coils were so wound that a throttle condenser capacity of 50 mmfd. was sufficient, instead of the more usual 0.00014 mfd., 0.0002 mfd. or 0.00025 mfd. This, too, had the indirect result of cutting down the frequency ratio, that is, the resultant number when the highest frequency in any band was divided by the lowest in that same band. In general the frequency ratio was 1.85, but for the two smallest coils increased just a bit.

Coils Made Experimentally

Tuning was begun at 1,700 kc by winding a coil experimentally. Then the next coil was built to pick up at 100 on the dial where the other left off at 5 on the dial, and so on, until the total number of coils was completed. The usual inductance computations did not apply, due to the shielding effect of the box and the nature of the windings, and only experimental work rendered the result desired. The lowest-frequency coil had 55 1/6 turns of No. 26 enamel, tickler 17 turns No. 32 single silk covered.

The regeneration control was excellent, and the stability of the audio amplifier likewise. The B voltage was only 45 volts, but could be increased to 90 volts without requiring any circuit change. However, one reason for the extra tube, the 30, is to permit high results with only 45 volts, as the extra tube in the long run is cheaper than the extra battery or B voltage.

Frequency Calibration Tried

Some experiments were conducted with frequency calibration. Since the circuit is regenerative, naturally the throttle condenser capacity in use had to be varied, and this would change the frequency in the grid circuit, because of the reflected effect of the other capacity. Nevertheless, when the regeneration point, just below spillover, was used as the datum, this could be substantially repeated time and again, and offers the idea of frequency-calibration of such modest sets.

Of course, the antenna series condenser has an effect, too, but this need not be front-panel accessible, hence varied from time to time, if the capacity is selected at some reasonable value, for then the detuning due to shifting this capacity is absent. A capacity of 20 mmfd. was used as a fixed one, and results were good, except on the last or smallest coil, when oscillation stopped. To avoid an extra switching operation, and because there isn't much on the air that one cares a great deal about in this band, the expedient of using only a few feet of aerial was resorted to for this band only. Then regeneration was excellent. Otherwise a regular outdoor aerial was used and there was neither failure of regeneration nor absence of response at any setting.

A Prophecy

Even the producers of inexpensive short-wave sets, even of the one-tube, two-tube and three-tube types, manufactured or in kit form, will have to get themselves equipped to furnish suitable calibration, as at present users are having too much trouble trying to locate the desired foreign stations. Besides the folly of tuning for them when the stations are not on the air, the average user is strictly up against it, not knowing what the dial setting should be, until it is obtained after patient practice. Thus to get a suitable assortment of settings might take weeks or even months.

Two factors tend to render difficult this calibration of the small sets. One is the series antenna condenser, which changes the resonant frequency of the grid circuit. The other is the feedback control, of whatever type, which does the same.

Beat Method

However, the receiver could be calibrated for oscillation, the station found that way, by beating, and then the fine point of tuning to just below oscillation in regenerative sets could be established after the whereabouts of the station was determined. Also, the set then could be used as an oscillator.

[The circuit diagram of the receiver, with some additional comment, will be published in next week's issue, dated June 16th.]

Calibration of High Frequencies

(Continued from preceding page)

860 one of 555 cycles. The unknown frequency is 95 or 95/2 or 95/3 etc., and the quotients, if any, can be determined by the receiver difference method.

As for higher frequencies than those of any standard, using harmonics, the measurements may be made as already told, and also another method is useful. This is for determination of an unknown high frequency, using a low-frequency oscillator. The standard should not be extremely low compared to the unknown, but its lowest extreme may be up to one-twentieth or so of the expected frequency. If a broadcast-band oscillator is used, it will provide good results, say, up to 30 mgc.

That method consists of setting the unknown at some frequency to be measured, and if the unknown is oscillating, register a beat with it by using an harmonic of the lowest frequency the test oscillator will generate to cause such a beat. Note this frequency. Then slowly and carefully tune the low-frequency oscillator to higher frequencies and cause other beats to be heard, counting them. When one comes to the last one, and tries for another, at a higher frequency of the low-frequency oscillator, it is not there, so move back to the really final one, and read it carefully. The unknown frequency is the product of the two extreme frequencies, and one number less than the number of beats counted, divided by the difference between the extreme frequencies. As an example, if the low-extreme fundamental was 600 kc, the high-extreme fundamental was 1,500 kc, and the total number of beats counted was 11, the unknown is 600 x 1,500 x 10/900 or 10,000 kc or 10 mgc. This brilliant method is due to Edward M. Shiepe.

A De Luxe Auto Super

A Six-Tube Receiver Equipped with Remote and Automatic Volume Controls

By Samuel Miller

Postal Radio Corporation

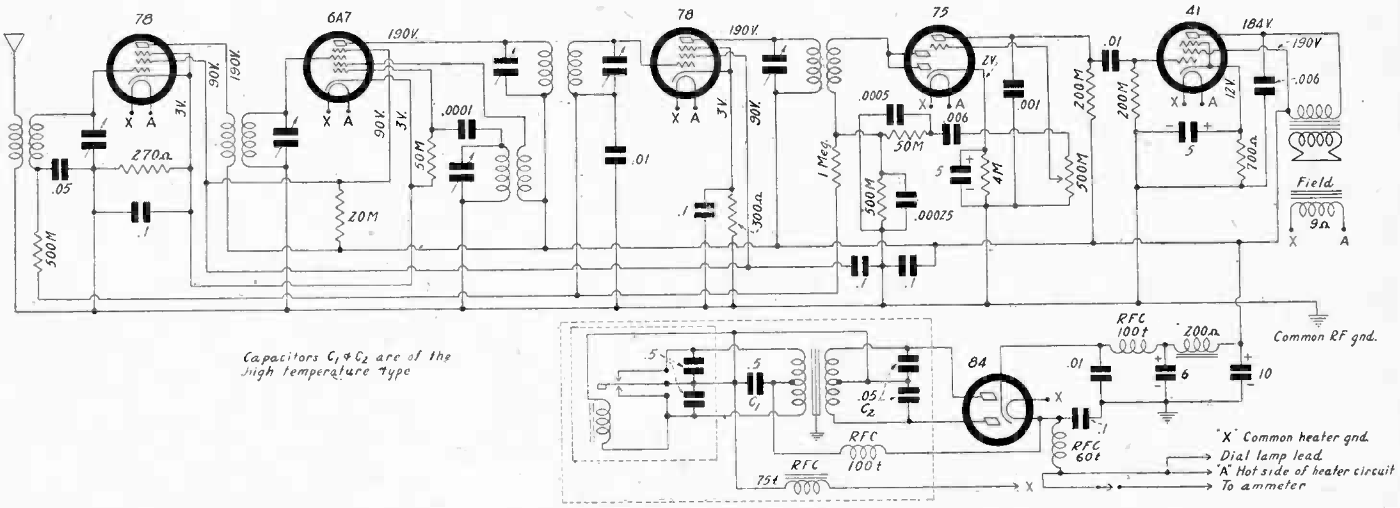


FIG. 1

The circuit diagram of a six-tube automobile superheterodyne, equipped with automatic volume control remote tuning control, and a vibrating type B supply.

