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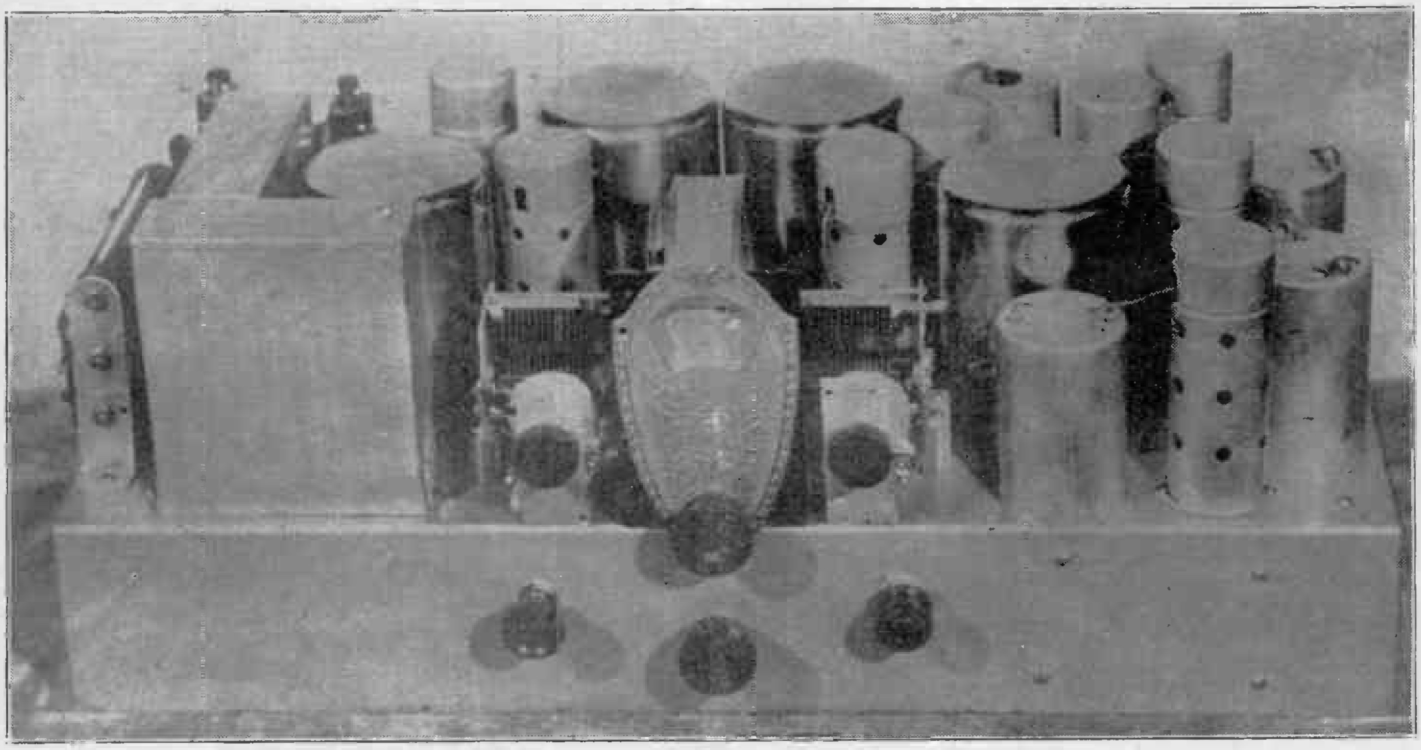

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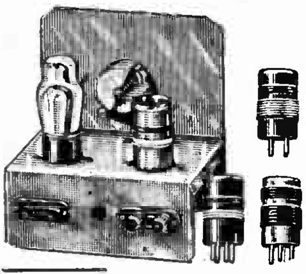

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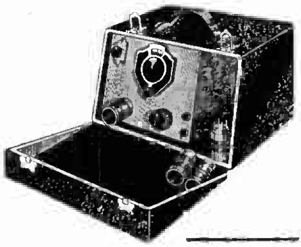

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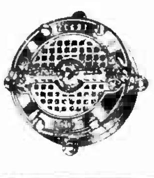

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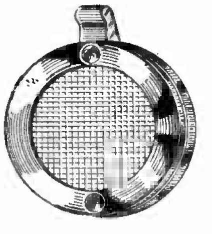

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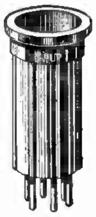

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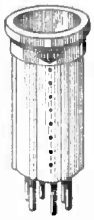

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The First National Radio Weekly
THIRTEENTH YEAR

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Vol. XXV JULY 14th, 1934 No. 18. Whole No. 642

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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Tube "Constants" Vary

Nothing Stays Put, Not Even the Mu

By Einar Andrews

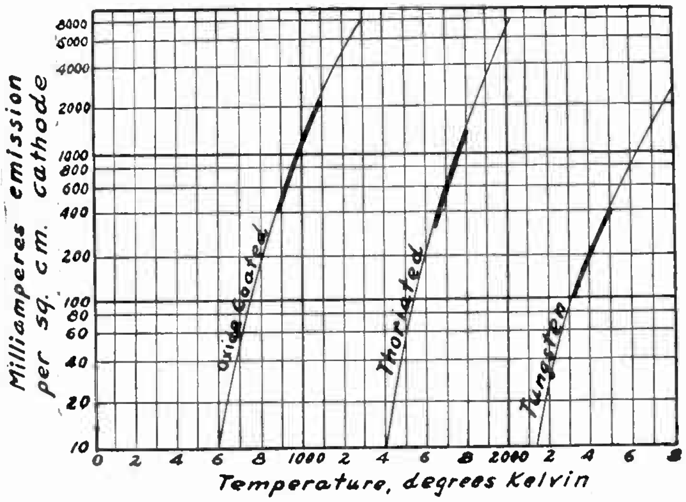

FIG. X-I (above)
Variation of emission with temperature.

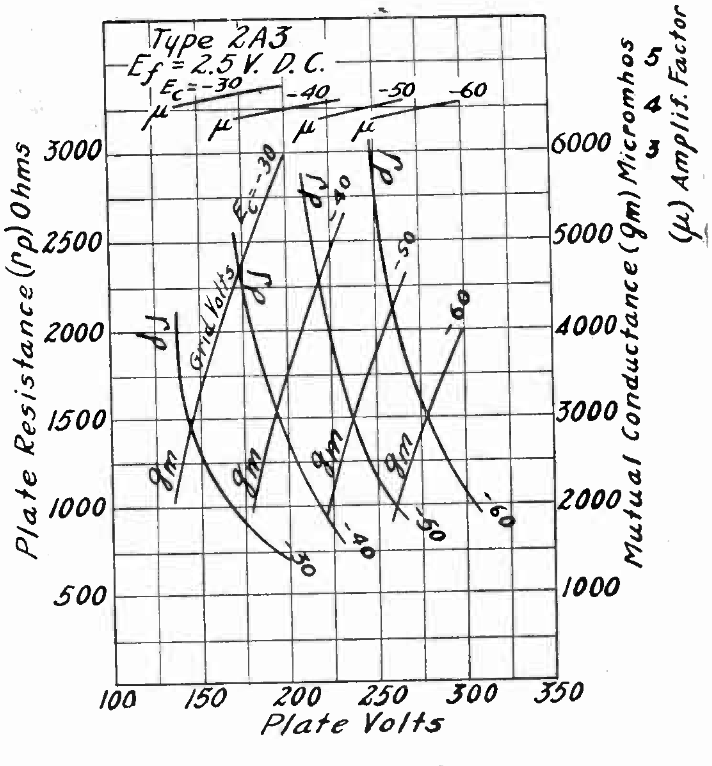

FIG. X-11 (right)
Magnitude of changes in the amplification factor.

THE value of thermionic vacuum tubes as amplifiers and detectors depends on the emission of electrons from the heated cathode. The increase in the emission is very rapid as the temperature increases. Considering the fact that the filament current, which determines the cathode temperature, may vary appreciably during operation, it is clear that the emission efficiency, and hence the effectiveness of the tube, will vary also. Just what the emission will be at any given temperature is illustrated in Fig. X-1, which gives the emission from each square centimeter of heated cathode surface in milliamperes for three different emitters and for different values of absolute (Kelvin degrees) temperature. The three emitters are pure tungsten, thoriated tungsten, and oxide-coated metal. It will be noticed that on each curve there is a heavy section. This represents the practical operating range.

A large divergence is noted in the emission efficiency of the three substances. Thus the pure tungsten cathode will give an emission of 200 milliamperes per square centimeter when the temperature of the emitting surface is 2,400 Kelvin, the thoriated tungsten will give 600 milliamperes when the temperature is only 1,700 Kelvin, and the oxide-coated emitter will give about 1,250 milliamperes when the temperature is 1,000 degrees Kelvin. Of the three the oxide-coated emitter is vastly superior.

Emitters Compared

The difference in the temperatures of the three cathodes at the practical operating conditions is easily seen in the luminosity of the surfaces. Thus the tungsten filament is brilliant white, the thoriated tungsten filament is bright yellow, while the oxide-coated emitter is dull red. Because of the feeble glow of the oxide-coated surface at the correct operating temperature, this is often called the dull emitter.

(*Continued on next page*)

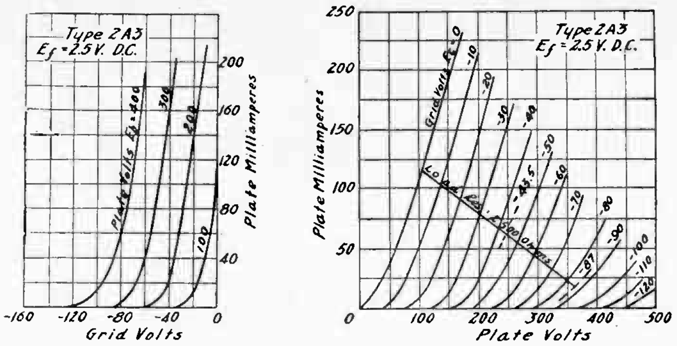

FIG. X-3

Plate current-grid voltage curves. Four curves are shown for different plate voltages as indicated.

(Continued from preceding page)

The steepness of the three curves in Fig. X-1 shows the great rapidity with which the emission increases as the temperature increases. This means also that the emission increases rapidly with the filament current. There is little difference among the three emitters in this respect, for the three curves run practically parallel. The great advantage of the oxide-coated filament is that the emission is high for a low heater current, that the emitter is very efficient.

Regardless of the type of emitter that is used, it is clearly important that the filament current, or voltage, should be held as constant as possible, for changes in the emission will cause changes in the operating characteristics of the tube. It is easier to hold a low temperature constant than a high one, a fact that favors the oxide-coated emitter.

The filament will also last longer when it is operated at a low temperature than when operated at a high temperature. If the oxide-coated filament has been made and treated properly it will last many thousand hours, whereas a tungsten or a thoriated tungsten filament might not last more than one thousand hours. Even in this respect the oxide-coated filament is superior.

Possible Damage

If the heater current is excessive permanent damage will result to all the emitters. The pure tungsten filament is operated close to the fusion point of tungsten, which is 3,000 degrees Centigrade, and therefore if the current should be a little high the filament might burn out. There is no comfortable margin of safety. The thoriated filament, also, is easily damaged by excess current. While in this case there is comparatively little danger of burning out the filament, there is danger of evaporating the thorium atoms which cover the surface of the metal and which make the emission efficiency high If this should happen it is sometimes possible to restore the tube by "reactivation," a process of forcing the absorbed thorium atoms to the surface to form a new active layer. In case the heating current is excessive in the oxide-coated filament, the active coating will crack and fall away from the supporting wire. This, of course, will ruin the tube without leaving any way of restoring it to usefulness.

Constants of a Tube

We are wont to speak of the "constants" of a thermionic tube when we really mean its variable characteristics or properties. It has no constants. We have just found that the emission varies with filament temperature, yet this is not the only variation in the emission. If it were, we could hold the emission reasonably constant by holding the heating current constant. There is also a variation due to the gradual exhaustion of the emissive power, and it is this variation that ultimately determines the tube's usefulness.

The one property of the tube that might be called a constant is the amplification factor, μ, for this is supposed to be a geometric property. But it is not strictly a constant, and for two reasons: first, the geometry of the tube does not remain fixed, due to stresses and temperature changes; second, it is not strictly a geometric property, even if allowance is made for the changed geometry. It is true that the changes in the amplification factor are small, yet they exist. The magnitude of these changes is illustrated in Fig. X-2. At the top of the figure are four short curves giving the measured values of the amplification factor as a function of the voltage on the plate for four different grid voltages. Thus if the grid voltage is held constant, the amplification factor varies as the plate potential varies; and if the plate potential is held constant, it will vary as the grid bias. The mean value of the amplification factor is about 4, but it may assume values approximately 20 per cent. higher or lower than that.

Not only does the amplification factor vary with the potentials of the elements of the tube, but it varies with frequency. However, the effect is not noticeable until the frequency becomes very high—in the so-called ultra-high frequency band—and then it is no longer a real number, mathematically, but complex. Practically this means that the tube causes a change of phase of the signal as well as a change in the magnitude of the signal.