HIGH sensivity is the most important characteristic in an automobile receiver, for without high sensitivity very little can be expected in a car. The pick-up is too small. A receiver may be entirely satisfactory in the home or the laboratory but a complete failure in the car.

Another important feature that an automobile receiver should have is an automatic volume control. This is essential because as the car moves about it will continually pass through regions of different field strength. The automatic volume control holds the output of the receiver practically constant even though the input may vary over wide limits.

As a means of obtaining a high sensitivity we have such tubes as the 78 for radio and intermediate frequency amplification, the 6A7 for oscillation and first detection, the 75 for diode detection and audio amplification, and the 41 for power amplication. Each one of these is most suitable for the purpose for which it is used.

A Six-Tube Auto Set

In Fig. 1 is shown the diagram of a receiver designed for automobile use in a logical manner. It contains six tubes in all. The first is a 78, which is used as a radio frequency amplifier. The second is a 6A7, which is used both for oscillation and frequency changing. The third is another 78, used as intermediate frequency amplifier. The fourth is a 75 duplex diode triode, used as a half-wave rectifier and as first audio amplifier. The fifth tube is a 41 pentode, used as power amplier. Finally, the sixth tube is an 84 rectifier. Every tube with the exception of the 84, is a high gain tube.

It will be observed that there are two r-f tuners in the circuit. Thus there is ample selection ahead of the first detector to suppress any image interference. The oscillator utilizes the third section of the tuning condenser and the inner elements of the 6A7. The oscillator is of the tuned grid type and has a stopping condenser of 0.0001 mfd. and a grid leak of 50,000 ohms.

Following the oscillator-detector is a doubly tuned intermediate coupler, and after that comes the second 78 amplifier. The second intermediate coupler is primary tuned only.

The manual volume control is placed in the grid circuit of the triode of the 75 and takes the form of a 0.5 megohm potentiometer. Note that the 75 is biased by means of a 4,000-ohm resistor and that the grid is isolated from the voltage in the load resistor of the diode. This arrangement is about the only one that is satisfactory when a high-gain tube like the 75 is used as detector and amplifier.

Automatic volume control is obtained by returning the grids of the two 78s to the negative end of the load resistance of the diode detector through a 1-megohm resistor.

Vibration Type Generator

The high voltage for the B supply is obtained through a vibrating interrupter and a step-up transformer. The vibrator is of the symmetrical type, or what might be called the full wave type. Thus the output of the rectifier is a symmetrical wave. The supply leads from the storage battery to the interrupter are well filtered to prevent radio-frequency components of the interruptions from straying into the rest of the set.

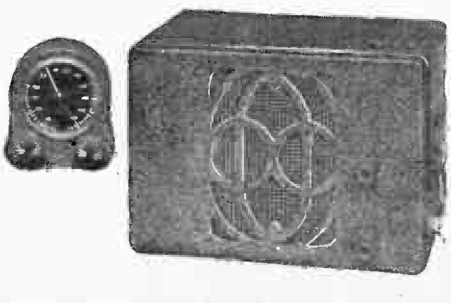
The 84 rectifier is also of the full wave type. As a means of removing some of the higher harmonics of the high voltage generated by the interruptions, a 0.05 mfd. condenser is connected between each plate of the 84 and the center of the high voltage winding. In the output of the rectifier is additional radio frequency filtering. The vibrator element is mounted inside an iron shield, and this box in turn, together with the transformer and filter chokes and condensers, is mounted inside another iron box. Thus there is thorough shielding and filtering from noise that might arise in the rectifier and vibrator.

Service Notes

The circuit diagram shows all the necessary resistance and capacity values for servicing the set.

(Continued on next page)

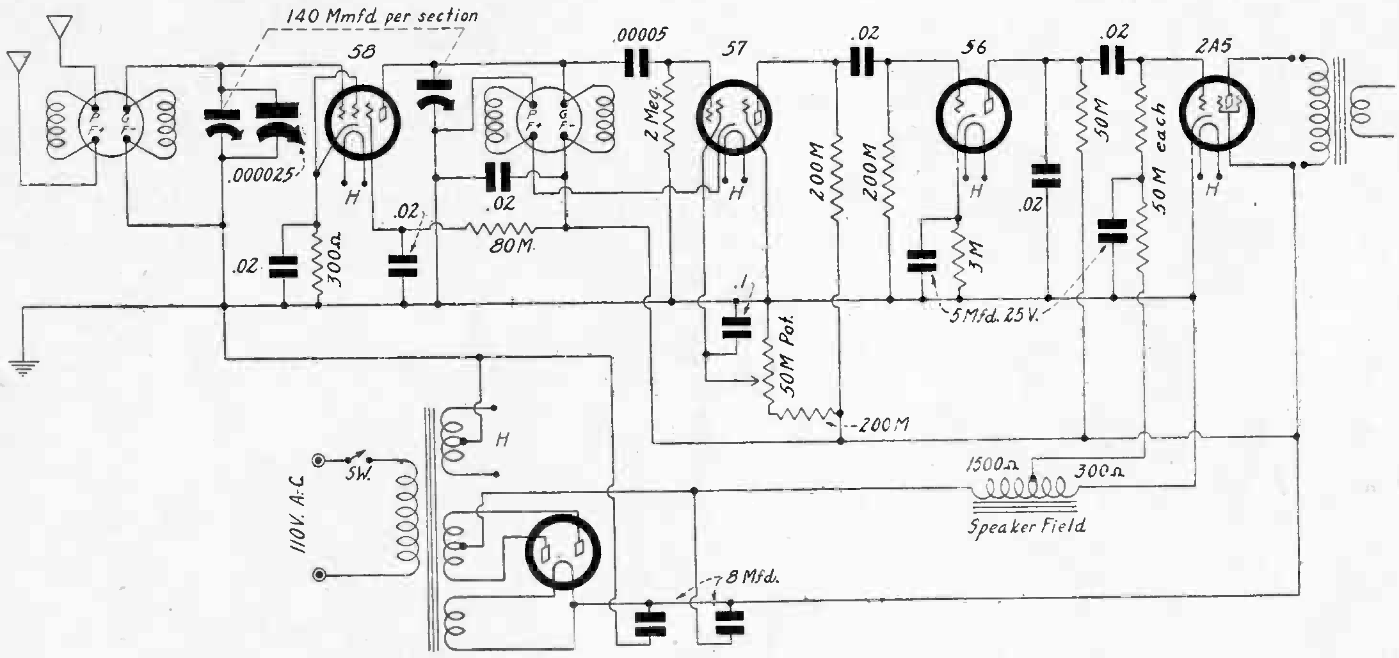
FIG. 2 Front view of the six-tube automobile superheterodyne, together with the remote control device at left.



A Short-Wave Midget

Plug-in Coils Used in Regenerative Set That Has Stage of T.R.F.

By Leo Sharon
Leotone Radio Company



A two-gang 0.00014 mfd. tuning condenser is used, with two plug-in coils for each band, total of eight coils for four bands, in this short-wave a-c receiver.

THE five-tube midget is giving satisfaction in thousands of homes. Judging by the huge number of final sales, this circuit is decidedly acceptable. That is for broadcast reception. How is it on the short waves? Will it perform on these waves also if it is provided with appropriate tuner? We do not have to guess as to whether it will perform on these waves, for all we need to do is to look at the results obtained.

When one of these short-wave midgets is set up in the laboratory it does pull the stations in, not particularly from the immediate locality but from across the ocean also. Just any afternoon they pick up English, German, French, Italian, Spanish, and other European stations. But Europe is not the limit by a long stretch, for even African and Australian stations come in. That's what the little set will do in the laboratory. The query is, Will it do as much in the home of the purchaser? Well, perhaps not, and perhaps much better. So much depends on the location of the home and on the antenna that has been erected for the short-wave set. And much depends on the tuning skill of the man who has bought it. The proof that the set is doing as well in the home, on the average, as it does in the laboratory is that the receivers are bought on demonstration and they stay sold.

Many short-wave receivers are battery operated because of the difficulties with hum in a-c operated circuits. But this midget is a-c and hum has been conquered. This fact would not be so remarkable were it not for the additional fact that the circuit is regenerative. It is not easy to eliminate hum from the output when hum exists around the set, when the circuit is regenerative.

Yes, the circuit is regenerative, but the fact is not at once obvious by looking at the diagram, Fig. 1. But note that the cathode of the second tube, the 57, is connected to the F+ post on the second coil socket. The P on that socket is connected to ground, and therefore the smaller winding is effectively connected in the plate circuit of the 57 and is in inductive relation with the tuned winding, which is in the grid circuit of the same tube. This feedback calls for control of some kind and therefore the screen, plate and cathode voltages are simultaneously controlled by the arm of the 50,000-ohm potentiometer.

This type of control introduces a minimum of frequency change during adjustment.

Adjustments for Auto Superheterodyne

(Continued from preceding page)

The intermediate frequency coils are peaked at 175 k.c. and are adjusted through the top of the tall cans by means of a small screwdriver and a 5/16 inch socket wrench. The chassis must first be removed from the cabinet and signal from test oscillator fed into grid cap of the 6A7 tube.

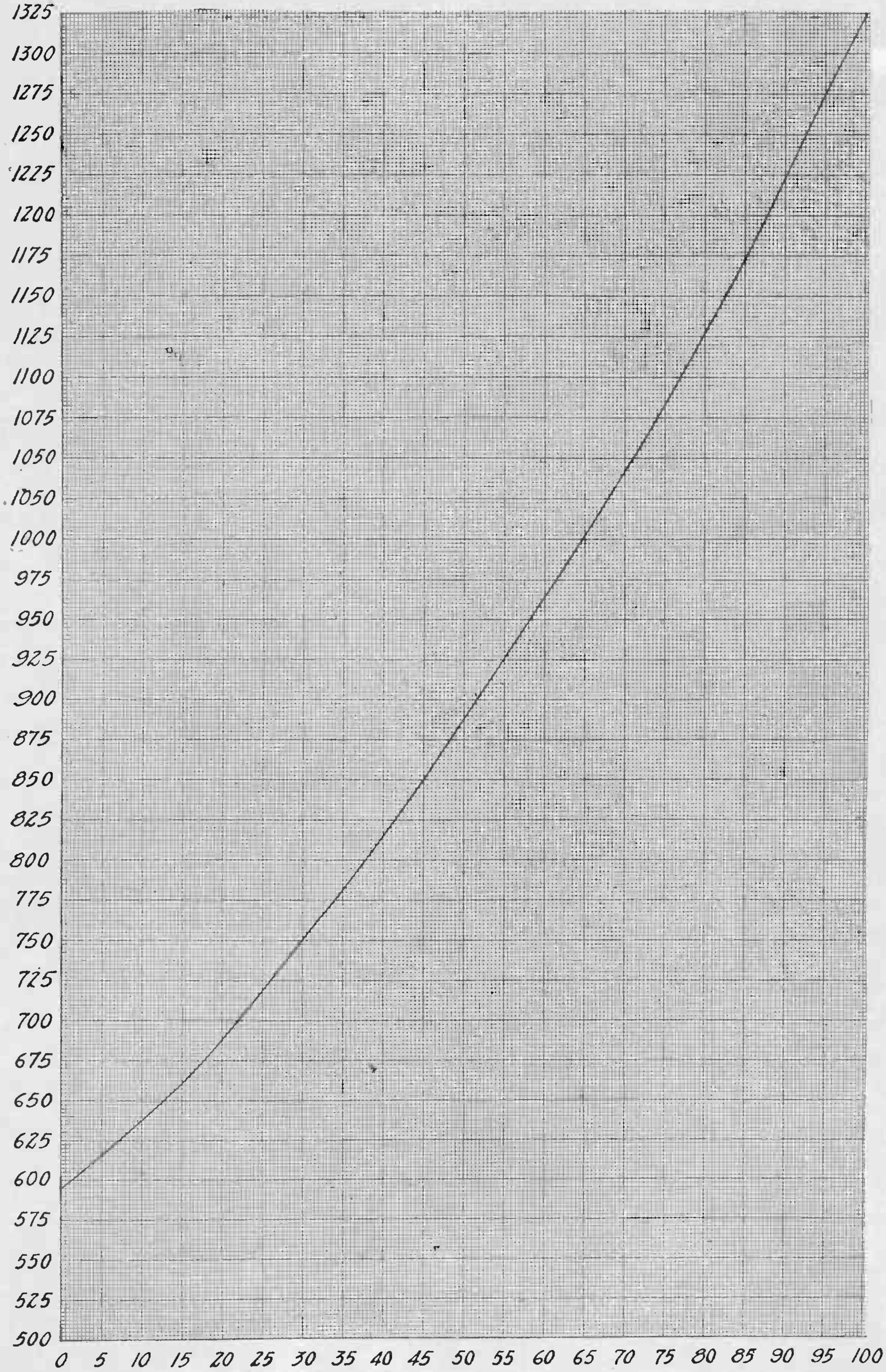
Balancing R-F Coils. The tuning control must first be attached to tuning condenser shaft with pointer set to 530 k.c. when tuning condenser is turned to maximum. Tune in a weak signal at its proper dial marking near 1400 k.c., and adjust first and second trimmers on variable from front of chassis for loudest signal. If the signal does not come at the proper dial setting, carefully adjust rear trimmer on variable to shift signal to its proper location and then readjust first and second trimmers. After re-installing set in the car, slightly readjust first trimmer through hole in top of cabinet.