Internal Resistance

The internal plate resistance of a tube is often thought of as a constant, but, of course, it is not fixed in value. Indeed, it varies very much, as is clearly shown by the resistance curves in Fig. X-2, those marked r_p. The variation is large for the lower plate voltages but decreases as the plate voltage increases. Since the curves are different for different grid bias values, it is clear that the resistance also varies with the grid bias.

The transconductance (g_m) varies in a manner similar to that of the plate, but in the opposite direction. That this should be so is clear from the fact that the transconductance, the internal plate resistance, and the amplification factor are connected by the relation, $g_m = \mu/r_p$.

Mutual Characteristics

The transconductance is a mutual figure of merit of a tube, that is, it tells what the change in the plate current will be for a change of one volt in the grid potential. The practical interpretation of the transconductance is the slope of the grid voltage, plate current characteristic. Four curves showing the relation between the plate current and the grid voltage are given in Fig. X-3 for four different plate voltages as indicated. The curves are very steep, suggesting the fact that the transconductance is very high for the tube in question.

Three of the curves are not plotted for all negative values of the bias because the plate currents for the lower bias values would be very large. The cessation of the curves does not mean that the plate current continues to rise at the same rate as it does just preceding the end of the curves. At a certain value of current the curves will begin to bend toward the right, that is, saturation will set in.

Push-Pull Amplifier of Radio Frequencies

When ultra-high radio-frequency signals are to be amplified it is usually advantageous to employ push-pull, for with such an arrangement the gain will be greater and the stability of the circuit will be better. A push-pull amplifier utilizing a couple of 30 tubes for gain and another for detection is shown here. The coil L is coupled to the antenna in the usual manner, that is, by means of a small inductance. The voltage that is developed across the coil and the condensers is divided equally between the two tubes by means of two equal condensers across the coil.

On the output side of the push-pull stage the signals from the two tubes are combined in the usual push-pull fashion. Both tubes contribute equally to the signal in the second tube circuit, which is the input circuit to the detector.

It may be pointed out that an arrangement of this type is suitable for a direction finder. L in this case is a loop and the two condensers are not only used for tuning but also for balancing out the capacity effect, or antenna effect, of the loop. The detector in this case makes the circuit suitably sensitive for the purpose of direction finding.

Practical Padding

As Applied to All-Wave Supers

By J. E. Anderson and Herman Bernard

(The following is an instalment of "The Short-Wave Authority" and deals particularly with tracking. Previous instalments dealt with the history, development and refinement of short-wave radio. Future instalments will include constructional articles for short-wave devices, particularly receivers.—EDITOR.)

While the curves in Figs. IX-4 and IX-7 apply directly only to broadcast frequencies, they can be applied to higher frequencies under certain conditions, and with some modification. The first requirement is that the frequency ratios be maintained. Suppose that we wish to pad an oscillator covering the range of frequencies from 1,500 to 4,090 kc, a band having the same ratio as the broadcast band. For this high frequency band an intermediate frequency of 465 kc is suitable. What is the corresponding intermediate frequency in the broadcast band if the same frequency ratio is maintained? By simple proportion we find that it is 170.5 kc.

From the inductance curve in Fig. IX-7 we find that L_o is 193 microhenries, but that is only when the inductance in the radio-frequency circuit is 245 microhenries. Without doubt, the inductance will be much lower in the high-frequency circuit than in the broadcast circuit. But whatever it may be the ratio of the oscillator to the radio frequency inductance will be the same, namely, 193/245.

The padding capacity, Cs, can be found in a similar way. At 170.5 kc on the curve we find Cs = 900 mmfd, which would be the series-condenser capacity if the tuning capacity in the high-frequency circuit were the same as in the broadcast circuit. It is probable that it will be smaller, and therefore Cs will be smaller, but the same ratio will obtain. Suppose that the capacity in the high-frequency circuit is 140 mmfd. and that in the broadcast circuit 350 mmfd., at the corresponding frequencies. Then Cs in the high frequency circuit would be (140/350) 900 mmfd., or 360 mmfd.

In exactly the same way the minimum capacity Cm can be obtained. From the curves we have Cm = 4.4 mmfd., which is correct only when the inductance in the circuit is 245 microhenries. If it has some other value so that the capacity ratio is 140/350, as in the case of the series condenser, the actual value of Cm in the high-frequency circuit is 4.4 x 140/350, or 1.76 mmfd.

It is of little importance whether the values of Cm and Cs are obtained accurately or not. All that it requires is that condensers used should be adjustable to the values required, that is, that they should have the right range. The inductance should be known more accurately, and the value obtained for it by the method just described is more accurate than the values obtained for the condensers.

When the method of equal ratios is used for determining the padding constants for a high-frequency circuit, the tie-down frequencies will also be determined on the same principle. For example, the three tie-down frequencies in the high-frequency band will be 1,636, 2,727, and 3,950 kc, for these occupy the same relative positions in the high-frequency band as 600, 1,000, and 1,450 kc do in the broadcast band.

Decreasing Need for Padding

The curves for Lo, Cs, and Cm show clearly that as the intermediate frequency decreases relative to the signal frequency, the need for padding decreases. Thus as the ratio of the intermediate frequency to the signal frequency decreases to zero, Cm approaches zero, Cs increases indefinitely, and Lo approaches L, the inductance in the radio frequency circuit. These facts show that if the intermediate frequency is held constant and the signal frequency is increased, as is done in short-wave sets, the need for padding becomes less and less pressing.

There is another reason why padding becomes less important as the frequency of the signal increases, the intermediate being held constant, and that is that the frequency coverage is less. For example, instead of having a tuner that covers a ratio of 3-to-1 a tuner covering only 2-to-1 is often used. The reason for this smaller coverage is that tuning becomes less critical and difficult. Even with this relatively narrower band the absolute width of the band is greater, which may be verified by a simple test. Suppose, for illustration, that the broadcast band goes from 500 to 1,500 kc, a relative difference of 3-to-1 and an absolute difference of 1,000 kc. Now take the next band, from 1,500 to 3,000 kc. This has a relative difference of only 2-to-1, yet it has an absolute difference of 1,500 kc. It is because of the rapidly increasing absolute differences that the relative differences are decreased, and this for the purpose of facilitating tuning at the higher frequencies. It is fortunate that this reduces the necessity for exact padding.

Padding by Simple Method

For the higher frequencies the padding constants may be worked out by the simple method (Case I.) provided that the intermediate frequency is not excessively high. For illustration let us work out the padding for a tuner in which the tuning range is from 1,500 to 3,000 kc and the intermediate frequency is 465 kc. At the high frequency end, 3,000 kc, the series capacity has no appreciable effect, and Cm is assumed to be zero. The oscillator frequency must be 3,465 kc. Therefore the inductance in the oscillator circuit must be $Lo = L(3{,}000/3{,}465)^2$, or 0.75L, where L is the inductance in the radio-frequency circuit. At 1,500 kc the oscillator must generate a frequency of 1,965 kc, and this requires that the capacity in the oscillator circuit be 8,740/L. But the variable capacity in the radio-frequency circuit at 1,500 kc is 11,230/L. Therefore Cs = 39,400/L.

We have now obtained the inductance and the series capacity in the oscillator in terms of the inductance in the radio-frequency circuit. To obtain actual values we have to fix the inductance in the radio-frequency circuit. Let us start by assuming that the tuning capacity of the radio-frequency circuit, and hence of the oscillator, is 140 mmfd. when the circuit is tuned to 1,500 kc. According to these assumptions the inductance in the radio-frequency circuit must be 80.3 microhenries, which entails that the inductance in the oscillator should be 60.3 microhenries and that the value of Cs should be 490 mmfd.

Padding at Higher Frequencies

By way of comparison let us find the padding constants at the next frequency band, that is, 3,000-6,000 kc, using the same intermediate frequency. At the higher frequency limit we have $Lo = L(6{,}000/6{,}465)^2$, or Lo = 0.86L. At the low frequency end we obtain Cs = 43,600/L. As before let us assume that the capacity in the radio-frequency circuit at 3,000 kc is 140 mmfd. Then the inductance L is 20.05 microhenries, and Lo = 17.28 microhenries. The series capacity is 2,170 mmfd. This condenser is so large in comparison with the variable tuning condenser in series with it that it is hardly necessary to use it. Thus there will be sufficient padding if only the inductance be given the proper values.

Although the minimum capacity trimmer has been omitted in this derivation of the padding constants, it should not be ignored, for the theory requires that the capacities be equal in the two circuits at the high frequency end. It is necessary to use the trimmers on both circuits to make them so, or to give them whatever values that will result in highest sensitivity at the high frequency end.

Switching Padded Circuits

In a short-wave receiver provision must be made for changing the coils, for a single coil cannot be used to cover the entire short-wave band. Indeed, if we are to have a frequency ratio of 2-to-1 in each band and the entire tuning range is to be from 1,500 kc to 24,000 kc, there must be a total of four coils for each tuner. A switching arrangement must be provided by means of which any one of the coils may be inserted in the circuit. One method of doing this in a padded oscillator circuit is shown in Fig. IX-9. Four switch decks are shown, two for the radio frequency coil and two for the oscillator. If another radio frequency tuner is to be used in the circuit, two more switch decks will be required.

The oscillator is padded by the method in Case 3, for this is the most suitable. The adjustable trimmer condenser furnishing the capacity Cm is permanently connected across the oscillator coil and may be adjusted for that coil once for all. Likewise Cs is permanently connected in series with the parallel circuit formed by Lo and Cm, and this condenser, too, can be adjusted once for all to fit Lo. It is only C and the grid circuit of the tube that are move when another coil is selected. At the new point there is another oscillator coil, another minimum capacity, and another series capacity, all designed and adjusted for the new band. If there are four steps and two tuners, the switch required should be a four-deck, four-stop gang switch. If another radio frequency tuner is to be used, the switch should have two more decks.

It will be observed that the stopping condenser has been

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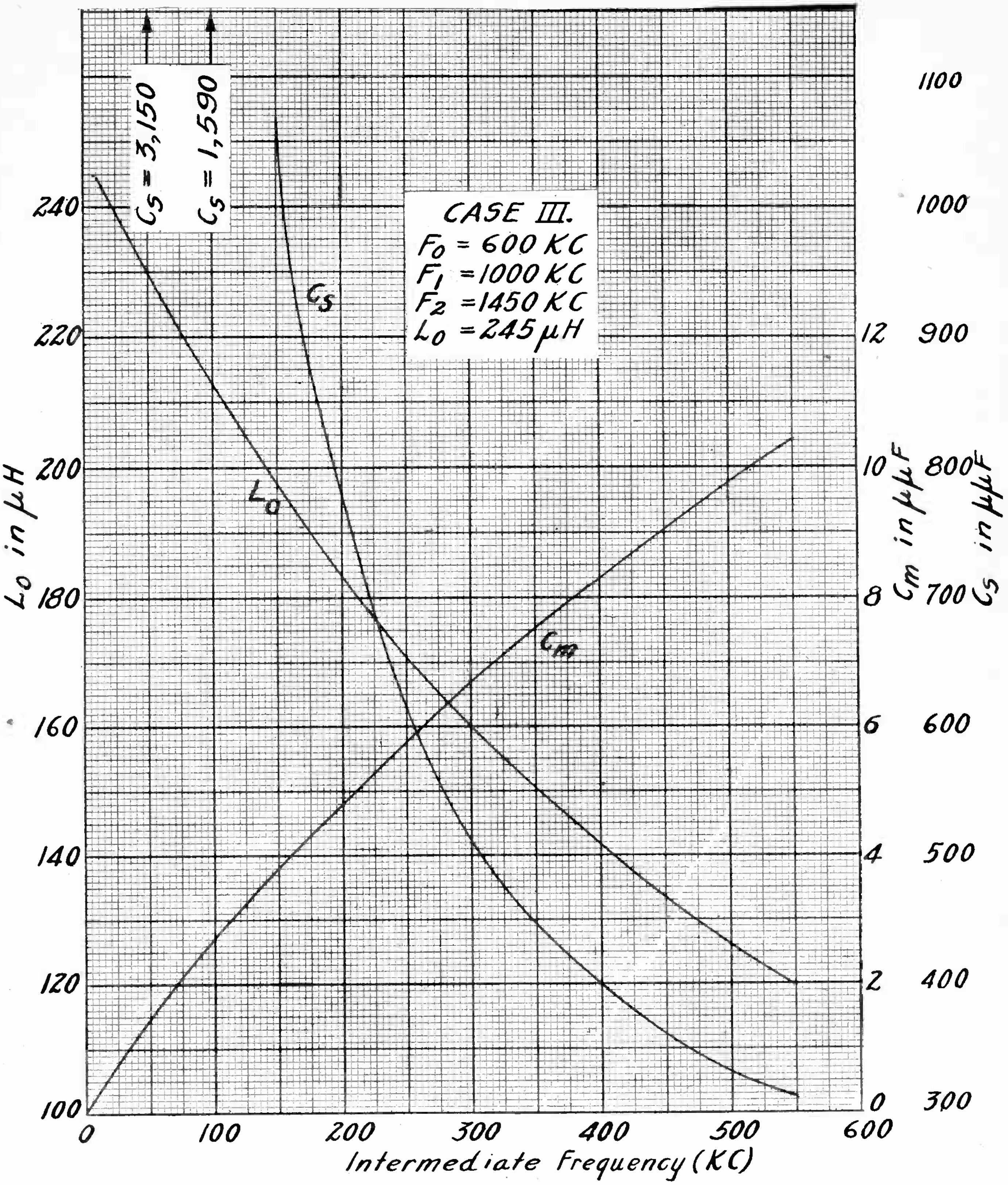

FIG. IX-7

The curves give the minimum capacity, Cm, the series capacity, Cs, and the inductance, Lo, for the broadcast band and intermediate frequencies up to 600 kc.