The B supply requires little attention. The only two things likely to require any attention are the vibrator points and the rectifier tube. The tube is easily tested in the usual way. The vibrator should make a slight buzzing noise when it is operating properly. If this noise is not present, some fault has developed, and the set should then be taken to the dealer or to some other competent man.

The spark plugs on the car should be kept in good condition, for if they are fouled or improperly adjusted, not only will there be noise in the radio receiver but the car will not run as well.

This receiver takes all its power from the storage battery, which in turn gets it from the engine by way of the charger. Since more current will be drawn from the battery when the receiver is operated, more current must also be put into it, for otherwise the battery will run down. The charging rate must be adjusted to prevent this.

610 to 1,325 kc Chart for Bud 0.00014 mfd. and Large Alden Broadcast Plug-in Coil



Curves Show Frequencies Tuned In

This series of curves, being published weekly, relates the frequencies and dial settings of popular tuning condensers and plug-in coils, as used in an oscillator, the diagram of which was printed last week. For actual reception of stations there might be a slight difference in frequency from what the curves reveal, due to the difference occassioned by oscillation. However, in a regenerative circuit, which is the principal one used, the difference is negligible.

The Oscillator

The oscillator which was the basis of running these curves was built on a metal chassis and used without cover. If there is metal even within a few inches of the sides and tops of the coils the curves would be altered materially. If a set is built on a breadboard the curves will track closely with the receiver performance.

Many no doubt will want to build an oscillator, using any one of the condensers and any of the sets of plug-in coils, and then the device may be used as a station-finder in conjunction with a receiver, by loosely coupling the oscillator to the antenna when tuning for stations.

Coupling

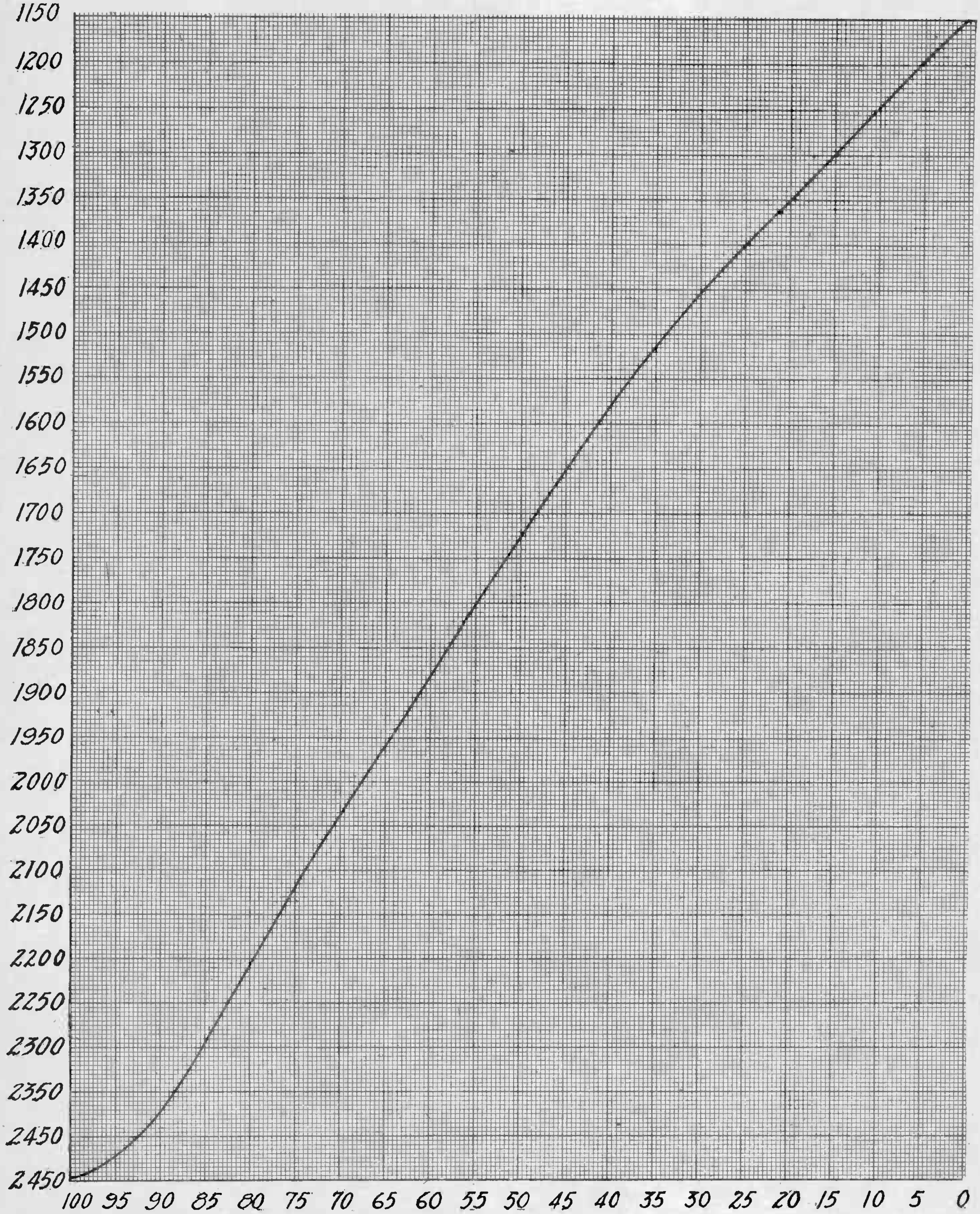
This coupling usually is sufficient if only a few turns of the insulated wire lead from the output of the oscillator are wrapped around the aerial somewhere near where it is connected to the set.

If the receiver is of the regenerative type, without t.r.f.. for the last or highest-frequency band, if regeneration is weak or fails, use only a few feet of wire indoors for areial, and results will be good.

Using the frame type of Bud condenser, not the single-hole panel mount type, the tuning curve obtained with the large broadcast plug-in coil made by Alden is as shown above. The circuit used for the test was printed last week, issue of June 2nd.

[***Last week's four charts gave the curves for the same Bud condenser and the Insuline plug-in coils. Other charts henceforth will give the frequency results using the Bud and other condensers, and all the popular commercial plug-in coils.***]

1,150 to 2,450 kc Chart for Bud. 0.00014 mfd. and Small Alden Broadcast Plug-in Coil



The broadcast band is completed, and some frequencies in the intermediate short-wave band are included in the above curve. If desired, one may remove turns from the secondary of this coil to reduce the overlap from 170 k.c. to 25 kc, so close to 1,300 kc would be the low end, and 2,770 kc the high.

Radio University

By-Pass Condenser Value

AFTER the detector it is usual to have a condenser for by-passing the radio frequencies. I am informed that if there is a high resistance load on the plate circuit that the condenser may be small, and in general a value around 0.0001 mfd. to 0.00025 mfd. may be used. This is for broadcast frequencies. Is there any difference for short waves?—K. C.

There is no difference for short waves, as the audio frequencies are the same, and the by-passing relates to them. The higher the carrier frequencies the better they are by-passed by a given capacity, but the attenuation of audio frequencies is no greater for the short waves than for broadcast or lower frequencies.

* * *

Noise Level

WHAT determines the noise level of a receiver and what is the relationship between noise level and reception?—J. C. S.

The noise level is determined by all reproduction not occasioned by the modulation of the desired carrier. Hence it includes all the extraneous sound, such as that due to noise from tube activity in the receiver, and static of both natural and man-made types, as well as any hum in a-c sets due to inadequate filtration. The higher the noise level, the stronger the desired signal has to be to overcome it sufficiently to make reception clear. Therefore the noise level is highest in receivers of greatest sensitivity, but means are provided for reducing the sensitivity, and this is usually a form of volume control placed ahead of the detector particularly, although the general rule holds no matter where this control is placed, as audio-frequency amplification increases the sensitivity just as much as an equally gainful radio-frequency or intermediate-frequency amplifier. At higher than audio-frequencies, however, the highly-sensitive tubes are subject to modulation by the noise due to electron bombardment, and particularly at very high frequencies this bombardment may be pronounced, due to the extreme velocity of the electrons and the high potential difference between elements of the tube. Therefore attenuation of amplification at radio-frequencies acts more substantially in noise-reduction than than does audio-frequency amplification. The tube noises, so-called, are ascribed to the shot effect, or uneven emission. So, the desired end is to keep the signal-to-noise ratio high, or the noise-to-signal ratio low, and various means are used, including special noise-reducing antenna systems, where the pick-up put into the set is that from the antenna proper, all or practically all pick-up killed between antenna and receiver by use of a special type of lead-in, known as a transmission line. This may consist of transposed lead-in or two concentric hollow copper tubings, one inside the other, which, though awkward and expensive, represent the best form of a transmission line for radio frequencies, because there is no radiation from such a system, hence no pick-up, when one of the tubings is grounded. This is usually the outside one.

* * *

Effect of Automatic Volume Control

HAS automatic volume control the effect of a eliminating fading, and if so is it not a requisite in a short-wave set, where fading otherwise might be extremely bothersome?—U. D. C.

Automatic volume control does correct somewhat for fading, but cannot be described at all as a cure for fading. The general system of a. v. c. consists of having the signal control the bias on tubes ahead of an audio-frequency detector, by rectification of the carrier to produce D. C. voltage for bias. Thus with a linear detector the bias is directly proportional to the carrier amplitude. However, the controlled tubes are not linear, and therefore a linear variation of bias does not create a characteristic linear with carrier intensity. In fact, the controlled tubes must have a remote cutoff, that is, be of the type where the current through the plate circuit changes gradually with comparatively large changes in bias. Nevertheless, the higher the carrier amplitude, the greater the negative bias, the less the amplification, hence the tendency toward leveling. Another factor to consider is that all a. v. c. is at the expense of sensitivity, therefore not all receivers profit greatly by inclusion of a. v. c., despite the theoretical advantage. Besides, to prevent the drain on sensitivity from being too great, sometimes delay is introduced, meaning that the circuit in the a. v. c. detector is so constituted that not until the carrier attains a certain value does any rectification, hence any application of a. v. c., take place. This means that for low carrier intensities there is no a. v. c. whatever, hence if a signal is inherently weak, though fading from weakness practically to silence, then coming up to weak reception again, no benefit from any a. v. c. whatever is attained. In general, for tuned-radio-frequency and regenerative sets, even of the shortwave type, a. v. c. is not recommended, because there isn't the sensitivity to spare. For highly-sensitive superheterodynes for short-wave reception it has a decided advantage.

* * *

Disclosure of Messages

IS THERE any reason why I cannot discuss with my neighbors conversation that I heard from ship to shore, when listening to my short-wave set?—K. D. C.