(Continued from preceding page)

omitted from the oscillator in Fig. IX-9. The reason for this is that Cs serves to block the grid. There is no good reason, however, why a regular blocking condenser should not be used in addition, and some advantages may accrue if one is used. It should be inserted in the lead between the connections of C and R, and its value may be of the order of 0.0001 mfd. The reason why another condenser may be used to good advantage is that Cs may be very large for some of the bands. A smaller grid condenser will improve the frequency stability of the circuit, and important consideration in the design of short-wave superheterodynes.

Coupling to the Oscillator

The most satisfactory method of coupling the oscillator to the frequency changer is by a pick-up coil on the form of Lo and connected in the grid circuit of the first detector. This method, however, is not practical in a short-wave circuit where the coils are switched, for it would necessitate another switch for the pick-up coil. There would have to be one pick-up coil for each oscillator coil. Some more practical arrangement is necessary. Sometimes an extremely small condenser is connected between the grid of the first detector and the grid of the oscillator, but this has the disadvantage that it will be more effective the higher the frequency. It seems that the most practical way of coupling is by means of resistance, for resistance coupling is practically free from frequency effects.

A simple way of utilizing resistance coupling between the oscillator and the first detector is to connect the suppressor grid of the first detector tube to the grid leak of the oscillator. If any desired degree of coupling can be obtained. The coupling undoubtedly be too close, and if it is made near ground of the oscillator leak, it will be too loose. Between these two extremes any desired degree of coupling can be obtained. The coupling may even be made variable by making R a potentiometer and then connecting the suppressor grid to the slider. Naturally, this method requires that the first detector tube has an extra grid, but most tubes now used for first detectors are of the super-control type with the suppressor grid accessible.

Harmonics Generated

There is one serious drawback in coupling that is independent of frequency, and that is that harmonics generated in the tubes are impressed on the detector. This is true for all types of coupling, of course, but the pick-up of the harmonics is least when the detector is coupled in some manner to the oscillator resonant circuit, for in this circuit the harmonics are vanishingly small. When the coupling is made either to the grid or the plate circuit of the oscillator, the harmonics picked up are very strong; and this undesirable condition can be avoided only by so designing the oscillator that the harmonics generated are weak.

The harmonics are weak when the generated wave is nearly pure, and this it is when the grid swing of the oscillator is small, that is, when the intensity of oscillation is low. One way of limiting the oscillation and at the same time improving the frequency stability of the circuit is to use the highest value of grid leak resistance that can be employed without blocking. It is seldom, however, that a higher value than 100,000 ohms can be used safely. Still another way of holding down the intensity of oscillation is to use a tickler that is just sufficient to maintain oscillation. Naturally, there should be a margin of safety so that oscillation will not stop on slightest provocation. The extra grid stopping condenser already mentioned is also an aid in preventing the oscillation amplitude from becoming excessive.

Effect of Harmonics

At first thought it would seem that the presence of harmonics, whether strong or weak, would not be a serious matter, for is it not a fact that only one frequency can get through the intermediate selector at one time? That is true. Only one frequency can get through the intermediate selector, but that one frequency can be produced in an infinite number of ways. We have already discussed one of these and suggested a remedy for it, namely, the image frequency. But that is only one possible way of producing the frequency that goes through the filter.

If we only consider the signal frequency and all the harmonics of the oscillator frequency, we arrive at the conclusion that there is an infinite number of possibilities of producing the heterodyne that equals the intermediate frequency. If we reverse the point of view and consider only the fundamental of the oscillator frequency and all the harmonics of only one signal frequency, we arrive at the same conclusion that there is an infinite number of possibilities. Then if we remember that not only are all the harmonics of the oscillator present, but also all the harmonics of the signal frequency, then we realize the enormous confusion that must exist in the output of the first detector and the difficult task that the intermediate selector has.

Still we are not at the end yet. We have only considered one signal frequency with its harmonics. There will be many more signal frequencies, some exactly equal with the frequency we desire, some differing by only 10 or 20 kc above or below, and for each of these there will be an image. Moreover, we may have stations operating on lower frequencies such that their harmonics will coincide with the signal desired or with its image. On top of all these we have the products of cross modulation, some of which may be equal to the intermediate frequency while others may be equal to the signal frequency desired or to its image. There are countless possibilities for the generation of the intermediate frequency.

Noise Generated

Surely the intensities of these possible heterodynes are vanishingly small so that they will not interfere with the signal after the intermediate filter! Even the sum of all the intensities should be so weak that no interference would result! No, this is not necessarily so. There may be one interfering signal that will give rise to a squeal here, another there, and if there are many of these squeals, the usefulness of the receiver is much impaired. And besides actual heterodyne squeals there may be growling and sputtering and hissing, all the direct result of heterodyning of harmonics, of harmonics of harmonics, and of stray signals.

Not all these noises come through the filter as separate intermediate frequency components, but some may cross over as modulation on the regular intermediate carrier. It is likely that much hiss reaches the speaker in this manner, as well as much hum.

Tracking Precautions

Good tracking of the oscillator and radio frequency circuits is essential for good selectivity and for a minimum of noise, and this means permanent tracking. It is comparatively easy to make the circuits track by making adjustments, but it is not so easy to make them stay in alignment. Temperature and moisture variations, mechanical jars, and wear all contribute to upsetting the tracking. The changes in the circuit need not all be in the three padding constants, but they may be distributed throughout the receiver. The tracking may be upset by changes in the capacities of the variable condensers, by changes in the inductances of the radio frequency circuits, by changes in the inductances or capacities in the intermediate frequency circuits, or even by changes in the operating voltages in the circuit.

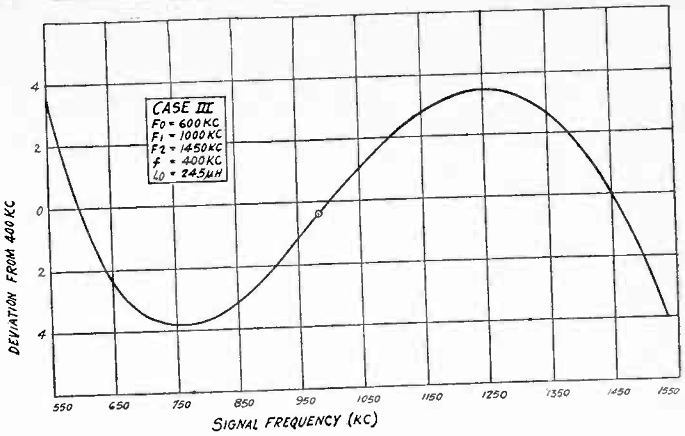

FIG. IX-8

A sample tracking curve for Case 3, the intermediate frequency being 400 kc and the coverage being from 550 to 1,500 kc.

Compression type variable condensers especially are subject to variation as a result of changes in temperature, moisture, and jars. Such condensers, therefore should be avoided. Whenever possible, and in a short-wave superheterodyne particularly, all variable condensers should be of the air dielectric type, and even these should not be compressional. There are commercial intermediate frequency couplers available in which the tuning condensers are of the air dielectric type and in which the capacity is varied by turning one set of plates with respect to the other. Once adjusted the capacity retains its value.

Series Padding Condensers

The trimmers on regular variable condensers are nearly always of the compressional type, and for that reason they do not hold their capacity. Much lack of tracking in broadcast superheterodynes, especially on the higher frequencies in the band, is due to this variation in capacity. The situation becomes much worse as the frequency is increased because a smaller change in the capacity will produce a larger change in the frequency of resonance. Therefore in a circuit such as that suggested in Fig. IX-9, compression type trimmers should be avoided. Air condensers for trimmers superior to those ordinarily mounted on tuning condensers can easily be improvised.

Just as the parallel trimmer condensers must be free from accidental variation in capacity, so the series padding condenser must be constant in capacity. In nearly all cases this condenser is of the compressional type, yet there is no provision for holding capacity constant once it has been set. Its variation will cause large divergence from tracking at all frequencies, but especially at the low frequencies of each tuning band. The departure from tracking will be greater the smaller the padding condenser, wherefore the tracking will be worst at the low frequencies in each band and in the lowest frequency band.

Manual Trimming

While it is inconvenient to use air dielectric condensers for series padding, it should be done if possible. As a compromise it is practical to use fixed mica condensers for the larger part of the capacity and small air condensers for trimmers. Fortunately, the need for series condensers becomes less pressing the higher

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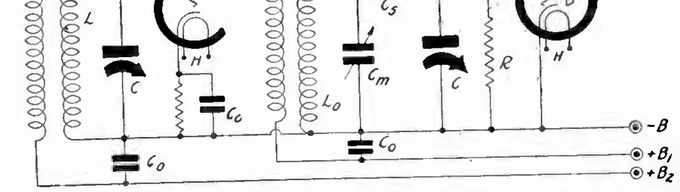

FIG. IX-9

This illustrates how a short-wave superheterodyne may be padded. The arrangement of the parts is that of Case 3. Each of the oscillator coils should be treated the same way.

(*Continued from preceding page*)

the frequency, inasmuch as the required padding capacity increases rapidly, and therefore small changes in the capacity have little effect in upsetting the tracking.

In many high-frequency circuits the tuning is so critical that it is impossible to obtain best results with a padded circuit, and a manual trimmer is used to bring about exact resonance. This manual trimmer may be put either in the oscillator circuit or in the radio frequency tuner. If there is only one radio frequency tuner on the gang, it is preferable to put it on this rather than on the oscillator. If there are two or more radio frequency tuners, on the other hand, the most logical place is to put it on the oscillator. With a manual trimmer it is scarcely necessary to use any padding except to employ a lower inductance in the oscillator and perhaps a series condenser for the first high frequency band above the broadcast band. Naturally, regular padding does not harm even when the manual trimmer is used.

One method of treating the tracking problem in cases where there is only one radio frequency stage in addition to the oscillator is illustrated in Fig. IX-10, in which the two variable condensers C are ganged and are equal at all settings. These condensers constitute the main tuning control, where as Ct serves as a manual trimmer only.

In designing a circuit of this kind, it is permissible to assume that the minimum capacities in the two resonant circuits are equal, for this condition can always be brought about by simple adjustment; and when this has been done, the inductances in the two circuits can be selected so that the maximum frequency of the oscillator exceeds the maximum of the radio frequency circuit by the amount of the intermediate frequency. It is understood that the minimum of Ct is included in the minimum of C across which it is connected.

For the sake of definiteness let us assume that the intermediate frequency, f = 465 kc, that the lowest signal frequency is F_1 = 1,500 kc, and that the oscillator frequency ratio is 2-to-1. Then the lowest oscillator frequency will be 1,965 kc, the highest, 3,930 kc, and the highest signal frequency, 3,465 kc. Now, if we assume that the maximum value of C is 140 mmfd., the oscillator inductance must be 46.8 microhenries. Since the capacities in the two circuits are equal at the high frequency end, the inductances in the two circuits should bear the same ratio as the ratio of the squares of the oscillator frequencies. The oscillator frequency is 3,930 and the signal frequency is 3,465 kc. The square of the ratio is 1.288, and therefore the radio-frequency inductance should be 60.2 microhenries. With this inductance in the radio frequency circuit, the total capacity required to tune to 1,500 kc is 187 mmfd. Since C will contribute 140 of this, Ct need only be 47 mmfd. The higher frequency bands will not require as much disparity between the two condensers. Hence if the maximum capacity is 50 mmfd. the trimmer will be large enough for all the shortwave bands. It may be well, however, to make the trimmer a little larger in order to provide a margin for likely errors in the inductances.

Design of Sets of Coils

The first thing we must know when we set out to design coils is the inductance of each coil; and this can usually be computed from arbitrarily selected values of capacity and frequency with the aid of the usual formula connecting frequency, inductance, and capacity, namely, $L = 0.2533/CF^2$, in which L is the inductance in henries, C the capacity in farads, and F the frequency in cycles per seconds. Suppose, for example, that we decide to start the tuner at 1,500 kc with a tuning condenser having a maximum capacity of 150 mmfd., including stray capacities of the coil and the tube. The formula then tells us that the inductance should be 75 microhenries.

Before we can determine all the inductances in a set of coils, we must know the capacity ratio of the tuner, that is, the ratio between the maximum and the minimum values of the tuning capacity, for this ratio determines how high in frequency the first coil tunes and therefore where the next smaller should begin. The capacity ratio is more or less arbitrary, for we can select a large condenser or a small one, or we may adjust the minimum capacity to any desired value. Suppose that we adjust the minimum capacity to 37.5 mmfd., assuming the maximum to remain at 150 mmfd. The capacity ratio is then 4-to-1 and the frequency ratio is 2-to-1, for the frequency ratio is always the square root of the capacity ratio.

The second inductance is to be such that the frequency is 3,000 kc when the capacity is maximum, that is, 150 mmfd. We can apply the same frequency formula once more in order to get the second inductance. When we do this we obtain L = 18.75 microhenries. It will be noticed that this is exactly one-fourth of the preceding value. Hence we could have obtained it by dividing the first inductance by 4, or by the capacity ratio. This is general as long as we retain the same capacity ratio. There fore the third inductance should be 4.69 microhenries and the fourth, 1.172 microhenries.

Variation in Ratio

Now it may be that the capacity ratio is not exactly 4. If it is less than 4, all the frequencies will not be covered by the tuner; if it is more than 4, there will be considerable overlap of adjacent bands. In all practical cases there should be just a little overlap, and this can be secured by making the minimum capacity just a little less than it was assumed to be during the process of computing the inductances. Overlap must be provided for as insurance against possible lack of complete coverage, for it is not always feasible to make the inductances of just the values computed. One turn more or less, or even a

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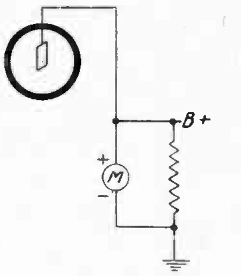

FIG. 1

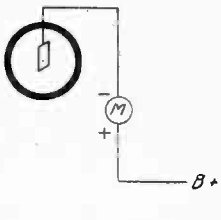

FIG. 2

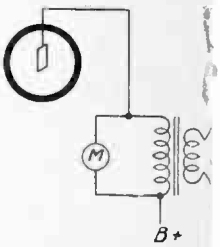

FIG. 3

A voltmeter is connected in parallel with the measured
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WHILE the mere reception of programs requires no technical knowledge, the construction or repair of radio receivers does, and in this connection it is necessary to have some knowledge of measurements. Often, if there is trouble in a set, some particular measurement either will reveal the cause of the trouble or at least give a clue to a prompt remedy.

The meter most often used is the voltmeter. This measures voltage, that is, the potential difference between two points. Since there are two types of currents, alternating and direct, two different types of meters are necessary. Recently d-c voltmeters have been produced that have a rectifier built in, so that the same mechanical instrument may be used for both electrical purposes, by suitable change of connections. The voltage ranges are determined by (a) the sensitivity of the instrument, as to the smallest voltage that can be measured, and (b) the resistance of the multiplier as to the high limit.

Ohms Per Volt

The multiplier consists of a series resistance. The type of meter most often used is one having a sensitivity of 1 milliampere as a current meter, which, when the series resistance is added, is used as a voltmeter. The rating of the voltmeter is on the basis of the ohms-per-volt resistance at full-scale deflection. The ohms-per-volt rating is determined by dividing the full-scale deflection current into the number 1. This is known as the reciprocal of the current. Thus the quantity of the series or multiplier resistor does not figure at all, which is obviously true because the full-scale deflection current does not change, but the resistance in series with the meter is simply increased to accommodate the higher voltage requirements.

Thus for a 0-1 milliammeter, the full-scale deflection is 1 milliampere, and the reciprocal of the current is 1/0.001, or 1,000, hence the meter rating is 1,000 ohms per volt.

If the full-scale current were 1.5 ma the ohms-per-volt rating would be 1/0.0015, or 666.7 ohms per volt, and if the full-scale current were 2 milliamperes the ohms-per-volt rating would be 500.

Parallel Connection

It can be seen that the current flowing through the meter

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J. Medford

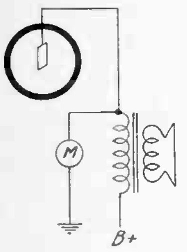


FIG. 4

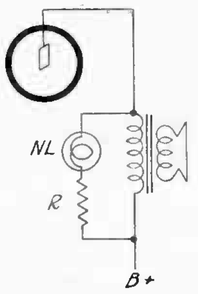


FIG. 5

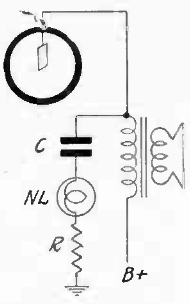


FIG. 6

source, a current meter in series. An output meter may ner or from plate to ground. Neon lamps may be used tion of output.

makes the meter useful, and the multiplier enables various voltage ranges, and therefore voltmeter sare current meters in which the voltages to produce certain currents through definite resistances are calibrated on the meter scale.

The voltmeter is connected in parallel with the measured circuit. Thus in a receiver, if the voltage between B plus and ground is to be determined, the meter is put between these two points, as in Fig. 1. If the current in the measured circuit is high compared to that drawn by the meter, then the voltage reading with the meter in circuit will not be substantially different from the actual voltage when the meter is out of circuit. All meters reduce the voltage, even if only a tiny bit, except those meters that draw no current, such as electrostatic voltmeters and vacuum-tube voltmeters.

The accuracy of the reading depends on the accuracy of the meter, and not on the proportion of current drawn by meter and the measured circuit. The reason is that when the meter current is large compared to the current in the measured circuit the voltage existing when the measurement is made is actually different, and if the meter is accurate the voltage read is the true voltage then existing. However, the desire is to determine what the voltage is when the meter is not in circuit, by making the measurement when the meter is in circuit. This permits only a very small meter current compared to the current in the measured circuit.

Limitations

Even the 0-1 milliammeter used as voltmeter, hence having a rating of 1,000 ohms per volt, does not always give receiver operating voltages when an attempted measurement is made. Many beginners are baffled by this fact, encountered for instance when the meter is connected between plate and cathode in a an effort to ascertain the voltage existing at the plate of a tube that is resistance-loaded.

Suppose the tube is a detector, the current in the plate circuit is 0.1 milliampere (0.0001 ampere), the meter at full-scale deflection draws 1 milliampere, and the scale is 100 volts. Suppose the reading obtained is 50 volts. Since the meter draws half of full-scale deflection current, or 0.5 ma, and the tube plate circuit still draws approximately 0.1 milliampere, the meter has

(Continued on next page)

fractional turn, will make a large percentage change in the inductance whe nthe coil has only a small number of turns. If there is not ample overlap, especially on the higher frequency band where the coils are very small, there is a good chance that adjacent chances will not even meet. Yet, the overlap should not be excessive, because it might easily be so large than an extra coil is required in a set in order to cover a given frequency band. No worthwhile gain is secured by duplication.

While we took a very simple case for illustration, the same idea can be applied to any case. The capacity ratio may, for instance, be only 1.5. If it is, the second coil is L/1.5, the third, $L/(1.5)^2$, the fourth, $L(1.5)^3$, and so on, where L is the inductance of the first-band coil, the value of which is determined with the aid of the frequency formula from the maximum capacity in the circuit and the lowest frequency to be tuned in.

Oscillator Coils

This short cut to the inductance value applies only when the capacity ratio remains constant. It does not do that in all cases. In Fig. IX-9, for example, the ratio in the oscillator changed from coil to coil, while that in the radio frequency tuner remained constant. In Fig. IX-10, on the other hand, the capacity ratio in the oscillator remained constant, while that in the radio frequency circuit varied. When the capacity ratio of one circuit varies from coil to coil, the various inductances have to be determined from the inductance in the other circuit as well as from the intermediate frequency. If the radio frequency circuit is straight and the oscillator is padded, the inductances for the radio frequency circuit should be determined first on the ratio principle and then the coils in the oscillator circuit should be determined by the rules for padding. If the circuit is arranged as in Fig. IX-10, it is the oscillator inductances that should be determined on the ratio basis, and the inductances in the radio frequency circuits should be determined in terms of the oscillator inductances and the frequency when the capacities in the two circuits are minimum and equal.

Let us find the inductance for the circuit in Fig. IX-10 on the assumption that the maximum capacity in the oscillator circuit is 150 mmfd and the lowest oscillator frequency is 1,965 kc. The capacity ratio in the oscillator is supposed to be 4. Therefore the inductance of the largest coil is 43.66 microhenries, and the three following are: 11.93, 2.735, and 0.684 microhenries.

When the oscillator is generating 1,965 kc, the radio frequency circuit is tuned to 1,500 kc; and when the oscillator is generating 3,930 kc, the radio frequency circuit is tuned to 3,465 kc. The inductance in the radio frequency circuit is determined from the second pair of frequencies, and it is $L = 43.66(3{,}930/3{,}465)^2$, or 56 microhenries. In like manner, when the oscillator is set for 7,860 kc, the radio frequency cihcuit is tuned to 7,395 kc. Therefore the second inductance in the radio frequency circuit is $L = 11.93(7{,}860/7{,}395)^2$, or 13.5 microhenries. In the same way we obtain for the radio frequency inductances corresponding to 2.735 and 0.684 the values 2.9 and 0.705 microhenries, respectively.

We have now determined the eight inductances needed in a circuit like that of Fig. IX-10 when the maximum value of the tuning condenser is 150 mmfd., when the intermediate frequency is 465 kc, when the oscillator tuning ratio is 2-to-1, and when the lowest frequency to be received is 1,500 kc. The next step would be actually to design the coils to give the inductances required. This, however, is another subject and it is discussed elsewhere. Incidentally, the simplest way of getting the specifications for coils to give predetermined inductances is to utilize prepared charts.

In a previous paragraph we found the inductances required in a four-step radio frequency tuner when the maximum capacity was 150 mmfd., when the lowest frequency was 1,500 kc, and the capacity ratio was 4, or the frequency ratio was 2. Now let us find the corresponding oscillator inductances when the intermediate frequency is 465 kc and when padding by Case 1 is of sufficient accuracy. The first frequency ratio is 1,500/1,965 and therefore the oscillator inductance is 43.66. The second ratio is 3,000/3,465, whence it follows that the oscillator inductance for this step is 14.08. Similarly we have for the third inductance, 4.03 and for the fourth, 1,088 microhenries.

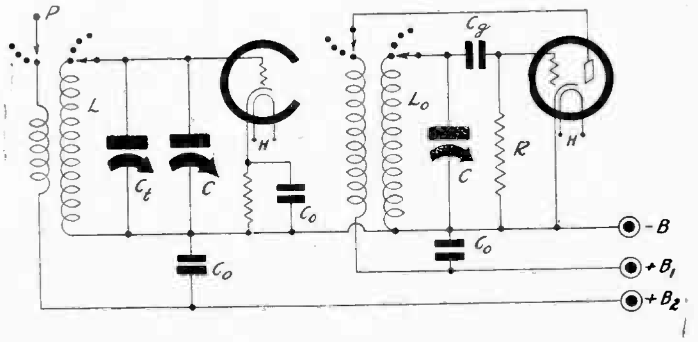


FIG. IX-10

A method of manual trimming of the oscillator in a short-wave superheterodyne. Condensers C are ganged and trimming is done with Ct in the radio frequency tuner.

(*Continued from preceding page*)

partly short-circuited the plate load resistor, and the operating current condition in the receiver circuit has been multiplied by 6, for the total current is 0.6 milliampere, where as without the meter in circuit it was 0.1 ma. Thus a reading of 50 volts is meaningless. If the plate load resistance is known, and the total resistance of meter and its multiplier, the true voltage of the operating receiver condition can be computed, but it is a complicated process.

Meter Accuracy

The accuracy of the meter, if the meter is of a substantial kind, is stated by the manufacturer. A usual condition is for a meter of 1,000-ohms-per-volt rating to have an accuracy of 2 per cent. As a rule a-c meters, including the rectifier type d-c instruments used for a-c measurements, are not as accurate, and are rated at 5 per cent. Particularly are the a-c meters not very accurate at the low-voltage readings of any range, and often are not calibrated from 0. Thus, for a range of 100 volts the minimum calibrated reading may be 5 volts. The accuracy of a meter when stated in percentage means that such accuracy obtains at full-scale deflection current, or maximum-voltage reading for any range. The accuracy at lower readings may be less.

The meter itself has some resistance, but for good meters of the fairly sensitive type, 1,000-ohms-per volt, the resistance is around 27 to 32 ohms. As meters are made more sensitive their own resistance is increased, so that a microammeter may have a resistance of a few thousand ohms, due to greater number of turns of wire on the coil in the meter. This wire has to be fine because a large number of ampere-turns of wire is required, and there is only so much space into which to put the coil. The object, of course, is to get the meter to operate under small current.