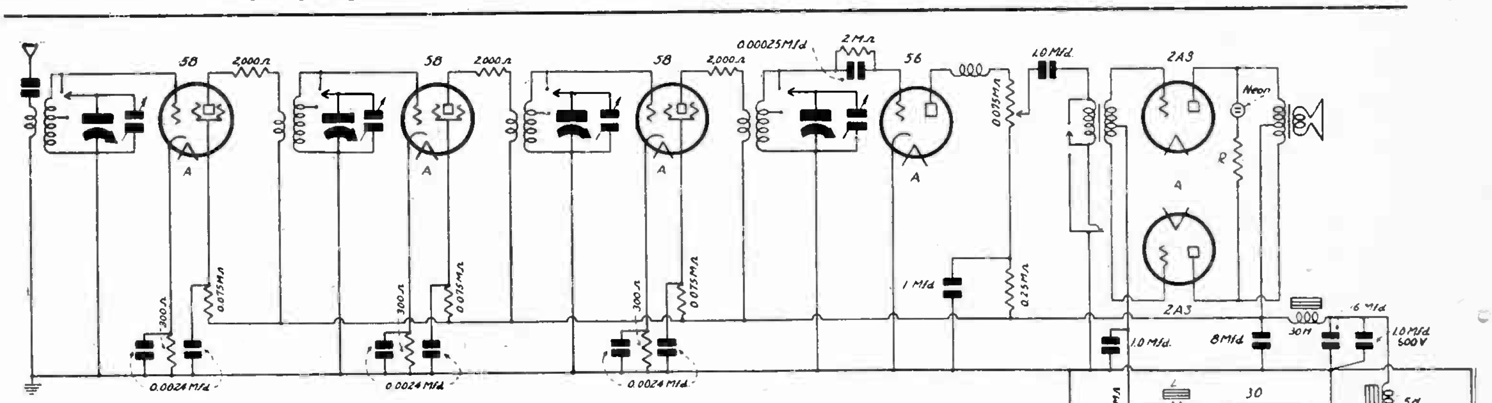
Yes. There is a Federal law in the United States prohibiting the revelation or discussion of what is heard, with some exceptions, but commercial message service is not one of these exceptions, nor are communications of the Army or Navy.

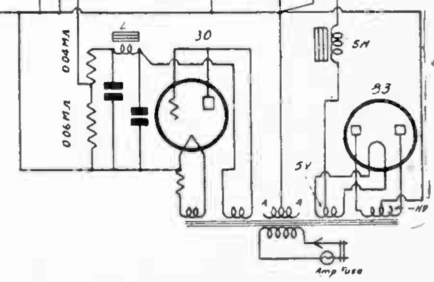
* * *

The Decibel

WHAT IS the decibel attenuation notation, and how does it apply to a short-wave receiver?—H. C.

The decibel rating is a substitution for the attenuation or lose in standard cable of telephone practice, and discloses how much the loss is, on a basis somewhat comparable to the sensitivity curve of the human ear. Roughly, one decibel is the smallest difference in power ratio that the human ear can detect. The fundamental unit is the bel, named for George Graham Bell, inventor of the telephone, but is too large for general practice, hence one-tenth bel, or decibel, is used. The comparison relates largely to audio-frequencies, hence is applicable to an audio amplifier, and not always associated directly with the tuner. However, certain extensions have been proposed for including the tuner, for instance, that selectivity may be rated in decibels down, for given values of frequency removed from the resonance point, in the absence of any other method of stating selectivity numerically. General sensitivity measurements at radio frequencies sometimes are based on the decibel system, but some of the uses of the decibel notation are perhaps a bit reckless. Some datum has to be assigned for the db use, but there is no standard. It is customary to state that is the power level used as datum, and this would be related sensibly to the system being measured.





Two-band coverage, using a switch. Note that the same primary is used. This necessitates a compromise, and results are not of as high an order as they would be if the primary impedance were different for each of the two bands.

Common Primary

WILL YOU kindly let me know whether it is satisfactory to cover two bands, say, 1,600 to 4,800 and 4,800 to 14,400 kc, using a switch system, common primary, and tapping the secondary once?—H. D.

It is permissible to do this as an expediency, but in that instance it must be definitely understood that of the two bands much better results are to be required in one than in the other. This is true because of the common primary, which is selected for better service in the preferred band, and cannot be equally effective in both. There will be reception in the other band, but not of comparable importance.