Meter's Resistance

The meter resistance normally is not an important factor, except for very low ranges, when the meter resistance has to be considered as a part of the multiplier resistor. Thus, if the meter has a resistance of 100 ohms, and the scale is to be 1 volt for a 0-1 milliammeter, the multiplier would have to be 1,000 ohms (since 1,000 ohms for every volt is required if the meter is of the 1,000-ohms-per-volt type), hence the limiting resistor would be 900 ohms, and the meter resistance of 100 ohms would make up the difference. If this factor of meter resistance were not taken into consideration, a 10 per cent. error would be introduced by selection of the wrong value of multiplier resistance.

When a voltmeter is connected as in Fig. 1, the positive negative side of the meter goes to B plus, the negative side to ground. It should be understood that the plate voltage itself is not being read, unless the cathode of the tube is at ground potential to direct currents and voltages. In battery-operated tubes the true plate voltage should be read between negative filament of the tube and the plate return, B plus in Fig. 1. For indirctly-heated tubes the plate voltage is read between plate and cathode. Seldom is cathode grounded, except in some output tube circuits, when the B filter choke is in the negative leg, and the grounded side of the receiver, or chassis, is therefore positive in respect to a tap on the filter choke used for grid return. So, when diagrams state that the plate voltage should be a certain value, say, 200 volts, that would mean by strict and proper interpretation the voltage between cathode and plate return.

With battery-operated tubes the difference between one interpretation and the other is small, but with a-c tubes of the indirectly-heated type, that is, having a heater and independent cathode, the difference may amount to 20 per cent. or more. Usually the statement is made that the voltage is read between plate and ground, and then that is those are the points between which to make the measurement, although that voltage must not be called the plate voltage. It is the sum of the plate a negative-bias voltages.

Dangerous to Meter

A d-c instrument will not measure a-c voltage or current, because a d-c meter measures averages, and the average of an a-c current or voltage, in either direction, is zero. Yet the a-c will flow through the meter. Hence it is dangerous to connect a d-c instrument to an a-c source, because the seeming condition of no current through the meter, or no voltage read, is misleading, for the a-c current may be high enough to burn out the meter, without registration of any needle deflection.

When indirectly heated tubes are measured for voltages, all voltages are positive in respect to the cathode return. This is usually grounded.

While voltmeters are connected in parallel with the measured source, current meters are connected in series. The positive of the meter is connected to the positive current, and in the case of a plate circuit current measurements, as in Fig. 2, plate is negative. This fact sometimes causes confusion, because of the standing rule that the plate is always positive. But the plate is always positive in respect to the cathode, not in respect to B plus. Since the plate circuit is completed to B minus, plate is nearer B minus than is B plus, hence plate is negative. But if the current is read in the cathode leg of a heater type tube, cathode is positive in respect to cathode return, therefore the meter has to be reversed. This point is of particular importance in the construction of set-testing equipment, using switches, for the reversal has to be introduced automatically, unless the meter connections are to be reversed independently, which cannot be done under all circumstances, due to fixed connections to socket plugs and adapters.

Shunts

Another contrast is that series resistors are used with current meters to constitute voltmeters of different voltage ranges, whereas the range extension of meters for measuring currents is accomplished by parallel resistors called shunts. Thus, shunting the meter causes some current to flow through the shunt and the rest through the meter, so the lower the resistance of the shunt, the higher the current that can be read at full-scale deflection. The current meter is calibrated in terms of the total current flowing, that is, the sum of the two currents, and not on the basis of the current through the meter. The maximum possible current through the meter is always kept to the full-scale deflection current, which is true of both voltmeters and current meters.

An a-c meter measures only alternating current or alternating voltage. As said before, we are always dealing with a current meter, but for voltage readings deal with the current in terms of the voltage required to deflect the needle to different positions, as appear on the calibration, when a certain resistance is in series with the meter. The a-c voltage is either the peak voltage or the root-mean-square voltage. The peak voltage is the potential difference measured between the crest of the wave and the zero axis. The root-mean-square voltage is the square root of the sum of the squares of numerous voltages during a cycle.

If the a-c meter is not specially designated as to the type of voltage or current for which it is calibrated, it is for root-mean-square values. Peak voltmeters, also called crest voltmeters, are always specially identified as such by the manufacturer. With few exceptions, root-mean-square voltages and currents are the ones read in radio work.

A-C Voltage Readings

The a-c voltmeter is used for measuring a-c voltages in receivers, and a-c line voltages. A-c voltages are nearly always closely associated with the line. For instance, the heater voltage of an a-c-operated tube derives its voltage from the line by step-down transformation. The voltage for the plate or plates of rectifier is taken from the line, stepped up instead of down, and even if heaters are in series, the voltage across each heater depends on the resistance of the heater and the current flowing through it, and this current is therefore partly determined by the line voltage.

The only other use for the a-c meter is to measure signal voltages in the audio range. Such a use includes measurements from stage to stage, to determine the gain, as well as measurements at different frequencies, to determine the characteristics of the audio amplifier. However, amplifier characteristics, and even gain per stage, are usually measured by more elaborate and precise means.

The audio signal measurement, however, is popular in the case of the output meter. This is merely an a-c voltmeter of suitable voltage range in the light of the signal in intensity. If the meter is connected as in Fig. 3, since the d-c voltage drop in the primary of the output transformer is small, there will be some reading, for d-c has an effect on a-c instruments, in fact measures the d-c without very obnoxious error, but the signal should be strong enough more than to double the reading, and resonance can be gauged by the maximum deflection of the output meter, when some modulated radio-frequency is put into the receiver, either at the antenna-ground posts, or r-f or i-f per-stage gain is to estimated, at one stage after another.

Accessibility

The modulation should be constant, therefore a station sending programs will not be satisfactory, for the needle would wobble greatly. A modulated test oscillator, now popularly called a signal generator, will suit the purpose.

Sometimes there is no convenient access to the two terminals of the primary of the output transformer. Adapters that fit in power tube sockets enable connection between plate and chassis, and in that case the meter may be so connected, although the percentage of movement of the needle for a given amplitude of audio signal will be less, due to the higher d-c flowing through the meter. It will be observed that the full d-c voltage, the sum of the plate and bias voltages, is applied to the output meter.

To avoid d-c flowing through the meter, a stopping condenser should be used, and this suggests also an audio choke load. The stopping condenser alone may be used, the primary of the output transformer serving as the choke, whereupon the connection may be made either to ground or B plus, other meter terminal to plate. The difference in voltage reading in the two instances, return to ground or B plus, will be nothing, or negligible. The stopping condenser should be of the paper dielectric type, of

(*Continued on next page*)

Casanova's Super

For All-Wave Coverage, D-C Operation

By Ralph Casanova

THE past few months have demonstrated beyond any doubt the wide popularity of the short-wave receivers. The most interesting subject today in the radio field is that of the all-wave superheterodyne properly padded, aligned and adjusted. Many different ways of attaining the desired results have been discussed. Only a superheterodyne seems suitable, for only in the superheterodyne does the main amplification occur at the same radio frequency level regardless of the frequency of the incoming signal.

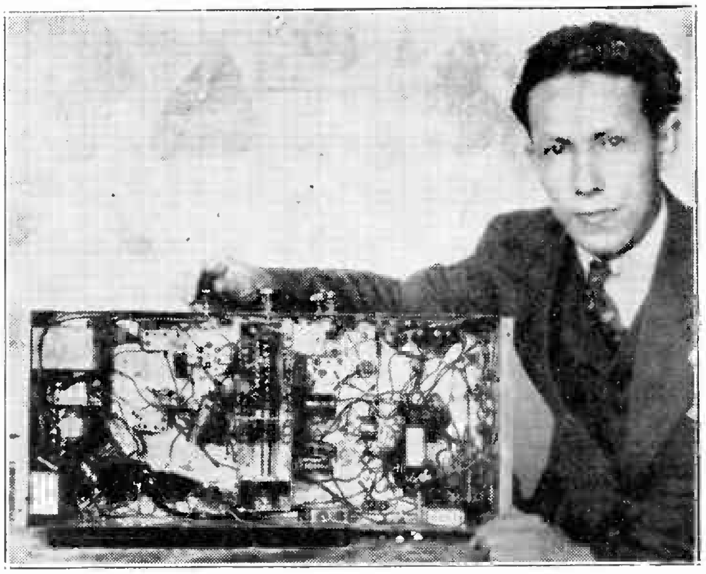
The circuit design shown in Fig. 1 is that of a high-powered all-wave superheterodyne for d-c operation. It is a ten-tube receiver designed to meet the requirement of short-wave and broadcast reception alike, properly padded and aligned for all its bands.

It has an untuned r-f stage with a variable-mu r-f pentode type 78 ahead of the modulator. This stage serves several useful purposes:

First, it boosts the sensitivity several times without introducing any tuning complications.

Second, it prevents radiation from the antenna.

Third, it removes the antenna constants from the r-f tuner that follows that tube (the modulator).



Underneath view of the set. The author is shown.

Intermediate Amplifier

With efficient design and tubes of the 78 type, a two stage i-f amplifier can be made to provide all the gain that can be employed effectively. Even this amount of gain seldom can be taken full advantage of, because it is more than adequate to get down to the noise level in even the most favorable location. Likewise, two stages (three coils) will provide ample selectivity to meet all normal requirement.

The intermediate-frequency amplifier contains two variable mu pentode tubes of the 78 type. There are three doubly-tuned i-f transformers each accurately adjusted to 465 kc. While these transformers are tuned to 465 kc. at the factory, they must be retuned after they have been connected into the circuit because distributed capacities are added in wiring the circuit and these cannot be allowed for at factory since they are unknown. The two intermediate tubes are operated in typical fashion with separate biasing resistors of 850 ohms connected in the cathode lead of each tube and shunted by a 0.1 mfd. condenser.

The ten tubes in the circuit are as follows: one 78 untuned r-f stage, one 44 modulator, one 37 oscillator, two 78 intermediate-frequency amplifiers, two 85 duplex-diode-triodes as full-wave detectors, automatic volume control and audio amplifier, one 37 audio amplifier and two 48 output power tubes in push-pull.

Series-Parallel Heaters

To hook-up the filament of all these tubes a series-parallel system was chosen. Assuming the voltage of the line is normally 115 volts even if the line voltage raise to 120 volts there is no danger as these tubes are not so critical and will stand the excess voltage.

Starting with the tubes requiring 0.3 ampere we find that the eight tubes require 50.4 volts, the excess voltage being 64.6 volts. Since the current is 0.3 ampere and the resistance of the ballast must be 64.6/0.3, or 215 ohms. The other part of the heater circuit consists of the two 48's and the pilot light. Each of the 48's takes 30 volts and the pilot light 6.3 volts, so 66.3 volts are needed. In this case a simple series circuit will not do, for the 48's tubes require 0.4 ampere, whereas the pilot light requires around 0.3 ampere. The ballast resistor for this circuit is 121 ohms rated at 25 watts or more and the drop in it is 48.7 volts. As the pilot light requires only around 0.3 ampere we must put a shunt resistor across this lamp and adjust it so that it will take the extra 0.1 ampere. This shunt resistor is given in the diagram as 40 ohms. It is not practical to connect the heaters of the 48's in series with the heaters of the 0.3 ampere tubes, even though a suitable shunt is used for the difference in current, because there is also a difference in the rate at which the filaments heat up and consequently in the time it takes for the heaters to reach their final hot resistance.

(Continued on next page)

Meter Measurements of A.C. and D.C.

(Continued from preceding page)

conservative voltage rating, and its capacity should be as large as practical. A value of 10 mfd. is recommended in a standard practice for laboratory testing, but service men do not use such large capacity. If a choke is used it should have a very large inductance, say, 100 henries.

A neon lamp of any easily obtainable size, even unto the type as short in length as a fingernail, may be used for visual indication of output. If the lamp is connected as in Fig. 5, where R is the limiting resistor usually built into the lamp, the audio amplitude will light the lamp, even on not very sensitive tuned-radio-frequency sets. The d-c drop in the primary may be 20 to 30 volts, and as the lamp will strike at about 65 volts, only 45 to 30 volts of a-c would be required, and these are readily obtainable. Oh practically any set, any signal generator will light the lamp.

Instead of connecting across the primary, which may not be accessible, the plate to ground method may be used. If a stopping condenser is used no d-c will flow through the lamp, hence the high potential difference between plate and ground will not render the lamp practically useless because of small change of illumination between signal and no-signal conditions. If a lamp that has no series resistance R built in is obtainable, C may be made small enough to substitute for the resistance. Otherwise C may be 1 mfd. or even less.

A-c currents are usually limited to small values in servicing instruments, or, if larger values are readable, there is some sacrifice in the accuracy. The rectifier type instrument impedance changes too much with changes in current. If the rectifier is made much larger, the capacity effect of the rectifier becomes too large. Many combination instruments with rectifier type meters do not measure more than 1 ma a-c.

(*Continued from preceding page*)

It is for this reason that a series-parallel system was chosen.

Speaker Requirements

The use of a dynamic speaker capable of withstanding power in excess of the output tubes is recommended. for this is one important reason for the faithful reproduction. Good tone quality, high sensitivity and good selectivity were the keynote in the design of this circuit. In this receiver two duplex-diode-triode type 85's are used as full-wave diode detectors and a-v-c and the triode part as audio amplifier, in this way almost doubling the capability of voltage handling, avoiding overloading even in the strongest signals and preserving tone quality.

Adequate filtration is advisable to keep r-f out of the amplifier unit of the 85, hence two chokes of 85 millihenries are used and three fixed mica condensers of 0.00025 mfd. are placed from the choke terminals to ground.

The voltage developed in the load resistance of the diode is utilized for automatic volume control and it is applied to the two intermediate frequency amplifiers and the 78 of the first stage. Three 0.1 meg. ohms resistors are used as part of the filter system in the a-v-c branches, its being high enough to prevent any serious reduction of the effective value of the load circuit on the second detectors. A 0.25 meg. ohm potentiometer is the load resistor of the full-wave diode detectors, the moving arm being connected to the grids through a 0.02 stopping condenser. Since there is a stopping condenser a 0.5 meg. grid leak is connected to the grids of the triode.

Unique Mixer Coupling

The coupling between the oscillator and modulator is done by connecting a 0.02 condenser between the two cathodes and using unbypassed bias resistors. This is a very simple method of coupling but highly effective over the whole frequency range, without a single dead spot on the dial. Dead spots result primarily from absorbent tuned circuits in inductive relationship to the coils being used. In other words, one or more of the other coils may be close enough to the one in use to act as a wave trap at critical frequencies. By shielding individually each coil, and separating the leads of one coil from those of another, one gets rid of the final danger of dead spots.

Since the intermediate frequency selected is 465 kc, and it ought to be that high so that some benefit will be derived from modulator tuning at the higher frequencies, the modulator for the broadcast band tunes from 540 to 1,550 kc, and the oscillator has to tune to frequencies 465 kc higher, or 1,005 to 2,015 kc. The tuning condensers are ganged, therefore the oscillator will have to be padded. The capacity actually necessary to tune in this band of frequencies is 0.00017 mfd. and as the tuning condenser is 0.00035 mfd., the padding condenser must have a minimum capacity about equal to the maximum capacity of the tuning condenser. The commercial type of padding condenser, 350-450 mmfd., therefore serves the purpose.

Padding

Padding for the first short-wave band, tuning range of modulator 1,500 to 4,285 kc while the oscillator has to tune to frequencies 465 kc higher or 1,965 to 4,750 kc. This can be accomplished by using a smaller inductance and a smaller effective capacity, values of 28.5 microhenries and 0.000227 mfd. having been selected, and the same type of padding condenser may be used, 350-450 mmfd. padding condenser.

The padding problem arises again in the third and last short-wave bands, tuning range for modulator 4,285 to 11,000 kc, while the oscillator has to tune to frequencies 465 kc above the modulator, or 4,750 to 11,465 kc. To accomplish the padding in this band we reduce a little the oscillator inductance and use smaller effective capacity. Padding condenser for this band 0.0019 mfd. The tuning range for the last short-wave band is modulator 8,560 to 23,000 kc, oscillator 9,025 to 23,465 kc. The padding condenser for this band is 0.0028 mfd. For inductances see coil winding data.

See the list of parts for values of the small trimmers condensers across each secondary. These small trimmers are connected across each secondary for the purposes of adjusting each band on the highest frequency extreme when making the padding for that particular band.

It will be noticed from the wiring diagram that the padding condensers for the last two short-wave bands are fixed. This is all right, but in case a little discrepancy occurs when padding on the lowest frequencies for those two bands it may be corrected by spreading or closing a little the winding on the coil. This will increase or decrease the inductance. Once the padding is perfectly done on each band a little coil cement should be spread over the winding so it stays fixed.

Some Bankspread

In looking over the diagram it will be noticed that there are two tiny parallel condensers or manual trimmers across each of the main tuning condensers of 15 mmfd. each. They are very useful in the highest frequencies because it is virtually the same as if the total tuning capacity were only that, because the main tuning condensers can be set for approximately the desired frequency, and the vernier condensers used for band-spread tuning. The surprising effect of this is to reveal the existence of, indeed the reception from, many weak stations otherwise hard to find. These small condensers have hardly any effect on the broadcast band, where no effect is desired, but begin to have some little effect on the first band of short-wave.

The receiver is single control and is padded perfectly over the whole range, so these condensers when not used for band-spread purposes on the short-wave bands could be set for minimum capacity and left thus.

Broadcast Band First

Do not attempt to wire in the switch and all the coils at first, but be content to get the set working satisfactorily on the broadcast band before proceeding to higher frequencies. Once you get the receiver working, the adjustment of the padding can be done in the regular way. That is, the circuit is first adjusted at the highest extreme or around 1,450 kc setting the main tuning condensers at about 92 on the dial and then tuning in the signal by means of the trimmers condensers across the grid winding inductance of the modulator and oscillator. (This dial setting for that frequency is recommended only if the same dial, capacity and inductance are used.) Then the circuit is converted to a t-r-f set and a signal of about 600 kc is tuned in and the dial setting noted then without touching the the tuning condensers the circuit is restored to a superheterodyne and the same 600 kc signal is tuned in with the padding condenser cp-1 till it comes in the same setting. If the padding was done right both circuits will track throughout the band and the sensitivity will be the same in both extremes. If reception is weak with many squeals and a mushy sound throughout. this is an indication that the intermediate channel is oscillating. The same method may be used when padding for the three other bands of short-wave but in this case a modulated signal from a laboratory oscillator would be necessary for proper adjustment.

LIST OF PARTS

Coils

A set of eight coils as described (see coil data).
Three shielded intermediate-frequency transformers peaked at 465 kc, one center tapped.
Three 85 mh r-f choke.
Nine 8 mh r-f choke.
Two special 8 mh r-f chokes with low distributed capacity, universal wound in three sections. For grid and plate of the untuned r-f stage.
One 30-henry B choke, d-c resistance 250 ohms.
One dynamic speaker 1,800 ohms field or any resistance up to 2,500 ohms with output transformer match for P.P. 48 with 11.5 inches diameter.

Condensers

Two separate sections 350 mmfd., each without trimmers, to be connected one one each side of the drum dial.
Two 15 mmfd. variable condensers (with three plates each).
Three 0.0001 mfd. fixed mica condensers.
Five 0.00025 mfd. fixed mica condensers.
Two 0.00015 mfd. fixed mica condensers.
One 0.005 mfd. fixed condenser.
Four 0.02 mfd. fixed condensers.
Sixteen 0.1 mfd. by-pass condensers.
Two 0.5 mfd. by-pass condensers.
One 1.0 mfd. by-pass condenser.
One 4.0 mfd. by-pass condenser.
Two 12.0 mfd. paper filter condensers.
Cp-1, Cp-2 Two padding condensers on isolantite base 350-450 mmfd. each.
Cp-3, one mica condenser 0.0019 mfd.
Cp-4, one mica condenser 0.0028 mfd.
ct-1, ct-2, ct-5, ct-6 Four trimmers condensers 4-50 mmfd. each.
ct-3, ct-4, ct-7 and ct-8 Four trimmers condensers 3-30 mmfd. each.

Resistors

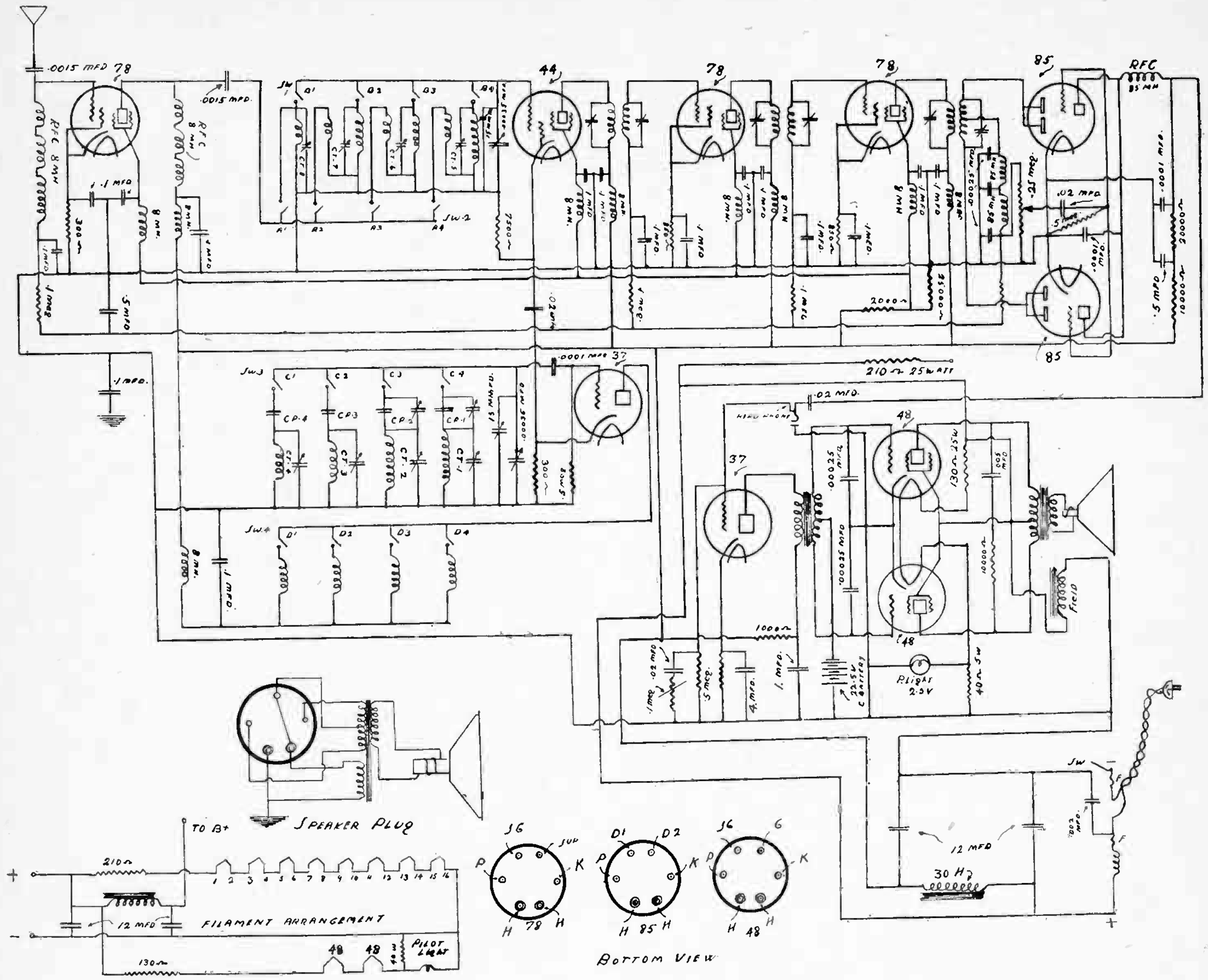
Two 300-ohm bias resistors.
Two 850-ohm bias resistors.
One 2,000-ohm bias resistor.
One 7,500-ohm bias resistor.
One 2,000-ohm 5-watt resistor.
Two 10,000-ohm pigtail resistors.
One 25,000-ohm 2-watt resistor.
One 20,000-ohm pigtail resistor.
Three 0.1 meg. (100,000-ohm) pigtail resistors.
Four 0.5 meg. (500,000-ohm) pigtail resistors.
One 1,000-ohm pigtail resistor.
One 40-ohm 5-watt resistor.
One 121-ohm 25-watt resistor.
One 210-ohm 25-watt resistor.
One 250,000-ohm potentiometer.
One 100,000-ohm potentiometer for tone control.

Other Requirements

One chassis, 20 inches by 10 inches front to back, 3.5 inches elevation.
One drum dial.
One 22.5 volts C battery.
One antenna ground binding post assembly.
Eleven sockets, seven six-pin type and four UY, the extra one for the speaker plug.
One four-deck four-position band shifting switch.

Well-Filtered B Supply

The B supply must be well filtered, for in short-wave particularly this is very important. There is one 12 mfd. paper condenser connected in each side of the filter choke and the B supply for all the plate currents are passed through this choke, except the power tube that gets the plate



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voltage directly from the line, it being only filtered by the first 12 mfd. condenser. Each rf. tube has an 8 millihenry r-f choke on the plate and screen supply lead by-passed by a 0.1 mfd. condenser, all condenser and each of these tubes has a mfd. condenser, all this filtering being necessary to avoid undesirable coupling between the different circuits that will affect the stability of the set.

There is a heavy r-f choke on the positive side of the line with a 0.002 mfd. mica condenser connected from the positive side to ground. This is very helpful for filtering the high frequency noises coming through the line. It is not practical to pass the plate supply of the 48's through the filter choke, due to the high plate current of these tubes, unless a very heavy choke is used and in that case the drop in the choke would be too high considering that we only have 115 volts to dispose with. A 22.5-volt C battery supplies the bias for the power tubes and lasts about a year.

Coil Data

For the broadcast and the 70 meter bands separate coils are used, each in shielding cans 2⅛ inches by 2½ inches, on 1-inch diameter tubing.

Band I (540 to 1,500 kc).

R-F secondary inductance, 246 microhenries; 123 turns No. 32 enamel wire.