An Audio Amplifier

With Power Supply, Volume and Tone Controls Built in

By Eugene Penzien

Mannion Radio Laboratories

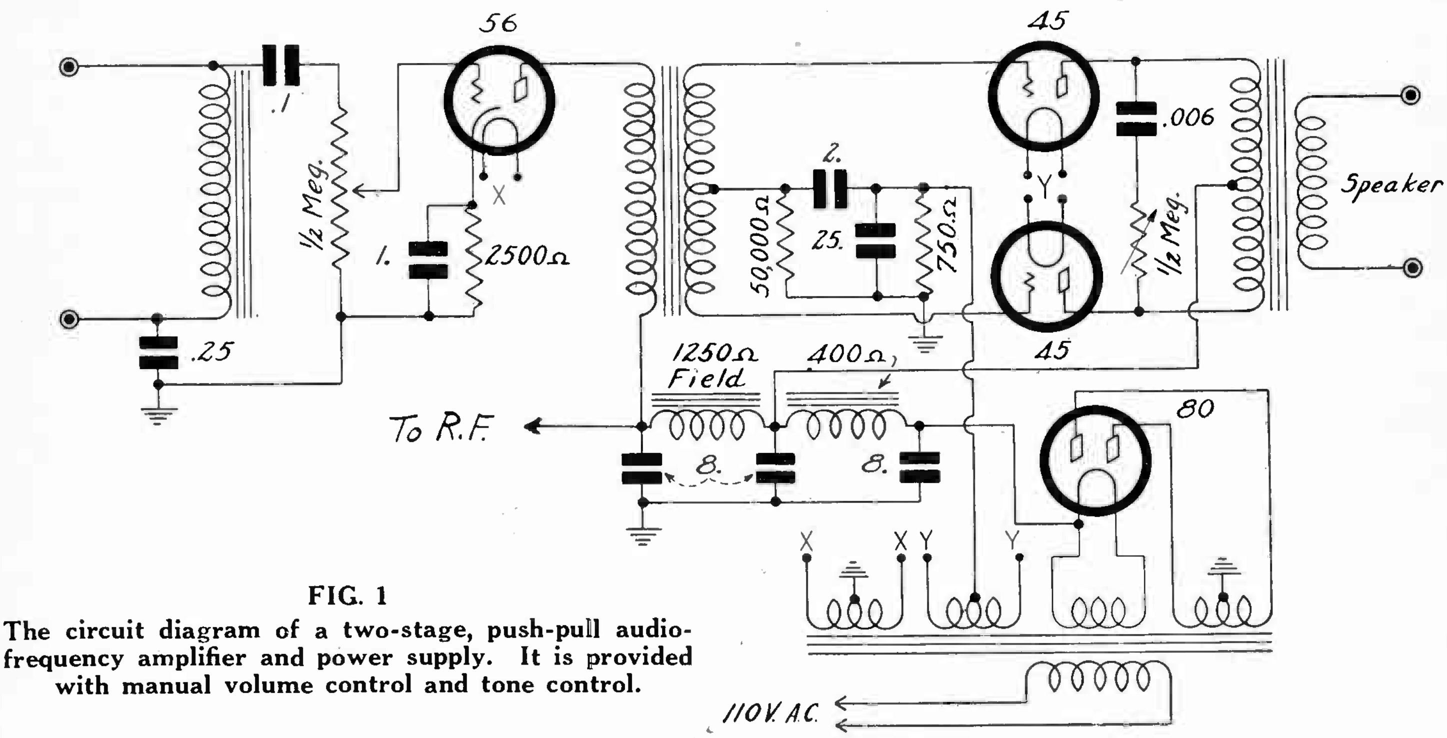


FIG. 1
The circuit diagram of a two-stage, push-pull audio-frequency amplifier and power supply. It is provided with manual volume control and tone control.

IT IS not often that one sees amplifiers built with such care and skill and good judgment as the one we are about to present. The assembly of the amplifier, which is depicted on the front cover, is a work of art, as near as a piece of mechanism can be a work of art. The wiring of the amplifier, as it is viewed from the bottom view of the chassis, is a work of art without any modification, for skill and good judgment have resulted in a pleasing combination. For all that, it is none the less utilitarian. It is correct technically.

Good assembly, layout and wiring are not suffiicent in an amplifier. There must also be a good circuit. But in this respect also the amplifier scores high, as is evidenced by the circuit diagram in Fig. 1. We have a stage of push-pull using 45s, about as good tubes as can be used for this purpose in a small audio-frequency amplifier; and preceding this we have a single-sided amplifier using a 56, the best tube available for the combination.

Coupling

Between the single-sided stage and the push-pull stage we naturally will have a push-pull input transformer, for there is no other satisfactory way of going from single to push-pull amplification. Indeed, we have no other choice. That does not mean that we are not free to choose the coupler. Not at all, for there are push-pull audio input transformers of all grades. As a rule, the more expensive a transformer is, the better is its performance in respect to quality, but this rule is good only if the transformer is obtained from a reliable house.

Between the source of the signal, which probably is a detector, is a direct coupler consisting of an audio-frequency choke coil, a 0.1 mfd. stopping condenser, and a half-megohm potentiometer. The main consideration in choosing a choke is that it have a high inductance and low distributed capacity, for there must be a high inductance if the low notes are to be amplified and the distributed capacity must be low if the high notes are to be amplified. The 0.1 mfd. stopping condenser is large enough for the transmission of the lowest notes that are likely to occur in the signal, especially in view of the fact that in series with this condenser is a half-megohm resistor. The audio choke, incidentally, may be the secondary of an audio transformer.

The output transformer, of course, is a part of the loudspeaker and is not represented on the assembly as it appears on the front cover. The specifications of the speaker are that it should be wound for two 45s in push-pull and have a field coil of 1,250 ohms, the field being used as one of the filter chokes in the B supply.

LIST OF PARTS

Coils

One power transformer.
One 400-ohm, heavy-duty filter choke.
One push-pull input transformer.
One high-inductance audio choke (about 100 henries).
One dynamic speaker with 1,250-ohm field and transformer for two 45s.

Condensers

Three 8 mfd. electrolytic, 575-volt condensers.
One 25 mfd. electrolytic, low voltage condenser.
One 2 mfd. condenser.
One 1 mfd. condenser.
One 0.25 mfd. condenser.
One 0.1 mfd. condenser.
One 0.006 mfd. mica condenser.

Resistors

One half-megohm potentiometer.
One half-megohm variable resistor.
One 2,500-ohm bias resistor.
One 750-ohm bias resistor.

Other Requirements

Three four-contact sockets.
One five-contact socket.
Seven binding posts.

Filtering

It is clear that the filtering in the circuit is very good. First we have three 8 mfd. electrolytic condensers in the B supply filter and two chokes. The first choke has a resistance of 400 ohms so that the voltage drop in it, although the total current flows through it, is not large. Through the second choke, that is, the field coil of the speaker, all the currnt flows with the exception of that to the push-pull tubes. Thus the current in the field is not exceedingly large. As the circuit is drawn only the current to the 56 flows through the field. This, of course, would not be nearly enough and additional current must be drawn through the field. This current is drawn by the radio frequency portion of the receiver as indicated by the arrow. This leads to an insulated binding post on the chassis and as there is another grounded post on the chassis connections to the radio amplifier is a simple matter. In the event the amplifier should be used with a phonograph pick-up independently of the radio receiver, the extra current can be drawn by connecting a variable resistor across the binding posts and adjusting its value until the right current is drawn. The extra current required is about 50 milliamperes.

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A DeLuxe Audio Power Amplifier