R-F primary inductance, 7 microhenries; 12 turns of No. 32 enamel wire wound over the secondary, on the ground end.

Oscillator: grid winding inductance, 145 microhenries; 76 turns No. 30 enamel wire.

Oscillator: tickler winding 19 turns No. 32 enamel wire wound over the grid winding on the ground end.

Band II (1,500 to 4,285 kc).

R-F secondary inductance, 35 microhenries; 26 turns No. 30 enamel wire.

R-F primary inductance 3.7 microhenries; 7 turns No. 30 enamel wire, wound near the bottom with a separation of 0.25 inch from the secondary.

Oscillator: grid winding inductance, 29 microhenries; 22 turns No. 30 enamel wire.

Oscillator: tickler winding 8 turns No. 30 enamel wire wound near the bottom with a separation of about 0.25 inch from the grid winding.

For the next two bands larger wire diameter should be used and space winding. They are wound on a coil form 1-inch outside diameter by 2½ inches long with No. 18 enamel wire.

These coils were designed to be used in a copper shield 3 inches diameter by 4 inches high.

Band III (4,285 to 11,000 kc).

R-F secondary inductance, 4.5 microhenries; 12 turns No. 18 enamel wire.

R-F primary 6 turns of No. 18 enamel wire, wound near the bottom with a separation of 0.25 inch from the secondary.

Oscillator: grid winding inductance, 3.9 microhenries; 11.5 turns of No. 18 enamel wire.

Oscillator: tickler winding 6 turns No. 22 enamel wire wound near the bottom with a separation of about 0.25 inch from the grid winding.

Band IV (8,560 to 23,000 kc).

R-F secondary inductance, .47 microhenries; 5.8 turns No. 18 enamel wire. No primary is used for this band.

Oscillator: grid winding inductance, .43 microhenries; 5.3 No. 18 enamel wire.

Oscillator: tickler winding 4 turns No. 22 enamel wire wound near the bottom with a separation of about 0.25 inch from the grid winding.

German Program for North America Scheduled

The German stations sending programs especially intended for North America, and the schedules for this month, are:

Call	kc	m.	EDST
DJB	15,200	19.73	9 a.m. to noon
DJD	11,760	25.51	6 p.m. to 11:30 p.m.
DJC	6,020	49.83	9:45 p.m. to 11:30 p.m.

Radio University

Leak-Condenser Values

CAN THE SAME value of grid leak and stopping condenser be used for a wide band of frequencies, as in the oscillator of an all-wave receiver, or should the values be proportioned to the frequencies?—K. L.

The values should be proportioned to the frequencies. A simple test is to touch the control grid connection of the oscillator with moist or wet finger, and hear the plop. When the finger is withdrawn the oscillator should resume oscillation at once. That is, there should be no appreciable lag between the withdrawal of the finger and the second plop. The first plop takes place when the grid is touched, the second one when the finger is removed. If there is a delay the time constant of the leak-condenser combination is too high. However, usually a compromise is struck, so that the leak and condenser are selected for the highest frequency to be generated, and left thus for all lower frequencies. That is done as a matter of economy. If the time constant is too high there will be grid blocking at the higher frequencies of generation, which may produce a continuous squeal in the receiver, or a droning sound. Reduce leak or condenser or both. Though the leak and condenser may be theoretically too low for lower frequencies, the compromise of a single combination does not produce any such interference. For frequencies up to 30 mgc a suggested combination is 50 mmfd. and 50,000 ohms, with series leak. If the grid condenser is connected between grid and the tuned circuit, and leak between grid and grid return, the leak value may be a little higher.

* * *

Efficiency of a Set

DOES NOT a sensitive receiver constitute a perpetual motion machine, in that it takes a feeble input carrier, amplifies it tremendously, rectifies or detects it, amplifies it some more, this time at audio frequencies, and then reproduces a loud signal, even though small power is expended?—I. J. C.

No, the radio receiver is far from being highly efficient. It might be argued that the crystal set is the most efficient of all, because no power is put in except antenna power, and yet audible results are attained. The greater the sensitivity of the receiver, as a rule, the lower the efficiency. Take an ordinary receiver. It may have a rating of 50 watts power consumption. This same set will put out 5 watts of undistorted power. This is an efficiency of 10 per cent., where efficiency means the output compared to the input. The antenna input may be neglected as too small to require reckoning. But the power used to heat the filament and to supply the B and C voltages is what has to be considered. The only efficient devices in sets are transformers. These may be close to 100%. On an efficiency basis, therefore the radio receiver is in about the same class as the automobile engine. This in no way approximates perpetual motion. It is generally accepted that perpetual motion is impossible. The law of conservation of energy is a denial of the possibility of perpetual motion, or any system of taking more out than you put in. That law is that you can neither destroy or create energy. Another way of expressing it is that the amount of energy in the universe is constant.

* * *

Electron Coupling's Effect

WHAT IS the effect of electron coupling as to the stability of the oscillator itself?—H. B.

The introduction of electron coupling in an oscillator described a few years ago gave birth to the idea of using this type of coupling. It might be called emission coupling, as it depends on the cathode emission, and not on external inductance, resistance or capacity for coupling, although some external load may be necessary to introduce d-c voltages and to provide a path for the a-c. The idea was to render the generator free from detuning effects due to the measured circuit, or so-called work circuit, on the generator or oscillator. Electron coupling is substantially free from such detuning effects and practically independent of frequency. However, the stability of the oscillator proper is in no way concerned. That stability is whatever is established in the generator itself. The freedom of the oscillator from detuning effects due to the load put upon it by the measured circuit is an entirely different matter. Conceivably the stability would not change at all though the frequency was changed by the load. The effects of the load are those of change of inductance, capacity or resistance in the tuned circuit of the oscillator. Thus the addition of a small parallel capacity or large series capacity in the tuned circuit would not change the stability, improve it or diminish it, though it would change the frequency. The point was not well brought out by the originator of the electron coupling idea, who associated the freedom from frequency change due to load effects, with the stability of the generator, whereas the generator stability is quite a thing apart.

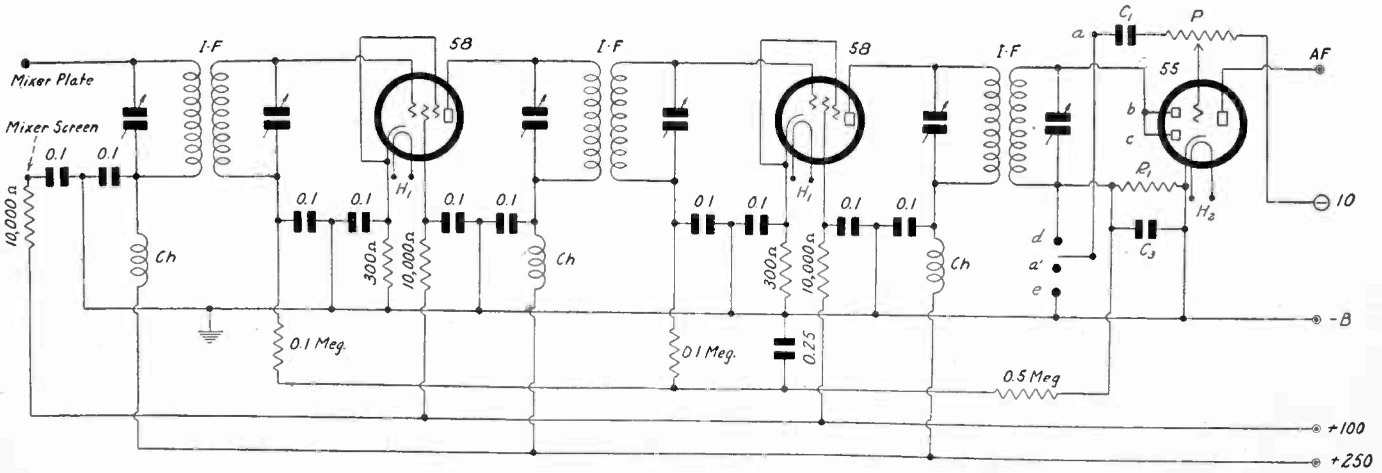
* * *

An I-F Amplifier

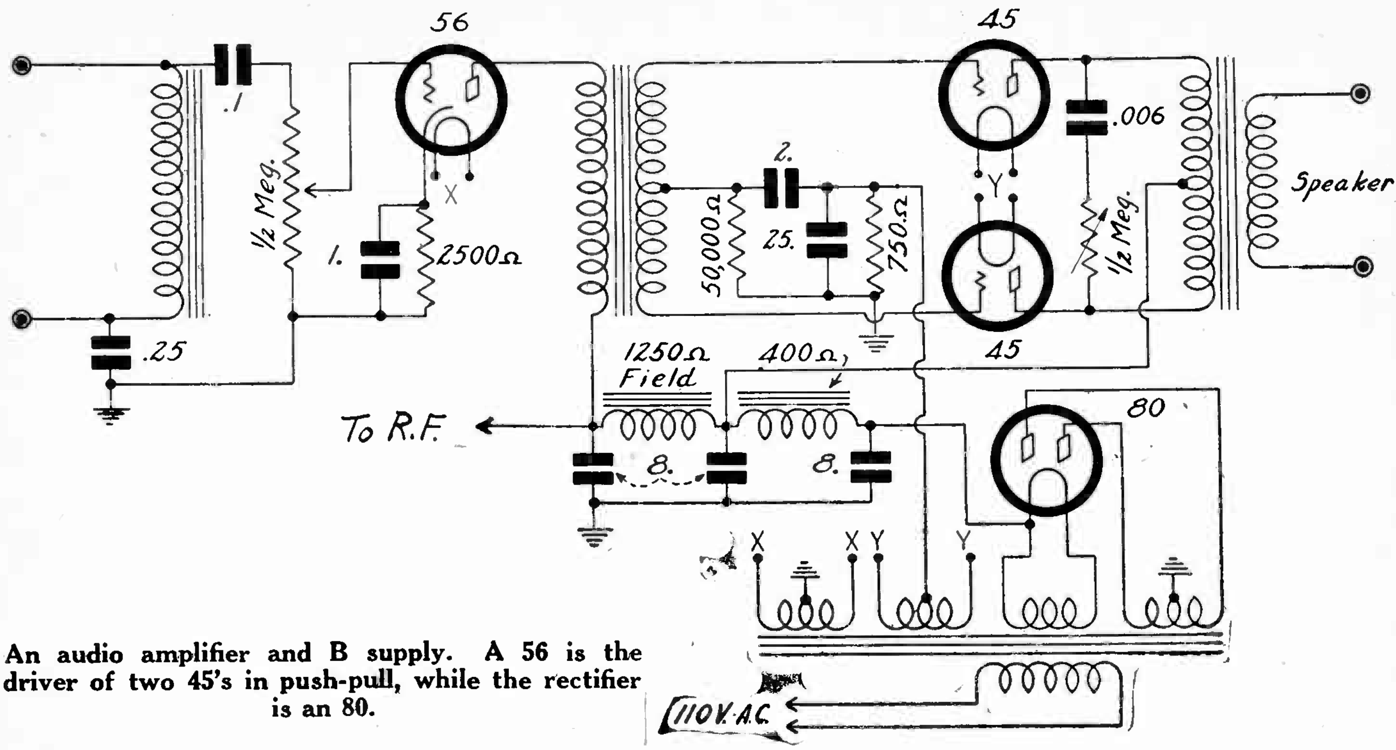
WHAT IS a good design for an intermediate amplifier, say, peaked at 465 kc, and one that has automatic-volume control with independent input to the audio amplifier, which amplifier is not to be a part of the design requested?—T. R.

Assuming a-c operation, with 58 tubes as the i-f amplifiers, and a screen grid tube as mixer, the design shown herewith may be followed, the screen and plate voltages for the mixer being taken care of in the illustrated circuit. The transformers marked IF are the intermediates, with primary and secondary tuned, and for the fastidious builder these should have air-dielectric condensers. The r-f chokes Ch may have any inductance, 10 millihenries or more. While the bypass capacities are shown as 0.01 mfd., if there is any trouble from oscillation in the intermediate amplifier, the condensers connected across the cathode biasing resistors, of which there are two, should be increased to 1.0 mfd., and if the squealing trouble was very bad to begin with (which it should not have been, if the circuit was carefully built), these two capacities may have to be increased to 2.0 mfd. each. The selection of i-f input to the detector is made by putting the switch (to left of the last tube) in uppermost position, d, in respect to the diagram. When the middle switch position e' is used, audio input is provided, if a microphone, microphone transformer, phonograph pickup unit or phonograph pickup transformer is connected between e and e'. The bottom position silences the speaker for all uses, valuable if one desires to tune past many strong stations without hearing those being passed over. P is a potentiometer of 500,000 ohms or more, while R, the detector load resistor (horizontal) is 500,000 ohms and the con-

A Two-Stage Intermediate Amplifier



An intermediate amplifier for a short-wave superheterodyne. It may be used also for reception of lower radio frequencies, by proper selection of values in the mixer.



An audio amplifier and B supply. A 56 is the driver of two 45's in push-pull, while the rectifier is an 80.

denser across it is 50 mmfd. C1, atop detector, is 0.01 mfd. or higher capacity.

* * *

Switching for Short Waves

DOES THE USE of a switching system in a short-wave set presuppose some loss, due to the switch, hence are plug-in coils superior in this regard? What are the shielding requirements for a short-wave receiver?—L. K.

There is some loss due to the switch, as heavy current must flow through the switch, resonance current always being comparatively heavy. Therefore it is important that the switch have low contact resistance. The better grades of switches have contact resistances from 0.1 ohm to a few thousandths of an ohm. Therefore the contact resistance is to be compared when a figure of merit is to be assigned to switches and plug-in coils. In general, the better grades of receivers have had plug-in coils, yet it is not to be assumed that the contact resistance is zero, in fact, using ordinary tube sockets of medium caliber, and especially coils wound on tube bases, the contact resistance may be expected to be higher than that of a good switch. The convenience afforded by the switching method has made it the more popular one, and for any much wider public acceptance of short-wave reception than prevails now, since much more than the purely experimental class would have to constitute the listeners, switching would seem to remain imperative. The shielding requirements for short waves are in general that if a stage of t.r.f. is to precede a mixer there should be at least partial shielding, and if two stages of r.f. are to be used the shielding would have to be total. But the shields should not be closer to the nearest part of any coil than the diameter of the tubing on which the coils are wound.

* * *

Honeycombs for Short Waves

ARE NOT HONEYCOMB coils suitable for short waves, especially as they are so compact that they permit running short leads?—I. H.

No, they are not very good for short waves. In general, honeycomb coils are suitable for frequencies lower than the lowest in the broadcast band, and for some special uses may be extended into the broadcast band, as in the case of test oscillators. But small coils are very practical for short waves and may be wound in solenoid style on the same sort of dowel pieces used for honeycomb coils. One such coil was put into a test oscillator and generated 30 mcg at the highest frequency.

* * *

Dial Scale Calibration

AS I WOULD LIKE to prepare my own calibrated dial for a short-wave set, will you please instruct me how this work should be done?—T. G. F.

A blank dial scale should be used, and some source of frequencies, preferably a signal generator. Then a sharp, hard pencil is used to register the points of various frequencies, possibly in even frequency distribution. For the lowest-frequency band, for instance, if it is 1,600 to 3,200 kc, the points may be 50 kc apart. This would yield 32 points. So for the next band 32 points might be used again, but the frequency separation of course doubled, being 100 kc. So the points are registered and noted on the blank scale. Then the dial is removed, the bars and frequencies inked in, and the integral frequencies assigned by dividing the main spaces into equal parts. For 10 kc separation there would be five divisions between main bars, including one main bar among the five. This subdivision can be done with a small compass, setting it so that the distance may be measured off five consecutive times to cover the space between main bars. For reproduction of the scale, protract the main divisions in degrees of a circle, and besides draw a curve on very large plotting paper, relating the frequencies and the degrees of a circle. Then the curve and the sample scale are sent to whoever is to reproduce the work.

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Vernier Dials

IS IT NECESSARY to have a vernier dial to tune in short-wave stations?—R. E. C.

It is necessary, in the sense that it is necessary to have a container from which to drink water, or to have a brake on an automobile. You could drink water directly out of a faucet, and an automobile will run without a brake. Today dual-ratio dials are popular, a reduction ration of 5 to 1 or so for the broadcast band, and lower frequencies, if any, and 40 to 50 to 1 for the short waves. Thus no matter how nervously a person may turn the knob at the high-ratio, the condenser plates engage and disengage slowly, and the tuner-in is compelled to go slowly. An objection to a high reduction ratio permanently applied is that it takes so long to go from one extreme of the dial to the other, but the dual-ratio method takes care of this.

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Celluloid Scale

WOULD A CELLULOID scale be suitable for a short-wave receiver, or would it be preferable to have a metal one?—K. M.

All the celluloid types of scales are subject to warpage and therefore accuracy is not served, no matter whether plain numerical registration is on the scale, or frequency calibration. The accuracy finally disappears. Heat, moisture, cold and the like cause the scale to stretch or shrink or even curl. An effort to get away from this, and still retain the desirability of a scale that is translucent, so that projected indication remains possible, is to "bead" the rim of the scale. This consists of causing a tool to put a stiff ridge on the scale, of the same material as the rest, but reducing considerably the troubles just outlined. In general, a stiff scale is preferable, and metal is highly acceptable.

* * *

Power Amplifier

PLEASE GIVE details of a sufficient B supply and audio amplifier for a short-wave superheterodyne tuner.—O. D.

The output tubes are 45's in push-pull, driven by a 56, while the rectifier is an 80, as shown in the diagram herewith. A very high inductance audio choke should be used as detector load. If the tuner delivers a strong output, the biasing resistor of the 56 should be 2,500 ohms, but if the input is not so strong, this resistance may be lowered to 1,000 ohms, and the audio sensitivity will be increased, and partly offset the r-f weakness. The B choke for the power tubes and rest of circuit is separate from the field of the speaker. All the B current flows through the 400-ohm choke, and all but the output tubes B current through the speaker field. The inductance of chokes for B filters should be as high as practical, consistent with low d-c resistance. Hence statement of d-c resistance infers that resistance should not be exceeded.

CITES COST OF TELEVISION AS FANTASTIC NOW

Philadelphia.

Speaking before the ninth annual convention of the Institute of Radio Engineers, W. R. G. Baker, vice-president and general manager of RCA Victor Company, outlined the difficulties that must be overcome before there can be a television receiver in the average home.

Describing some of the problems, Baker said:

"Considering the service range per transmitter of from 15 to 20 miles radius and in general limiting the locations to those capable of servicing 100,000 population, we have a possible coverage of 42,000,000 of the country's population."

Huge Investment Required

"Based upon our present tools and assuming a possible coverage of 42,000,000 people, we would require about 80 transmitters, with an investment of, say roughly, 40 million dollars. If we required the networking of these transmitters under present-day knowledge, an additional investment of probably 40 million dollars, representing about 5,000 miles of network—or a total investment of about 80 million dollars—would be necessary.

"The annual maintenance and operating costs would be about $14,000,000. The time required to set up such a system would be at least six to eight years and would take at least 41,000 man-years to accomplish.

"While the present sound broadcasting chains produce about 5,000 hours of entertainment a year, we will be fortunte if we have 2,000 hours of television talent available, including all the feature movies, stage productions, etc. The entertainment life of the television artist will be much shorter than that of the sound entertainer, due to the fact that the public will become tired of looking at the same artist."

"The question is—who will provide the capital? Even if the technical and financial problems are solved, there would still remain the question of what should be transmitted. The public has been educated by motion picture technique to expect high-class entertainment; television, therefore, can not hope to offer mere peep-hole images on its screen.

"Unlike radio, television will require undivided attention of the audience, which may mean television programs at only certain periods during the day. The investment will be idle unless the equipment is used for sound broadcasting during the off periods.

Still Hopeful

"While the problems of television are so complex and the capital required runs into fantastic figures, I really feel that these factors are hopeful rather than pessimistic. They simply indicate that we do not have the necessary tools or information on which to base a national system of television and they stand as a challenge to the engineers and to the radio industry to discover new tools and new methods in order that television may become commercial."

A THOUGHT FOR THE WEEK

FRIEDA HEMPEL, noted grand opera soprano, surely has made a friend of everybody connected with station WNYC. Mme. Hempel announces her desire to sing over that station in appreciation of the fact that New York City has been very good to her and has helped to make her life a happy one. This offer comes at a time when WNYC needs all the encouragement possible, for it has only a few months to prove to the satisfaction of Mayor LaGuardia that its personnel should continue on the municipal pay roll. In other words it's a question of continuing or passing out, and undoubtedly Mme. Hempel's announcement will help a lot when the decision is finally made.

A value of $25 was placed by Life Magazine on the line, "When a dog bites a man, that's news." This fact was brought out in a suit for that amount against the National Broadcasting Company, Standards Brands, Inc., and the comedian, Eddie Cantor.

It was claimed that this line had been used in a humorous piece representing a conversation between an airedale and a collie, printed in Life Magazine in March, 1934.

National Union Log Includes Short Waves

The latest edition of the National Union Radio Corporation Log Book, just released, has been modernized by the addition of a two-page world-wide Short Wave Time-Table.

The stations listed on this table have been heard at listening posts located throughout the United States and reported in to a Central Bureau. These posts operate from 5:00 a. m. EST, to midnight. Station listings are shown with both wave-length in meters and frequency in kilocycles.

The log includes biographical material on announcers and radio stars, a special story, "Back-Stage at a Broadcast," which gives a comprehensive idea of the creation of sound effects and a complete up-to-the-minute listing of stations in the United States by call letter and kilocycles, Canadian stations, Cuban stations, Mexican stations, experimental visual broadcasting stations in the United States, stations operating in the emergency service, licensed municipal Police Stations and construction permits issued for municipal Police Stations.

In a three months period, 300,000 of these National Union Logs have been placed in the hands of the radio trade throughout the United States and have been in tremendous popular demand by radio owners everywhere.

Set Definitions Changed

The term "dual wave" has been eliminated by Radio Manufacturers Association as an alternative definition for the "standard and short-wave" receiving set having a frequency range between 4,000 and 20,000 kilocycles. To this extent the original definition for this type of receiver has been modified.

The three classes of receivers are therefore:

(1) The "standard broadcast" receiver, frequency range from 540 to 1,570 kc to include recent extension of the broadcast band.

(2) The "all-wave" receiver, frequency range from 540 to at least 18,000 kc.

(3) The "standard and short-wave" receiver, having frequencies between 4,000 and 20,000 kc.

Station Sparks

By Alice Remsen

IT WILL SEEM STRANGE to tune in 7:00 p.m. on WJZ and not find Amos 'n' Andy—but don't worry; these two beloved comedians are not off the air-waves; their time has just been changed to 7:45 p.m., EDST. . . . And speaking of comedians, the Sisters of the Skillet, known to their friends as Eddie East and Ralph Dumke, are back again, and may be heard each day from Monday to Friday, at 12:15 p.m. These famous sisters have been featured over the NBC networks for several years. Their new programs will be heard from Radio City. . . . Wayne King has returned from his vacation of more than a month, and has resumed his broadcasts for Lady Esther, each Tuesday and Wednesday at 8:30 p.m. over an NBC-WEAF network. The celebrated waltz king spent a month in California with his wife and little daughter. . . . "Tim Ryan's Rendezvous"—the peppy pseudo-night club program produced by Tim Ryan and his pretty partner, Irene Noblette—has been given a time change; formerly heard on Saturdays at 10:30 p.m., they will now broadcast on Tuesdays at 9:30 p.m., EDST. . . .

Instrumental works by great composers, written for small groups of instruments, will be heard in a new series over an NBC-WJZ network, Sundays, at 7:30 p.m. . . . Well-known concert soloists will join with noted string quartets in this series to play some of the lesser known compositions of the masters. . . . Helen Jepson, a stately blonde soprano, has won a contract with the Metropolitan Opera Company as the result of her singing over the NBC networks. Miss Jepson is still in her early twenties and was born at Titusville, Indiana. . . . Frank Crumit, the genial master-of-ceremonies on the Schlitz Spotlight Revue" over WABC and the Columbia network each Friday night at 10:00, is just recovering from a violent attack of "nephew-and-niece"; the attack was actually named Peggy and Bud Trautman, aged sixteen and fourteen, who came East to visit their Uncle Frank at his Massachusetts home and insisted on having him take part in all their athletic pastimes, golf, tennis, riding and swimming, every day, and made him go to parties with them every night, until poor Uncle Frank was bruised and bleary-eyed. He's getting along nicely now, thank you! . . . Parker Fennelly, the "Uncle Abner" of the Spotlight Revue, was member of a Shakespearean touring company when he was a young man. . . . Classical music, including symphony orchestras, artists recitals, string ensembles and other similar features, now occupies 23% of the total air time on the Columbia broadcasting System. This is an increase of 17% over five years ago when such programs averaged only 6% of the program schedule. This indicates a decided change in the tastes of the listening public. . . .

Myrt and Marge start their fourth season on October 1st. They will be heard in the east on their former schedule of 7:00 to 7:15, EST, but western listeners will tune from 11:00 to 11:15 p.m., EST. . . . Frederick H. Weber resigned from NBC recently to become vice-president in charge of operations and station relations of the American Broadcasting System, the Eastern regional network organized by George B. Storer. . . . Archie Bleyer's Orchestra, broadcasting from the Commodore Hotel over the WMCA-ABS network, is one of the few dance units with a 'cello in the string section. Joe Furia plays the mellow instrument and doubles on the saxophone. . . . Speaking of orchestras reminds me that four more have been added to the dance parade of WMCA and the ABS, including Benny Goodman's and Jerry Arlen's orchestras, Charlie Eckel's "Mayfair" Orchestra, from the Red Lion Inn, and Udo's Dance Orchestra from the Gloria Palast, New York.