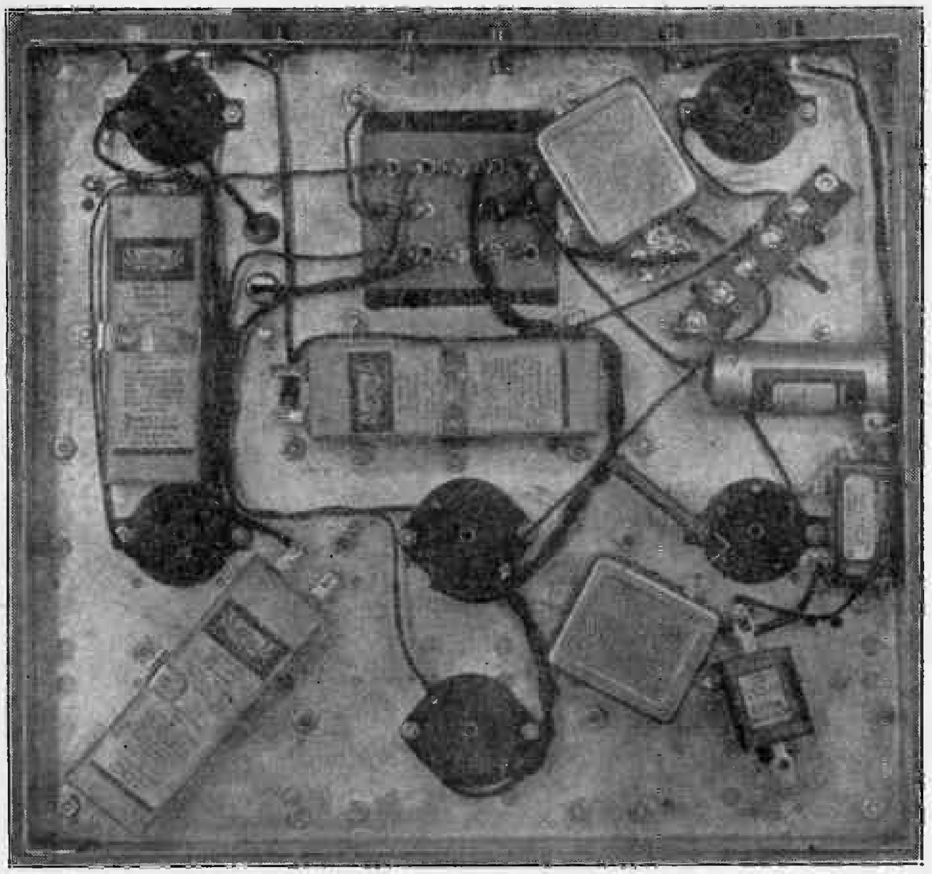


FIG. 2
Bottom view of the amplifier in Fig. 1 showing the layout of the smaller parts and the wiring.

(Continued from preceding page)

The grid return circuit of the push-pull amplifier is particularly well filtered. First we have a 25 mfd. electrolytic condenser across the 750-ohm bias resistor. Then we have a 2 mfd. condenser from the center of the secondary of the push-pull input transformer to the center of the filament winding serving the 45s. A 50,000-ohm resistor is connected from the center of the secondary to ground as an aid in the filtering. This thorough filtering is particularly advantageous on the low audio notes.

Biasing

The 0.25 mfd. condenser from the plate return of the detector (not shown) to ground is for the purpose of by-passing radio frequency currents as well as to prevent feedback which might either render the amplifier inefficient or oscillatory on certain notes. The one microfarad across the bias resistor on the 56 serves, of course, to prevent reverse feedback.

The 56 is biased by means of a 2,500-ohm resistor in its cathode lead. The tube draws a current of 5 milliamperes when the plate voltage is 250, the grid bias is 13.5, and the heater voltage is 2.5 volts. The 2,500-ohm resistor makes the bias about 12.5 volts, which is sufficient. The two 45s are biased by a single 750-ohm resistor between the center tap on the filament winding and ground.

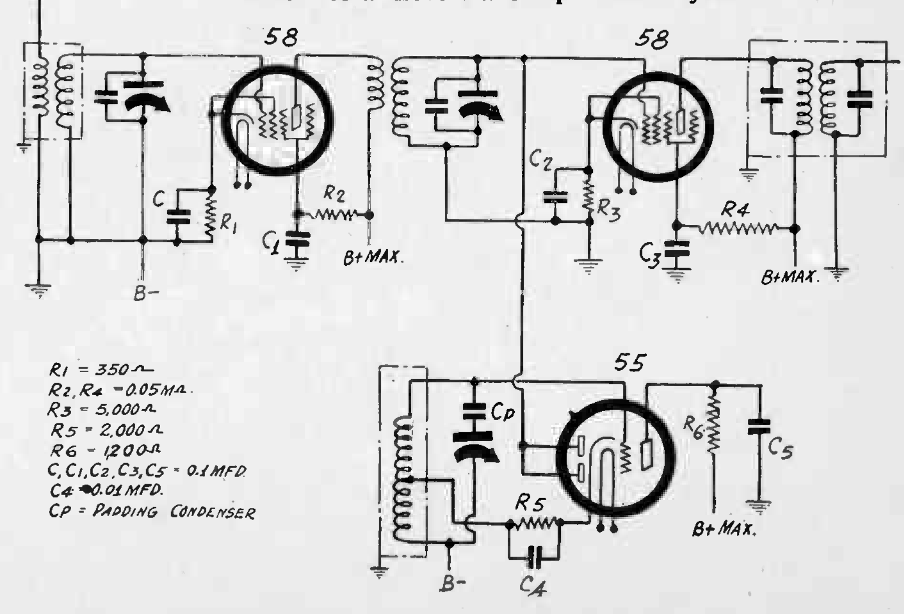
Has Tone Control

The largest of the transformers shown in the picture on the front cover is the power transformer. It has one 5-volt winding for the 80 type rectifier tube, one high-voltage centertapped winding for the plates, and two 2.5-volt windings, both centertapped, for the filaments of the amplifier tubes. Winding XX serves the 56 and winding YY the two 45s.

The amplifier is provided with a tone control consisting of a condenser of 0.006 mfd. in series with a variable resistor of one half megohm, the combination being connected from plate to plate of the output stage. By setting the resistor at a low value, a large part of the high frequency output can be eliminated.

Mixer for a Short-Wave Superheterodyne Uses Tube Capacity for Coupling

One method of coupling between modulator and oscillator in a short-wave superheterodyne is to use a very small capacity, principally one that does not change. Such a capacity may be attained nicely by using the paralleled diodes of a 55 tube. The triode of the 55 is used as the oscillator. The diagram represents a Hartley oscillator of the cathode-biased type. C4 may have to be reduced in capacity, perhaps even to 0.0005 mfd., or less, if there is audio oscillation due to the R5-C4 combination. The three coils may be of the plug-in type, the antenna and modulator wound for each band. The winding may coils regular, the oscillator coil specially have the same inductance as the two other coils for the highest and second-highest frequency bands. For the two lower frequency bands the inductance for the oscillator is less, and the series condenser Cp. used for padding, has to be different for each of these two bands. In general, for the lowest frequency band (intermediate short waves) Cp normally would be around 0.001 mfd. and for the next band around 0.002 mfd., if the tuning condensers are 0.00014 mfd.



A mixer for a short-wave superheterodyne.